PRODUCT WORK CLASSIFICATION AND CODING

PREPARED BY

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SEATTLE, WASHINGTON

JUNE 1986

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THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS
SHIP PRODUCTION COMMITTEE PANEL SP-4
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EXECUTIVE SUMMARY

"I think it is very important to apply group technology concepts for higher productivity of the U.S. shipbuilding industry. Not only are 'Zone Outfitting" and "Product Work Breakdown Structure" important, but also the overall implementation of group technology methods, *such as classification and coding, computer-aided process planning, design and process data retrieval, etc. are essential for further improvement of the industry."*

So said Dr. Inyong Ham, Professor of Industrial Engineering, Pennsylvania State University, when asked to comment on the application of group technology manufacturing methods to the U.S. shipbuilding industry.

The U.S. shipbuilding industry is at a crossroads. If productivity is not increased, only those ships most vital to the nation's defense will be built in U.S. shipyards. The rest will be forfeited to foreign competition as cost, quality and construction time become the key determinants in contract awards.

For many years, group technology has been endorsed by shipbuilders worldwide as one of the cornerstones of the shipyard of the future. In other industries, group technology has been an effective bridge to the benefits of advanced technology manufacturing. Part standardization, repeatable part assemblies, computer-aided process planning, automation, and robotics are benefits long overdue to the building of ships. The shipyard that adopts a wait-and-see attitude may wake up to find an industry dominated by competitors speaking a new and different language. The true peril of the current crossroads lies in the disparity between the long learning curves imposed by these new technologies and the short backlogs held by most shipyards.

The goal of this project was to shorten these learning curves. As Dr. Ham points out concepts are only a beginning. Tools for implementation of group technology work methods are essenntial for further improvement of the industry. Tools make technology more accessible. This manual and the classification and coding system contained herein were developed as tools to make group technology more accessible to the U.S. shipbuilding industry.

This manual

- discusses group technology and its application to shipbuilding,
- presents a classification and coding system based upon the concepts of Product Work Breakdown Structure,
- presents examples illustrating use of the classification and coding system in two forms; manual and computer-aided,
- discusses subjects related to use of the classification and coding System and
- lists resources for further information.

ACKNOWLEDGEMENTS

This publication was produced for Newport News Shipbuilding by Todd Shipyards Corporation, Seattle Division as a part of its commitment to the SP-4 Design/Production Integration Panel of the Society of Naval Architects and Marine Engineers. Todd Seattle was represented on the panel by Feite Posthumus.

The content of this manual was developed by a project team led by Tedd Hansen. Team members included Miles Webb and Diane Bradley of the Seattle Division and Rick Lovdahl, Juli Orr and Larry Chaplin of the Los Angeles Division of Todd.

Appreciation is expressed to the Cam Software Research Center at Brigham Young University for providing access to DCLASS and Paul Smith in particular for providing valuable assistance concerning its use.

This manual is an end product of 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 the Ship Reduction Committee of the Society of Naval Architects and Marine Engineers, is to improve productivity.

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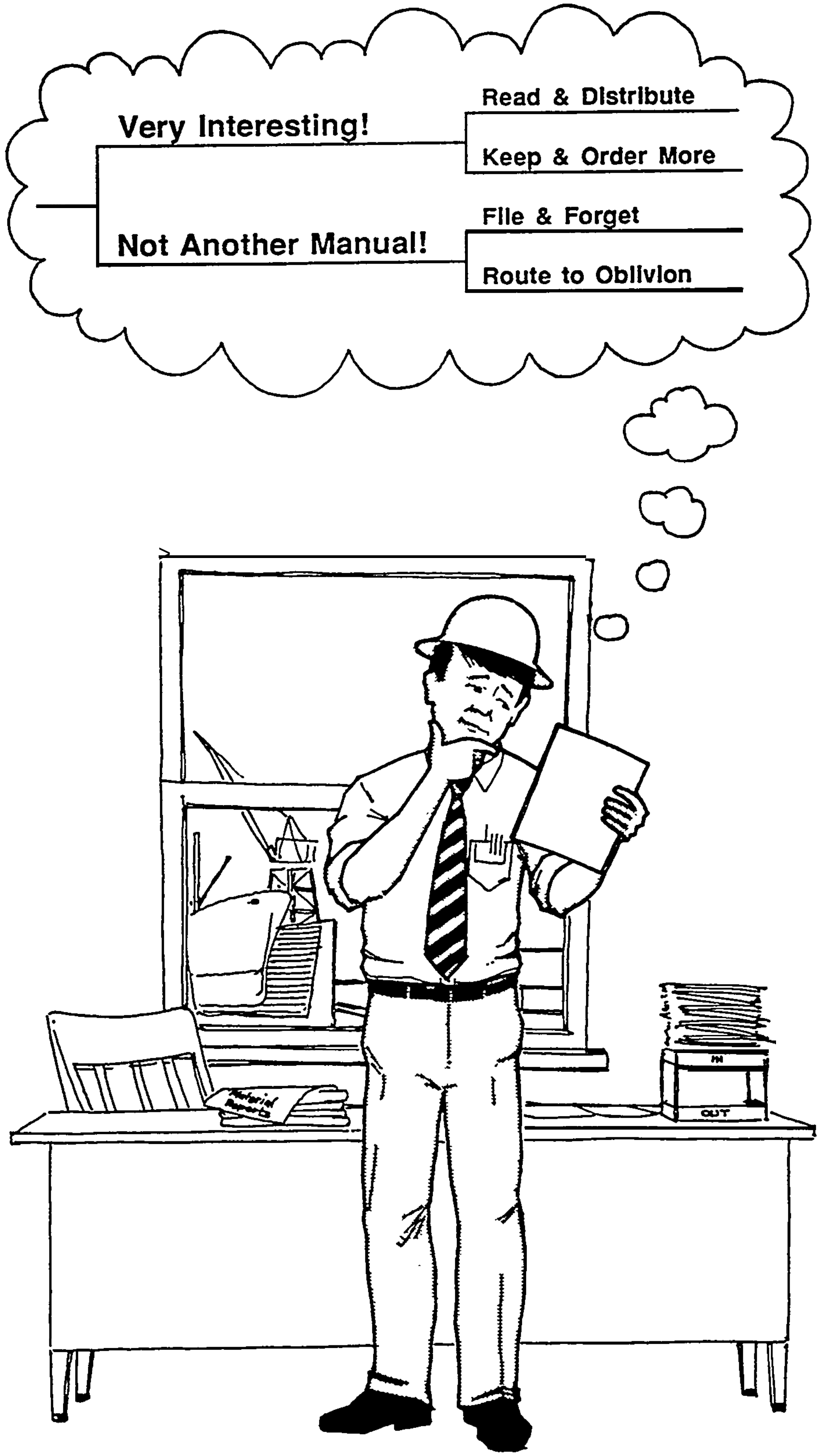

Very Interesting!
Read & Distribute
Keep & Order More
Not Another Manual!
File & Forget
Route to Oblivion

SECTION 1
The Project and this Manual

Section One acquaints the reader with the goals and methods of this manual and the study that produced it.

1.1 Introduction

This manual is the result of a two-year study conceived and administered by the SP-4 Design/Production Integration Panel of the Ship Production Committee. The members of this panel had witnessed the important role group technology was playing in a productivity revolution that was occurring in many industries. Similar benefits, they felt, could be realized in the building of ships. The panel instituted this project to explore the role classification and coding, an important aspect of group technology, would play in attaining these benefits.

At the heart of this effort, was the panel's conviction that many of the barriers encumbering productivity are a result of the polarization of design and production. In their view, design is, in fact, the first step taken in building a ship. Many factors affecting production efficiency are determined during design; it is essential to integrate these functions to ensure that features designed into a ship are suited to the facilities and resources that will be used to build it.

At the heart of his integration effort is effective communication. If ship designers and shipbuilders can develop a common language which communicates the needs and concerns of both, then a significant step toward true integration will have been taken.

Enter classification and coding. Classification began when man sought to understand the world around him. By identifying and placing plants and animals into hierarchical relationships with one another, classification provided a very precise language to describe life on this planet. In shipbuilding, the vast amount of work that goes into the building of a ship requires an equally precise language if it is to be understood. A classification and coding system will not, by itself, integrate design and production. But by providing a common language for the description of work. the panel felt one major obstacle toward that goal would be overcome.

Also considered as a part of this project were manufacturing technologies the panel had observed in other industries and concluded were downstream benefits of group technology and classification and coding. These included computer-aided process planning, flexible manufacturing and "Just-In-Time" material procurement. The effect classification and coding would have on the use of CAD/CAM, particularly in the areas of standard part libraries, standard structural configuration details, and standard equipment arrangements was also recognized as an important potential benefit of this project. Considering all the possible benefits that could result from the development of a classification and coding system, the panel deemed this project a wise investment on behalf of the U.S. shipbuilding industry.

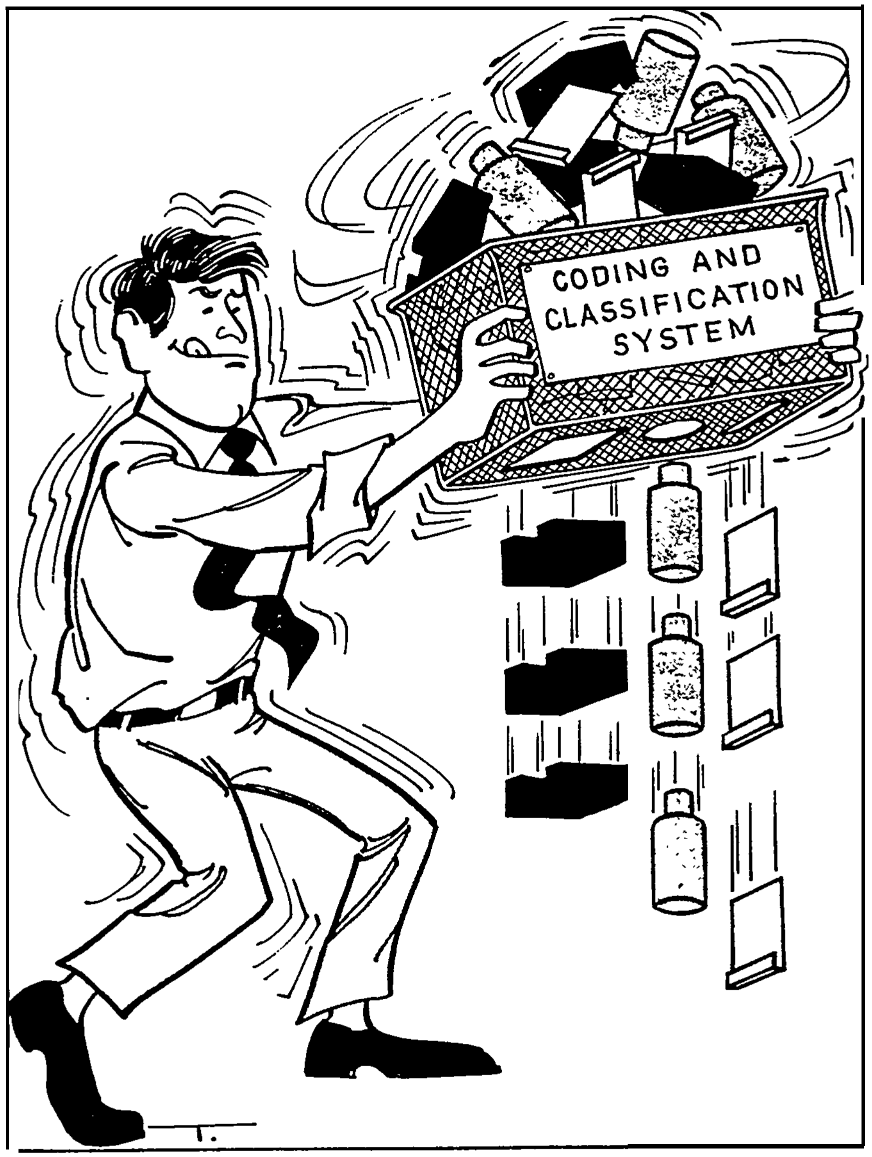
Todd Seattle was given the task of exploring group technology with the intent of developing art application of classification and coding for the shipbuilding industry. The results of this effort are presented in Section Three, Product Work Classification and Coding which traces the development, presents the configuration and explains the function of the classification and coding system, in a manual and computer-aided manner.

During the course of this study, information needed to define certain characteristics of the classification and ceding system was developed. This information presented in Section Four, Related Subject, should be reviewed by any shipyard implementing this system or developing one of their own.

As this study progressed and the classification and coding system began to develop, it became apparent that to communicate its function and configuration in this manual, it would be necessary to introduce certain terms and concepts not in general use in the shipbuilding industry. This information is presented in the following chapter, Section Two, Group Technology.

In concluding this introduction, it should be stressed that group technology is a productivity tool that tends to create broad and complex applications. The goal of this project was to provide a good foundation for an application that, for many shipyards, may grow to many times the size of the system shown herein. This manual is a chronicle of the research that led to the development of that system. ultimately, it is hoped that this manual will play a part in the shipbuilding industry becoming a pioneer in the application of group technology to large and intricate assembled products.

A glossary of terms and a catalog of the resources from which this study drew definitions, data, direction and information are presented in Appendix A - Resources.



AMERICAN MACHINIST

SECTION 2
Group Technology

Section Two provides a common understanding of the terms, concepts and goals Of group technology.

SECTION CONTENTS

2.1 *Introduction*

During the course of this study it became apparent that to report the findings of the research would require using certain terms and concepts which are not in general use in the shipbuilding industry. Rather than leave the meaning of these terms and concepts for the readers to discover on their own, this section was included to define them according to the needs of the shipbuilding industry. All of the terms defined in this section are included in the glossary in Appendix A-1.

2.2 *Definitions*

Group technology is a concept, a philosophy, a business, a theory, a system an approach and a buzz word. During its two-year study, this project uncovered literally dozens of viable definitions of group technology. All had meaning within the context of their use. All spoke of what group technology did for the industry to which it was applied. Few addressed how group technology accomplished work It might be helpful then to begin this introduction by defining group technology and examining the concepts involved in its use.

Considered separately, the dictionary defines the words **'group'** and **'technology'** *as:*

Group - A number of individuals or things considered together because of certain similarities.

Technology - The application of science especially to industrial or commercial objectives.

(From the American Heritage Dictionary of the English Language, New College Edition.)

An effective composite definition assembled from these might read:

Group Technology - A means of attaining industrial or commercial objectives by scientifically considering individuals or things together because of certain similarities.

Dr. Inyong I. Ham of the Pennsylvania State University, a noted authority in the field of group technology, inferred this idea when he defined group technology as

"A manufacturing philosophy ***which*** identifies and ***exploits the underlying sameness of parts and manufacturing processes".***

To better serve the needs of this manual, the following definition, more specific to shipbuilding, was developed.

Group Technology/Shipbuilding - A shipbuilding strategy that identifies similarities that occur at specific stages of the shipbuilding process, from design through delivery, and exploits those similarities to achieve the industrial goals applicable to that stage and/or the entire process.

23 *Concepts*

When group technology is applied to an industry, it typically manifests itself in the form of new methods for organizing and accomplishing work It may be helpful then to explore how group technology functions in terms of:

- group technology concepts for organizing work and
- group technology concepts for accomplishing work

2.3.1 *Group Technology Concepts for Organizing Work*

Group technology has made a significant contribution to many companies solely because of its capability as an organizing tool. In these companies, managers use group technology to organize parts, products, information, data and people. Because this study limited itself to parts and assembled products, this discussion will concern only these items. It should be remembered however, that the concepts defined here can be applied to the organizing requirements of many things.

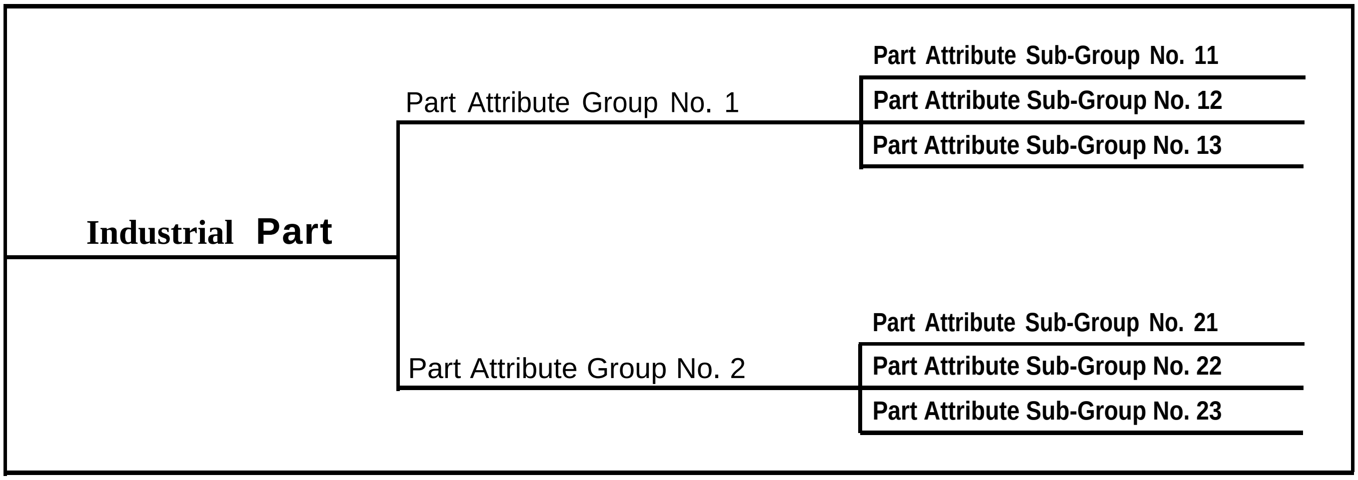


Figure 2.3-1
Generic Classification Coding Tree

Group technology derives its organizing capability by providing a structure or framework for the performance of work. Within this structre large, unwieldy quantities of parts and products can be sorted into smaller, more manageable groups according to specific attributes.

Attributes - An inherent characteristic of a part or product.

Significant attributes which enable parts and products to be sorted are identified with the aid of a classification and coding system.

Classification and Coding System - A structured arrangement of the significant attributes which a company uses to sort its parts and products and an abbreviated means of identifying them with code characters.

A generic classification and coding system is shown in Figure 2.3-1 in the form of a classification tree.

Classification Tree - A graphic means of portraying the structure, attribute groups and codes of a classification and coding system.

The tree is read, or traversed, from left to right as parts are sorted into groups which become progressively more specific.

The selection and structuring of attributes me two of the most important aspects of a classification and coding system. The identity of the attributes must sort parts and products into groups which are compatible with the prccesses that will be used to manufacture them. The structure of the attributes must reflect the organizational structure of the manufacturing facility.

In Figure 2.3-2, a classification and coding system for steel parts is shown.

This classification and coding system sorts steel parts according to attributes which are significant to their production processes. These processes will be discussed further in Section 2.3.2., “Group Technology Concepts for Accomplishing Work”. For this discussion concerning organization, it is important to recognize that this classification and coding system would provide a shop which produced steel parts with a means of organizing parts. Rather than attempting to manage all of its parts as a single entity, it can now sort those parts into four smaller, less complex entities.

Figure 2.3-3 illustrates how a variety of steel parts, each uniquely numbered, are sorted into groups possessing the attributes reflected in the classification and coding system. After classification, parts are identified by a two-part number made up of the part number and its group code. By identifying parts in this way, each part retains an individual identity for job assignment and a group identity for sorting.

This two-part number is the key to group technology’s organizing capability. It captures the information that enables a company to sort parts and store and retrieve related data by groups. This means of storing and retrieving part and product data is often the primary benefit many companies receive from using group technology. Some companies do this manually in file cabinets, others use computers. Either way, the concept is the same.

The classification and coding system and the logic by which it identifies and structures attributes are the heart of any application of group technology. By establishing the organizing characteristics for parts and products, the classification and coding system reflects organizing characteristics for the work that will be done to manufacture them.

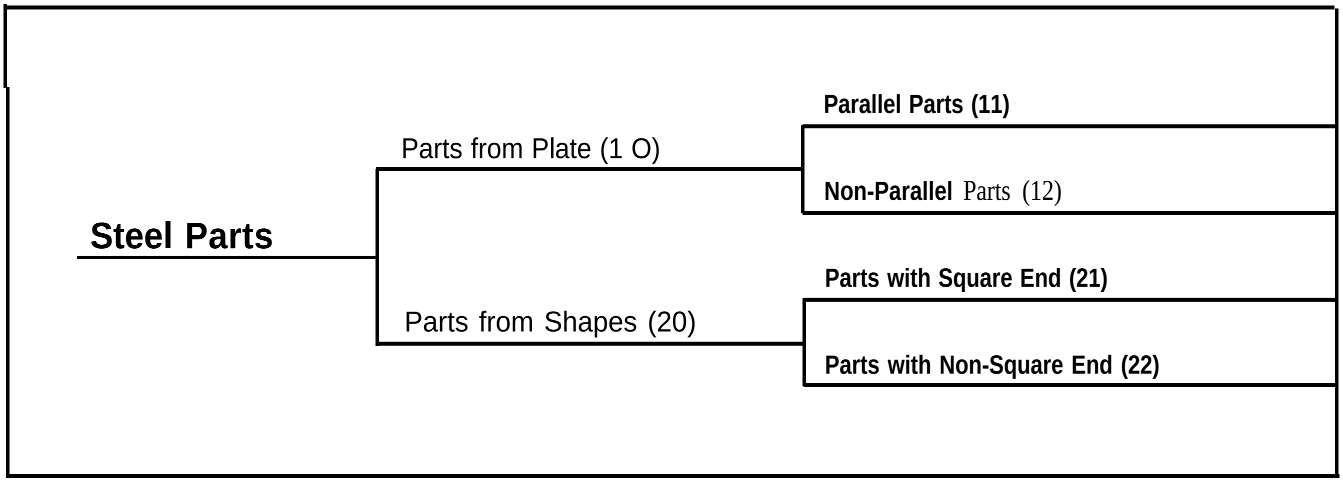


Figure 2.3.2
Steel Part Classification and Coding Tree

2.3.2 *Group Technology Concepts for Accomplishing Work*

Group technology's Power as an organizing tool has improved the efficiency of many companies. The greatest benefits, however, have been realized by those companies which have extended the logic used to organize parts and products into their production facilities. In these companies, group technology becomes a two-way street: Parts and products are organized according to the production processes they require, and production facilities are organized according to the production processes of the parts and products they produce. In companies which fully embrace group technology, the end use of a part or product is only significant during design and final testing. During the manufacturing cycle, the identity of a part or product is a function of its production processes.

The value of sorting parts and products into groups requiring similar manufacturing processes becomes apparent when the cost of maintaining those processes is known. If the number of required processes can be reduced by manufacturing similar parts and products by common prccesses, then production cost will be less than when similar parts and products were manufactured by independent prcesses.

Referring again to the classification and coding system shown in Figure 2.3-3, this application of group technology provides a means of accomplishing work by sorting steel parts according to their production processes. Those parts in Group 11, Parallel Parts from Plate, would be cut on a shear. Parts in Group 12, Non-Parallel Parts from Plate, would be cut with a numerically controlled torch. Parts from Shapes with a Square End Cut, Group 21, would be cut with a cut-off torch, while Parts from Shapes with Non-Square Ends would be cut with a saw. Certainly, other processes could be substituted in place of those mentioned here, depending on the configuration of the part and the tools available at the facility. It is apparent though, that this classification and coding system would enable the steel shop to route its parts to the tool which could most efficiently produce each part. The steel shop, in turn, would be arranged to reflect the most efficient routing for parts that required multiple prccesses.

This example has been kept relatively simple to demonstrate the relationship between the part attribute and its corresponding production process. In this case, a single attribute required a single process. Group technology becomes more complex when single attributes or combinations of attributes require multiple processes. However, the logic remains the same: The attributes dictate the selection of processes.

This discussion has tried to demonstrate that the full utilization of group technology is a two-step process:

Step 1: Parts or products are sorted into groups which possess similar attributes using a classification and coding system.

Step 2: These groups are exploited to yield the most productive use of the manufacturing facility and its production processes.

Further, these steps are interdependent: The classification and coding system is partially derived from the capabilities of the manufacturing facility, while the facility is often arranged to suit the production requirements of the part and product attributes.

2.3.3 The *Concept of the Interim Product*

Before discussing group technology and its relationship to shipbuilding, it is necessary to define the concept of the interim product. For it is this concept which enables companies to utilize classification and coding in organizing the manufacture of products which are assembled from large quantities of both fabricated and purchased parts. Further,

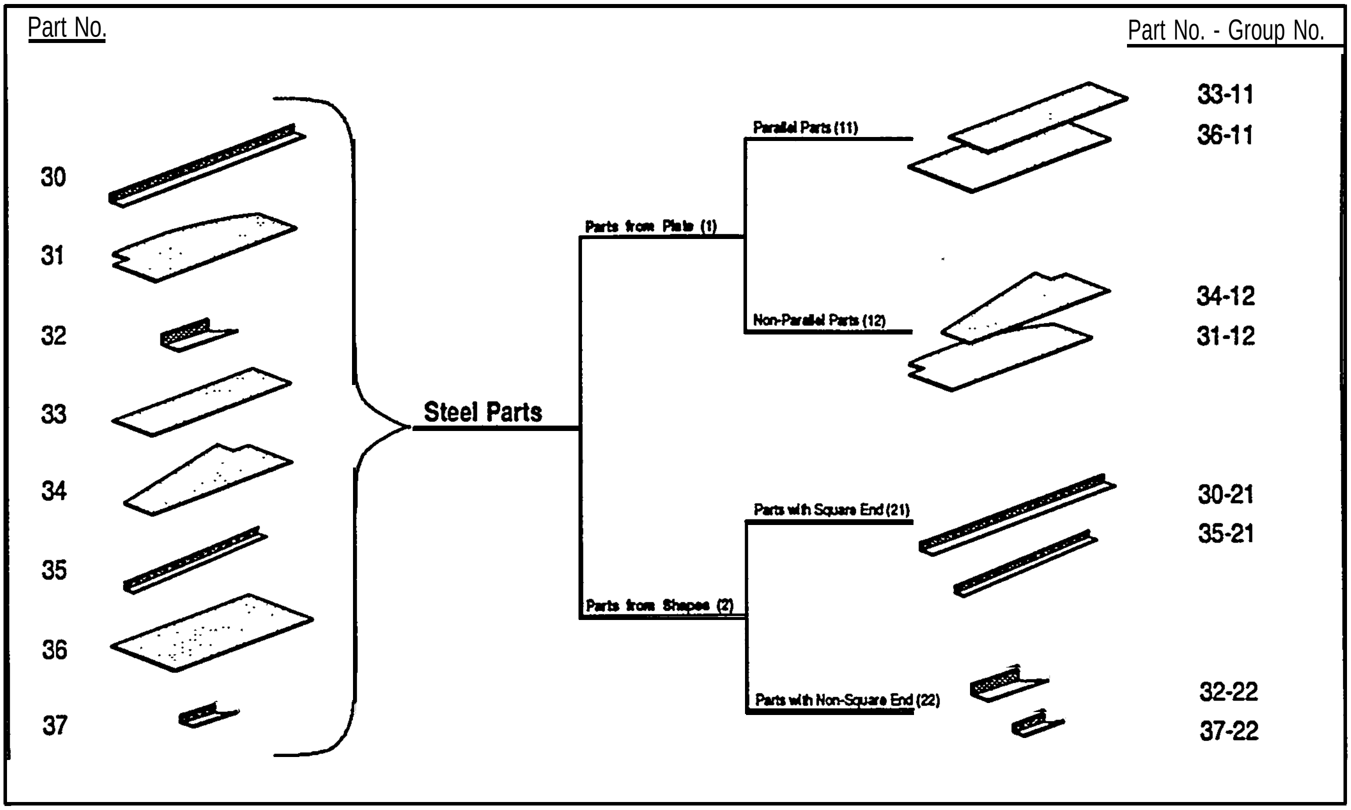


Figure 2.3-3
Sorting with Classification and Coding

because shipbuilding involves such a large number of assemblies and sub-assemblies, the term "part" does not provide an adequate vehicle for production control. The term "interim product" was devised to provide this vehicle for control.

Interim Product - An interim product is the end result of any one stage of production.

This definition is necessarily broad because of the many stages of production in building a ship. An interim product can be:

- An individual fabricated part,
- An assembly of individual parts; purchased, fabricated or both,
- An assembly of previously produced interim products,
- The installation of smaller parts or interim products into a larger interim product,
- The act of testing an interim product,
- The act of preparing purchase documents and palletizing parts and components,
- The act of cleaning, preparing the surface of, or painting an interim product,

In shipbuilding, it is the interim product which is classified and coded to form groups from which work packages can be planned.

2.4 *Group Technology in Shipbuilding*

The building of a ship, with its tremendous variety and volume of work, would seem to be fertile ground for an effective application of group technology. To search through the many divergent aspects of ship construction and identify the most significant attributes of the parts and products involved, however, seems an overwhelming task. But to wisely identify and exploit these similarities will benefit the industrial goals of the designer, the shipyard and ultimately the owner in ways no shipbuilder can afford to ignore.

In fact, the use of group technology in shipbuilding is not a recent occurrence. For many years shipbuilder have sought methods to divide the enormous task of building a ship into a series of smaller, more manageable projects. Many of these methods fall loosely within the definition of group technology because they attempt to divide the shipbuilding process according to some system of similarities which is then exploited to benefit the shipbuilder.

To establish a starting point for understanding group technology in shipbuilding, it will be helpful to quickly review one of the most popular applications currently in

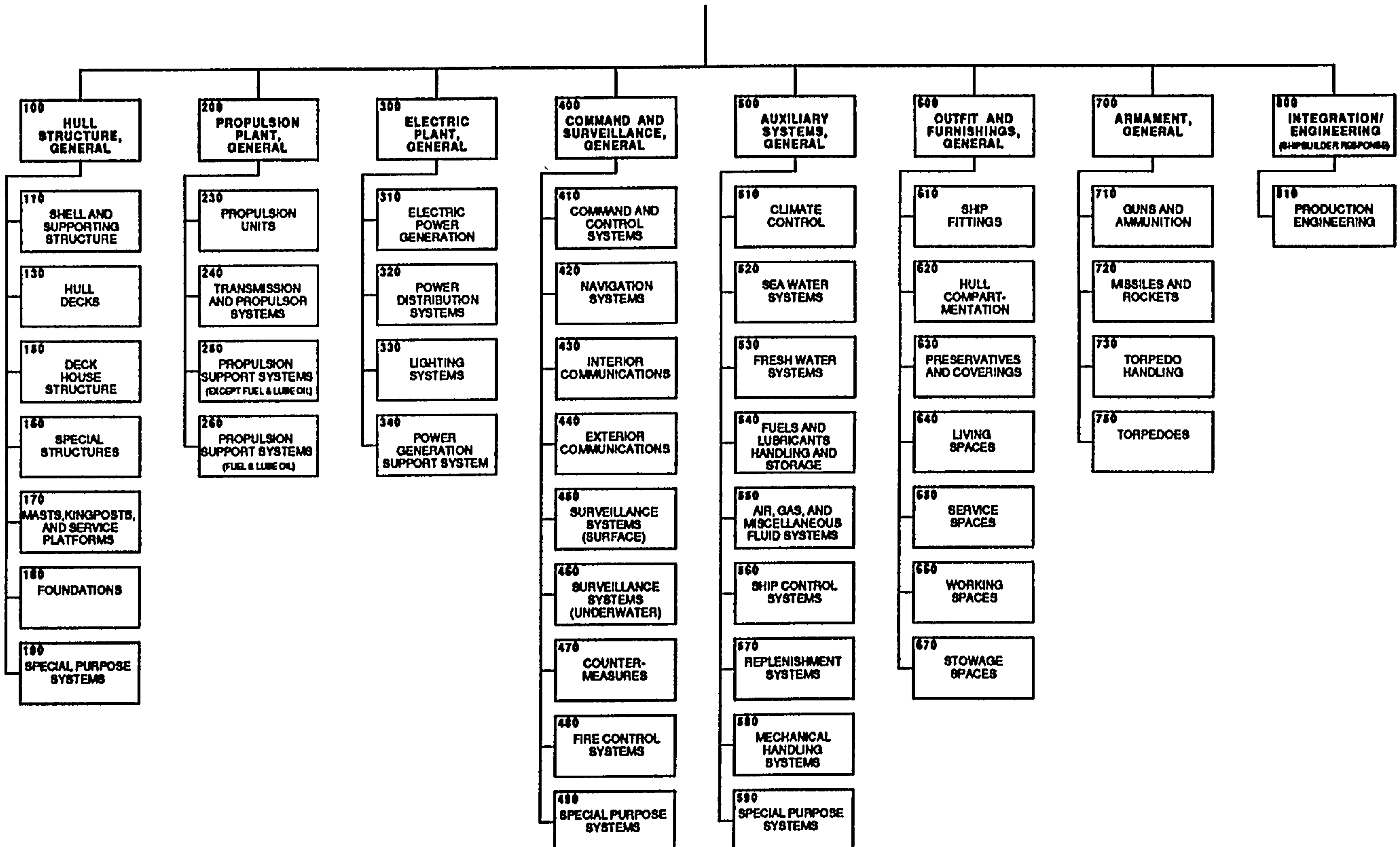


Figure 2.4-1
S.W.B.S. Classification and Coding Tree
(abbreviated)

use in U. S. shipyards: The Ship Work Breakdown System (SWBS). Under SWBS, similarities of system function are identified in a classification and coding system. The first two branches of this system are shown in Figure 2.4-1. In many shipyards, the SWBS classification and coding system is used as a means of organizing:

- Drawing schedules,
- Material catalogs,
- work planning,
- Work orders,
- Craft labor, and
- Cost collection.

SWBS and systems similar to it are widely used because they provide a single, consistent classification and coding system which can be used in virtually all aspects of shipbuilding, from preliminary design through life cycle maintenance.

Recently, a reduction in the number of ships being built worldwide has created a very competitive situation in the shipbuilding industry. To compete more effectively, many shipyards have sought means of increasing productivity. These shipbuilders witnessed the significant productivity improvements group technology had created in other industries and felt that similar improvements could be implemented in the shipyard. Of particular interest was the direct connection group technology provided between part or product attributes and production process selection. If shipbuilding processes could be selected by attributes found in the various parts and products that make up a ship, work could be planned and production managed more effectively.

SWBS and other incumbent, system function oriented classification and ceding systems were found to be inadequate for this purpose. While the attributes they possessed provided a means of organizing work, they did not capture the most effective information for accomplishing work. Attributes of system function did not provide an effective basis for process selection because

1. Work packages predicated on system function often contain a variety of work processes and make no distinction between fabrication and assembly work,

2. Systems typically run to many parts of a ship resulting in work packages that are spread over large areas making them difficult to monitor and coordinate,

3. Work packages often contain too many man-hours to serve as an effective means of process control.

To effectively utilize group technology as a means of organizing and accomplishing work, shipbuilders needed a classification and coding system that identified part and product groupings according to production process similarities, i.e., work packages, containing similar types of work, in manageable increments and areas.

To meet these needs, the most advanced builders of ships have begun to use an application of group technology called Product Work Breakdown Structure (PWBS). PWBS provides a scheme for sorting ship parts and products according to similarities of product work, rather than system function.

It would be a duplication of effort for this manual to describe, in detail, product Work Breakdown Structure. The reader is instead encouraged to read or review the manual, “Product Work Breakdown Structure”, a publication of the National Shipbuilding Research Program, 1982 revised edition. A classification and coding system that was derived from Product Work Breakdown Structure is presented in Section III.

The remainder of this section will be devoted to discussing, in general terms, the capabilities a classification and coding system provides.

2.5 *BEYOND CLASSIFICATION AND CODING - A CASE HISTORY*

Ultimately, a classification and coding system becomes a tool for capturing information, and it is information which is used to organize and accomplish work. In its research, this study witnessed applications of group technology that began with classification and coding of the work object and gradually accumulated more and more information until virtually every aspect of the journey through the manufacturing facility was defined.

The classification and coding system presented in the following section was developed with such an application in mind. Its objective was to classify and code the work object, i.e., the interim product, with the knowledge that this was but the first step in what would eventually become a much larger information capturing process.

The relationship between classification and coding and other aspects of this process is demonstrated in a case history presented as Figure 2.5-1, A Broader View of Group Technology, a paper by employees of the Boeing Commercial Airplane Company. This case history is significant to the goals of this study because it

1. concerns the design and production of a large, highly complex product,

2. the product is assembled from a large quantity of fabricated and purchased parts, and

3. the product is produced in relatively small quantities when compared to mainstream industrial manufacturing.

Although this case history describes work that was done in the late seventies, it accurately reflects many of the benefits and liabilities of implementing group technology.

Because group technology is at the heart of many productivity innovations occuring throughout industry today, the ways in which it is used are continually changing and expanding. Readers wishing to keep abreast of the latest developments in group technology are encouraged to subscribe to the publications and join the professional organizations listed in Appendix A - Resources.

Figure 2.5-1

A BROADER VIEW OF GROUP TECHNOLOGY

By

W. D. Beeby, Director - Engineering Computing Systems
A. R. Thompson, Manager- Classification Systems
Engineering Division, Boeing Commercial Airplane Co.

When the Boeing Company first approached the concept of classification and coding and group technology, our analysis of benefits was based on the traditional concept of utilizing family groups of piece parts to foster economy in design and production. It was anticipated that benefits would be derived from a library of drawings which would group the piece parts into families by their similarities so that the benefits of existing engineering could be derived through a system of design retrieval.

On the production side, it was assumed that family identification would permit grouped production. We also rightly assumed that the aforementioned benefits would justify the creation and the maintenance of a classification and coding system.

Subsequent events have led to the knowledge that our initial view was entirely too narrow.

During the period 1974 to 1977, we did develop and demonstrate a number of highly beneficial uses of group technology concepts which follow tradition. Before embarking on a discussion of the expanded applications to group technology now underway in the Boeing Commercial Airplane Company, a review of the 1974-1977 experience is appropriate.

CLASSIFICATION AND CODING

The first step in any group technology system must be the classification and coding of the elements of production. The Boeing classification structure is based on the E. G. Brisch concept of hierarchical classification. The system assumes that all elements of the Company are subject to classification: the product, the means of production, and the controls overproduction.

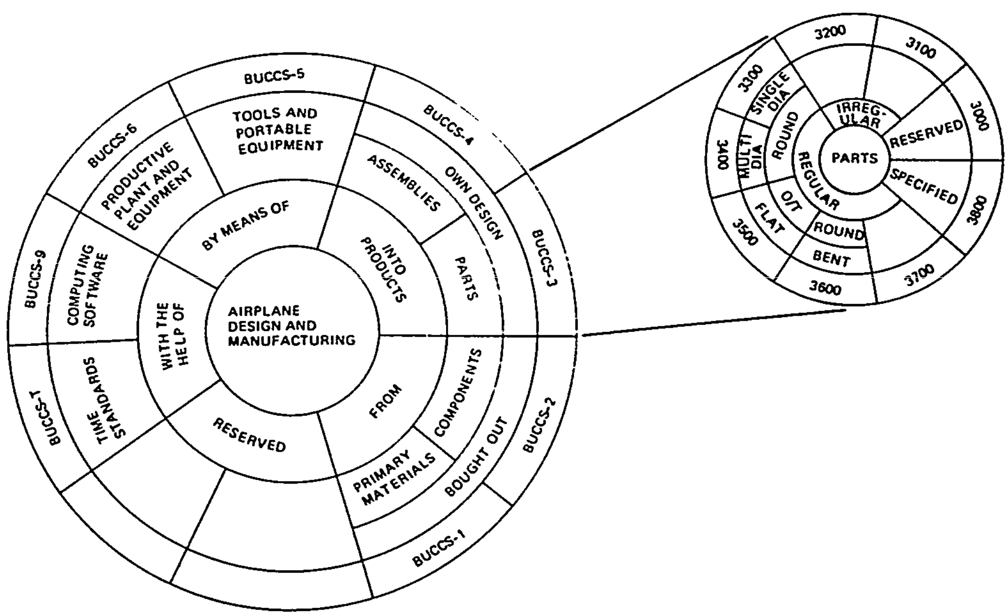


Figure 1. The Boeing System is Based on the E. G. Brisch Concept of Hierarchical Classification

Figure 2.5-1

To date, the Boeing system contains the classes which are shown in Figure 1. Figure 1 also indicates the hierarchical concept of classification where each level is dependent on the previous levels and which allows a great deal of information to be stored in a relatively small space.

The hierarchical (monoCode) concept of classification has been adopted for all Boeing classification schemes.

CLASSIFICATION STRUCTURE

The five character code which is used for all classes of items in the Boeing coding system is particularly adaptable to computer applications.

In the Boeing concept, a characteristic database is constructed in which the five character BUCCS code represents the least common denominator definition. This number is the address of its complete definition as common denominator, and also indexes any additional characteristic information which might be required for a using function. For example, the code BUCCS 12416 describes a 90 extruded angle, of uniform thickness, made from 7XXX alloy.

When using the classification system as a means to store and retrieve information, a design engineer would require additional information for a code different from the information required by a purchasing agent or manufacturing engineer. The supplemental characteristics required by each user are retained in the database in such away that the user receives only the information he requires. This concept is illustrated in Figure 2.

Appendix A contains a current listing and brief description of each of the classes within the Boeing Uniform Classification and Coding System (BUCCS). Our view of the system is that it should be flexible, and will constantly expand as operating organizations within the Company identify beneficial applications of classification techniques.

The structure of the classification for piece parts (BUCCS-3) is illustrated in Figure 3. This structure was prescribed by unique requirements for design retrieval. This system allows the subdivision of the total piece part population into 10,000 families which are characterized by their similarities. The classification for raw materials (BUCCS-1) is subdivided into families by material form and chemistry. In the Raw Materials Classification, each family has a more precise level of similarity than in the Piece Part Classification. Figure 4 shows the BUCCS Primary breakdown for raw materials.

DESIGN RETRIEVAL

The initial thrust of the Boeing classification and coding and group technology activity was to develop a retrieval system for piece part designs for the purpose of avoiding re-design. The piece part system (BUCCS-3) was implemented in May, 1976.

The ROI analysis of the system demonstrated the 2% design avoidance would pay for the entire system. In those organizations where the system has been fully utilized and disciplined, successful retrieval has been much higher than the *2%.* target. However, it must be pointed out that a design retrieval system will benefit an organization only if the management and technical staffs accept the responsibility of using the system diligently.

In a very large organization, such as Boeing Commercial Airplane Company, with literally thousands of design engineers and draftsmen as potential users, the administration, management, and control of the system becomes an extremely difficult task. Our experience has led us to the recognition that in some instances design retrieval at a centrally located design retrieval center may not be beneficial. As an example, in the highly stylized design of an aircraft wing structure, it is likely that design engineers already maintain extensive knowledge of design experience which a design retrieval system could not enhance. So, in our case, we have determined that design retrieval for the primary structure of aircraft wings is not economical compared to techniques already used.

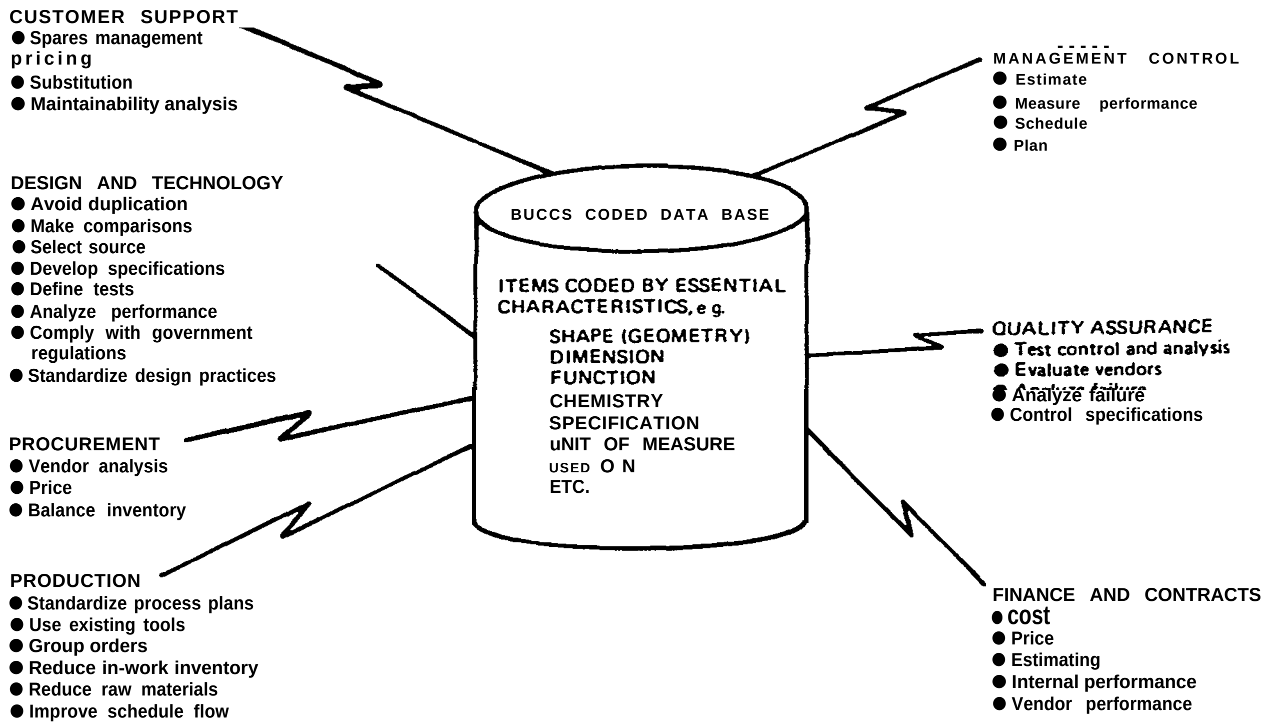


Figure 2. The Classification Data Base Can be Used to Sort, index, Store or Retrieve Product Information According to the Discrete Needs of the User

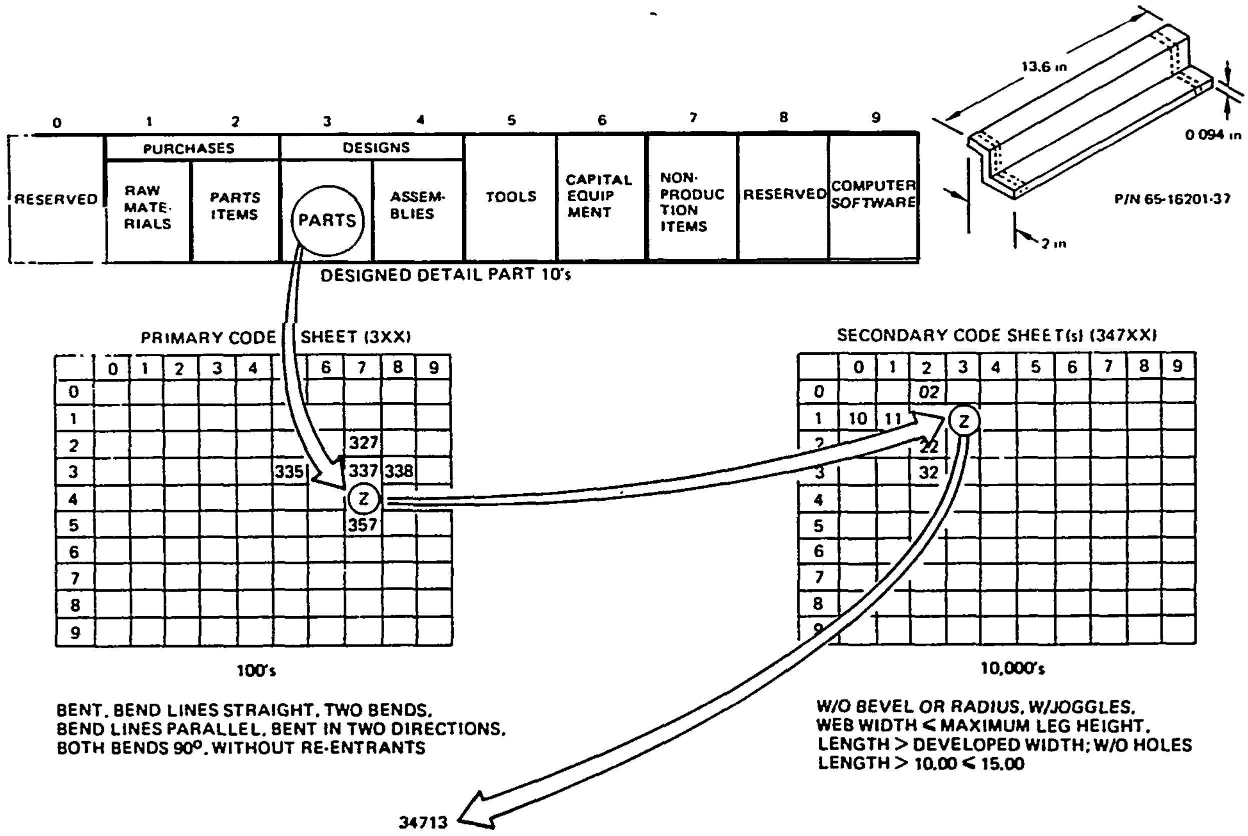


Figure 3. BUCCS Design Code Structure

Figure **2.5-1**

BUCCS FOR RAW MATERIALS D1-8248-1

PRIMARY CODE SHEET — 1XXXX — OCT 25, 78

	0	1	2	3	4	5	6	7	8	9
PRODUCTION MATERIALS — SPECIFICALLY DEVELOPED	FOR/AS									
	CONTINUOUS HINGE, HINGE PIN, EXPANDED METAL, MESH, GRATING, FLOOR PLATE HONEYCOMB 00	SURFACE PREPARATION, TREATMENT, FINISHING 01	ADHESIVE TAPE, FASTENING DEVICES, COMPOUNDS, ADHESIVES, AND SEALANTS 02	HYDRAULIC FLUIDS, LUBRICANTS, COOLANTS 03	ELECTRIC CONDUCTORS, EMI/RFI SHIELDING PERMEABLE MATERIALS 04	CARPET, CARPET UNDERLAY PAD, FLOOR COVER, DRAPERY FABRICS 05	MECH CONTROL CABLES, CHAIN HYDRAULICS, HOSES AND FILTERS STOCK 06	THREAD, ROPE, CORD, TWINE 07	08	INDUSTRIAL CHEMICALS 101XX/103XX 09
PRODUCTION MATERIALS — NOT SPECIFICALLY DEVELOPED — METALLIC ONLY — BASE — IRON STEEL	FLAT, ROUND, HEXAGON SECTIONS									
	IRON, CARBON STEEL, HIGH STRENGTH LOW ALLOY AND CONSTRUCTION STEEL 10	CORROSION, HEAT AND CREEP RESISTANT STEELS — SECTION: SOLID FLAT SOLID ROUND 11	CORROSION, HEAT AND CREEP RESISTANT STEELS — SECTION: OTHER THAN 111XX 12	13	14	15	16	OTHER THAN 110XX/116XX 17	CORROSION, HEAT AND CREEP RESISTANT STEELS 18	OTHER THAN 118XX 19
PRODUCTION MATERIALS — NOT SPECIFICALLY DEVELOPED — METALLIC ONLY — BASE — ALUMINUM				EXTRUDED SHAPES OTHER THAN 120XX						
				WITHOUT BULB PORTION(S) OR FULLY ENCLOSED PORTION(S) — EXTREMITIES						
	SOLID AND TUBULAR SECTIONS RECTANGULAR ROUND HEXAGONAL NOTE 20	FORMED SECTIONS OTHER THAN 120XX 21	22	TWO WITH ONE MEMBER INCLUDING FILLERS 23	TWO WITH TWO OR MORE MEMBERS INCLUDING ANGLES CHANNELS, ZEES AND HATS 24	THREE OR FOUR INCLUDING T J I, AND H SECTIONS 25	FIVE OR MORE 26	27	WITH BULB PORTION(S) AND/OR FULLY ENCLOSED PORTIONS 28	29
PRODUCTION MATERIALS — NOT SPECIFICALLY DEVELOPED — METALLIC ONLY — BASE — OTHER THAN 11XXX 12XXX	BASE									
	TITANIUM: FLAT ROUND HEXAGON SECTIONS 30	TITANIUM: SHAPES 31	MAGNESIUM 32	COPPER 33	NICKEL, COBALT, TUNGSTEN 34	LEAD 35	36	37	38	OTHER THAN 130XX/138XX 39
PRODUCTION MATERIALS — NOT SPECIFICALLY DEVELOPED — NON-METALLIC, METALLIC/NON-METALLIC COMPOSITES		FORMED FLAT ROUND SECTIONS					FORMED SHAPES O/T 140XX/145XX			
		SHEETING, STRIPS, BLANKETS					ELASTOMERIC		NON-ELASTOMERIC	
	UNFORMED 40	RUBBER, SYNTHETIC RUBBER, PLASTIC FOAM 41	PLASTIC O/T 141XX INCLUDING METALLIC NON-METALLIC COMPOSITES 42	OTHER THAN 141XX/142XX 43	TUBE, ROD 44	45	WITHOUT FULLY ENCLOSED PORTION 46	WITH FULLY ENCLOSED PORTION 47	WITHOUT MALE OR FEMALE SNAP-IN FEATURE OR ENCLOSING PORTIONS 48	WITH MALE OR FEMALE SNAP-IN FEATURE OR ENCLOSING PORTIONS 49
TOOLING MATERIALS	NON-METALLICS AND COMPOSITES				METALLIC ONLY					
						STEELS				
	90	91	92	93	ALUMINUM, ALUMINUM ALLOYS 94	CARBON ALLOY, EXCEPT TOOL 95	TOOL 96	OTHER THAN 195XX/196XX 97	COPPER, COPPER ALLOYS 98	OTHER THAN 194XX/198XX 99

1XXXX

Figure 4. Primary Breakdown of Raw Materials for Aircraft Production

Figure 2.5-1

Figure 2.5-1

There are, nonetheless, extremely fruitful opportunities for design retrieval which we are emphasizing. For example: an electrical/electronic design group requested that ***a*** limited number of designs, particular to their requirements, be extracted from the nearly 200,000 piece part design library. This specialized "mini-file" contains the preferred designs for electrical housings, bracketry, and similar parts appropriate to electrical designs, and has been classified to specifically satisfy the needs of the E/E design group. In this instance, as many as 95%. of the piece parts required for a new design have been retrieved from the system.

On a selective basis, we are emphasizing the mini-file concept for design retrieval and do not intend to enforce universal design retrieval without taking into account the knowledge and availability of existing design information already possessed by each design group.

PRODUCIBILITY TIP

The first experience of the Boeing Company in integrating design and production requirements in a group technology sense is our Producibility Tip concept.

Manufacturing engineers have traditionally worked with design groups at Boeing to advise design engineers concerning the producibility of a proposed design while it is in the definitive stage. Sound economic and production management principles can thus be incorporated into a design while it is being developed. This is a highly beneficial procedure and continues ***to*** be utilized in complex and sophisticated areas such as primary aircraft structures, in which the use of exotic materials and special forgings is frequent.

The BUCCS Producibility Tip concept extends producibility advice to all piece part designs. It is based on the theory that much of a piece part design represents the arbitrary decisions of designers ***or*** drafters. After the basic criteria is established and the design envelope is determined, the design requirements can be specified as a set of dimensional relationships. The balance of the design, even for the simplest of parts, is often a result of habit/personal preference or a choice made from a series of options (any one of which is acceptable). As a result, a number of parts which are otherwise exactly equal might vary by such non-critical differences as the bend radius of an angle, or type of corner relief.

To date, there are approximately 100 Producibility Tips covering every form of piece part in the BUCCS-3 Design Retrieval System. Atypical "tip" is illustrated in Figure 5.

When an engineer or drafter visits a design retrieval station, each is provided with producibility tip information covering the specific design being analyzed. The designer is encouraged to use a Producibility Tip as throw-away information, to be used only for the specific application at hand. Each time a design retrieval station is visited, the appropriate ***producibility tip*** information is provided.

A study of design change notices in a Boeing manufacturing plant disclosed that a significant number of changes would have been avoided had the producibility tips been used.

The long range plan for the Company is to benefit from productivity improvements by incorporating preferred design criteria into the decision logic of generative design systems, which are briefly described in the following pages.

ORDER GROUPING

When piece parts are identified by shapes into families of similar parts, one of the most obvious benefits from such information is the grouping of like articles for production. In the traditional sense of creating processing cells that include a variety of machine tools which together allow for efficient production of similar parts, in small ***lot*** quantities, it is necessary to establish characteristic information in greater depth than is provided by the BUCCS-3 five-character piece part code. However, looking at common characteristics of families of parts for application to a single machine tool is another matter.

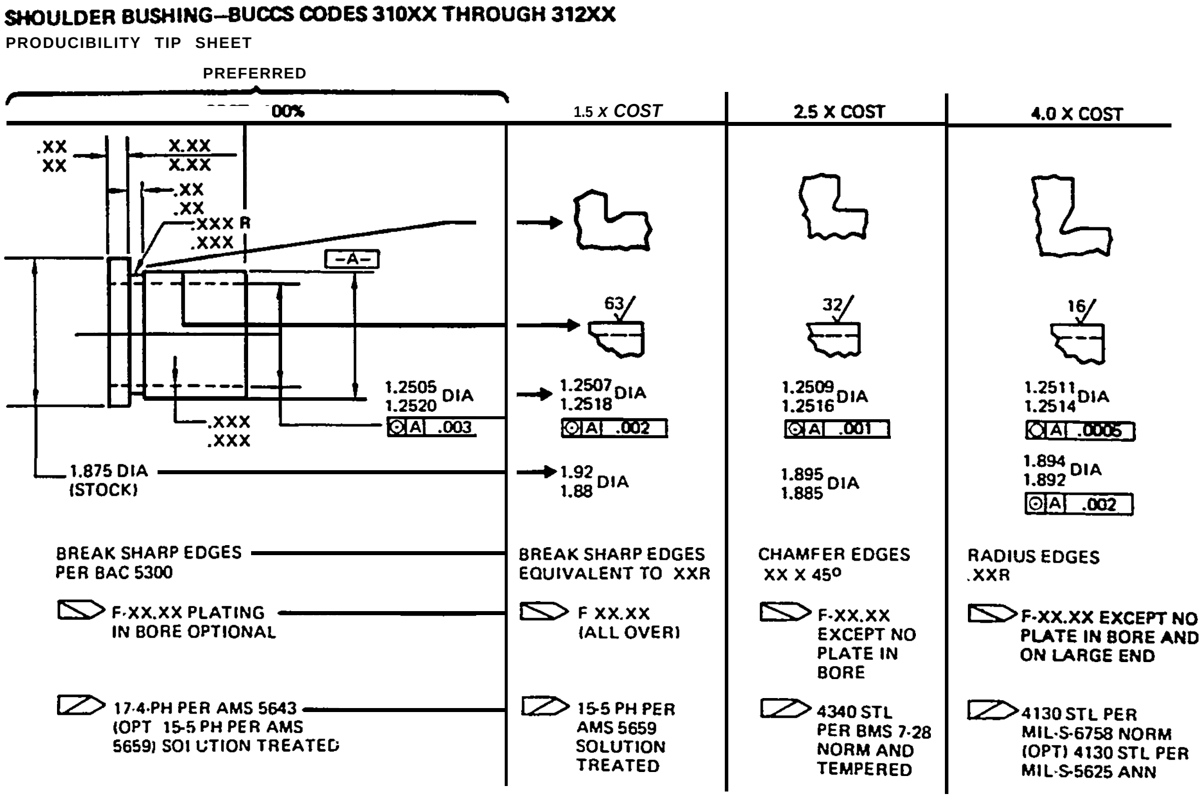


Figure 5. This Producibility Tip Shows the Designer or Draftsman the Preferred Method of Design From the Standpoint of Economics

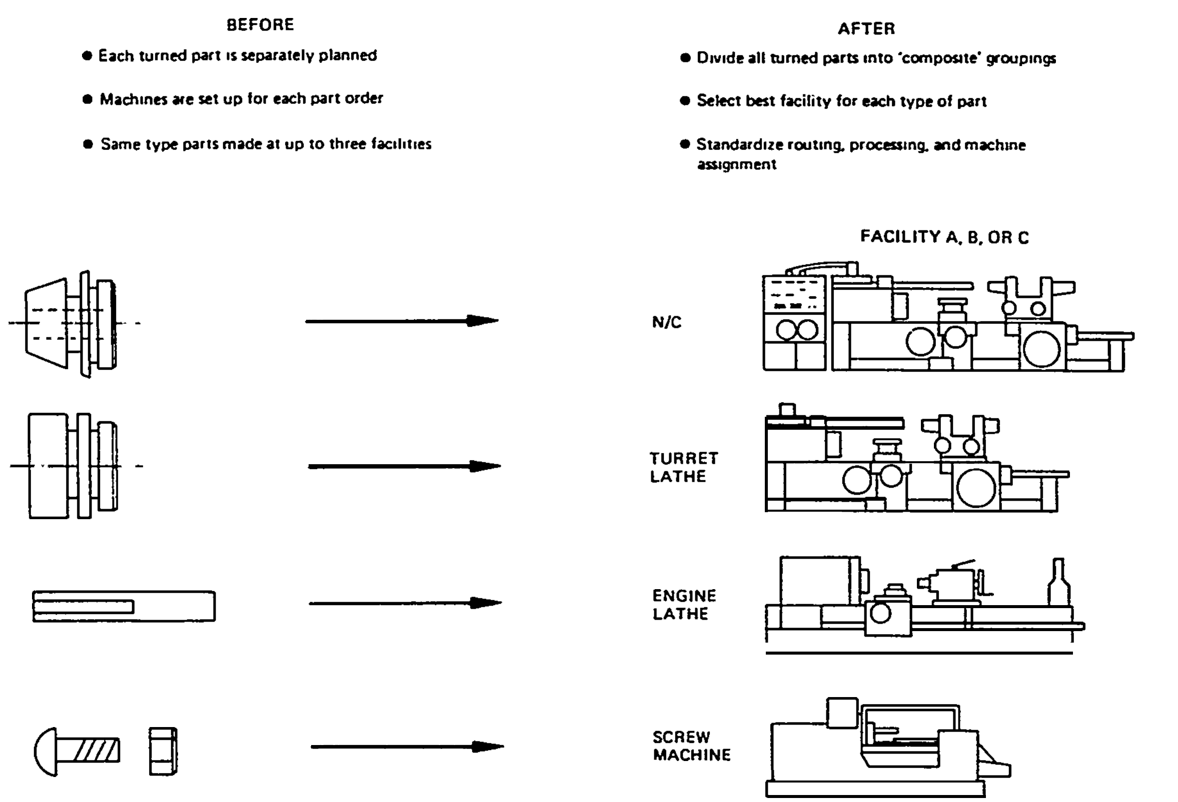


Figure 6. Grouping Turned Parts

Figure 2.5-1

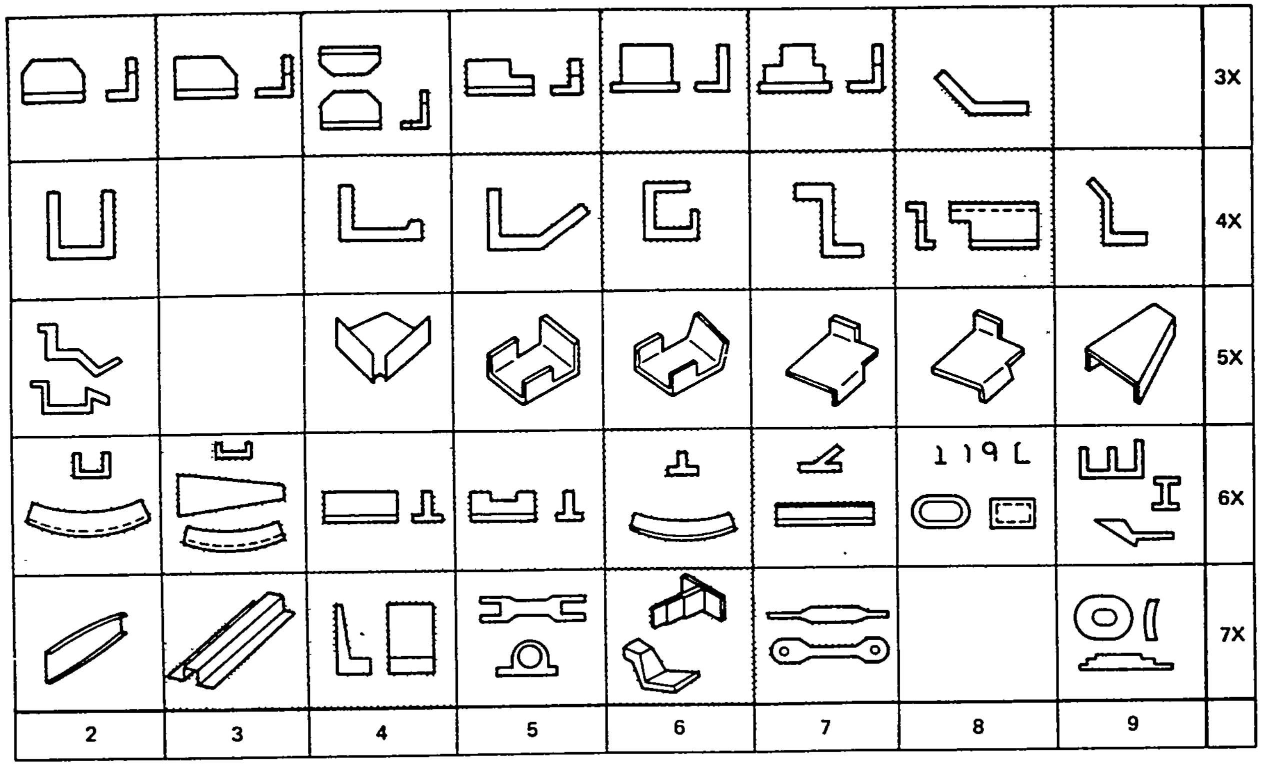


Figure 7. Over 10% of All Structural Airframe Parts are Made from Formed and Extruded Cross Sections That Lend Themselves to Numerical Control Machining

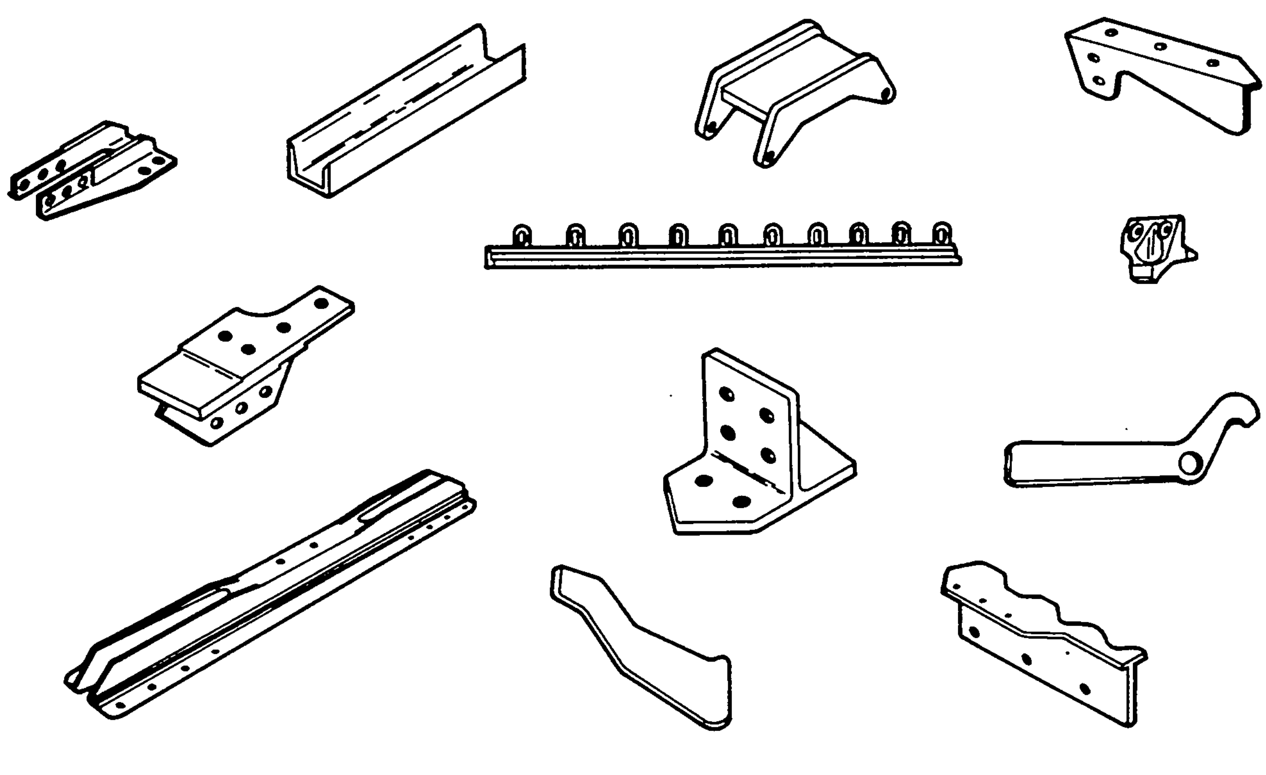


Figure 8. A Very Broad Variety of Parts Can Be Made From Extruded or Rolled Stock in Long Lengths

Figure 2.5-1

Figure 2.5-1

At Boeing, we determined that an analysis of our turned parts and the construction of composite configurations, as shown in Figure *6,* allowed dedicating both specific conventional and numerical control lathes for the turning of a wide variety of part families. The allocation of work loads in a machining area of approximately *50* machines, based on shape characteristics, proved that significant reduction in prior production costs could be achieved.

Looking more to piece parts which are specifically designed for aircraft structure led to similar order groupings. However, an even greater benefit from our knowledge of part families has been derived from the capability of the characteristic code to identify families of parts best suited for manufacturing on specific equipment.

EQUIPMENT LOADING

The basic airframe piece part classification demonstrates that a large variety of parts are designed and manufactured from formed and extruded cross sections. The Sunstrand "Partsmaker" is a highly efficient machine tool for the fabrication of this type of part. Figure 7 shows the categories of parts which would potentially be fabricated on this type of equipment. The problem in the manufacturing and industrial engineering communities is to assure that all parts configured from extruded cross sections of the type indicated in Fig. 7 are designed in such away as to lend themselves to fabrication by numerical control, so that a Partsmaker, which operates on the bar feeding principle, can be utilized to the maximum degree. Figure 8 illustrates the broad range of part configurations which are suitable for Partsmakerfabrication.

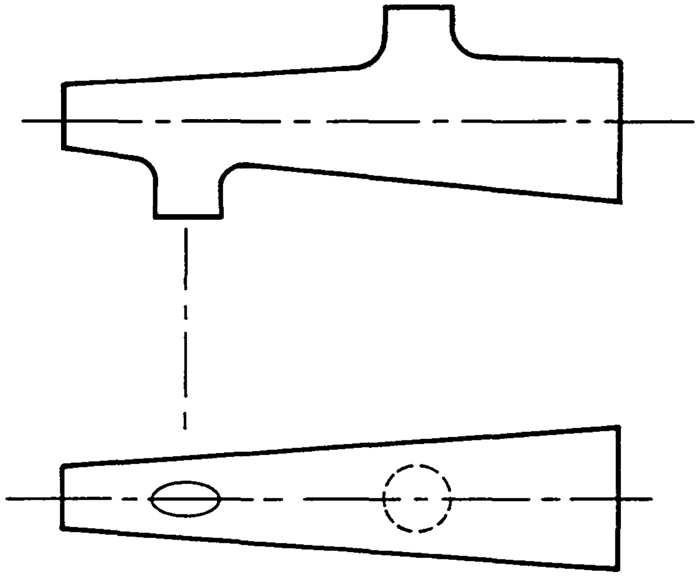
An optimum load for this type of equipment was readily obtained by analyzing the BUCCS-3 piece part drawing file and changing the processing on all applicable part configurations to NC processing. Through this procedure, the Company not only obtained optimum processing for a large number of part families, but also determined the optimum requirements for Partsmaker type equipment.

Another example of equipment loading includes the selection of optimum forming equipment, depending on shape characteristics of the part to be formed. For example, a particular part might be formed on a drop hammer, hydraulic press, bag press or by the electro-form process. In nearly every instance, one process is preferred over the others. Using the characteristics defined in the classification system, industrial engineers and process planners are able to determine optimum processing solutions.

Aircraft propulsion and passenger accommodations systems require a large amount of pneumatic ducting, all of which is configured to fit precise space and air flow volume criteria. Because of the unusual shapes, the ducts were typically formed over plastic mandrels from impregnated fiberglass cloth. This is an expensive process since each fiberglass duct is formed over a mandrel which is destroyed in the process and cannot be reused. A more recent process called "Rotomold" achieves the same process by rotating resins in an exterior mold which is reuseable after forming. The "Rotomold" process has the significant advantages of less labor in processing and reduced raw material costs as shown in Figure 10. After design engineers determined that polycarbonate materials were structurally and chemically equal, or superior, to fiberglass for these applications, decisions were made to use the new process where economically feasible. The classification system provides a ready library of existing designs. Each candidate part could be analyzed from the standpoint of production requirements, and re-engineered so the more economical process could proceed without delay.

EQUIPMENT DESIGN

The Boeing Company has used the classification system to provide data to validate the design of new equipment for improved productivity. This activity has ranged from the development of a multiple stage die, which produces a wide variety of simple piece parts, as shown in Figure 11, to the analysis of the entire population of aircraft sheet metal parts as an aid in the design of an automated sheet metal process center, as suggested in Figure 12.



FIBERGLASS LAYUP	ROTATIONAL MOLDING
Material-fiberglass cloth **Operations-16** **cost** **Average recurring/part-S79.98** **Average tooling–$1234**	**Matarial-polycarbonate resin** **O perations-5** **cost** **Average recurring/part-S4.84** **Average tooling-$3085**

Figure 10. Variance in Material and Production Costs for Parts in the same Family, made by Different Processes May be Very Great.

PROCESSES BUCCS FAMILIES
330XX(THROUOH 334XX

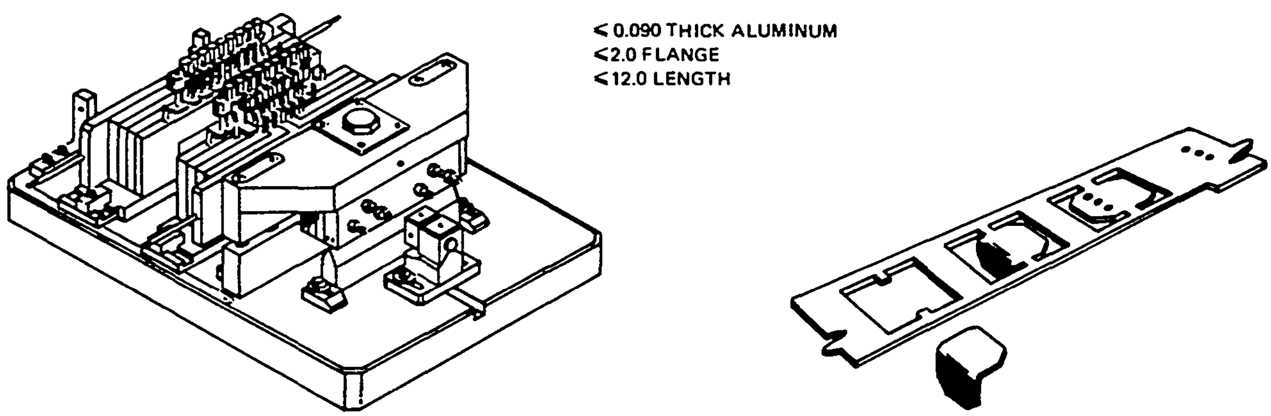


Figure 11. This Multiple Stage Die is Used to Manufacture a Wide Variety of Single-Bend Line Parts

Figure 2.5-1

Figure 2.5-1

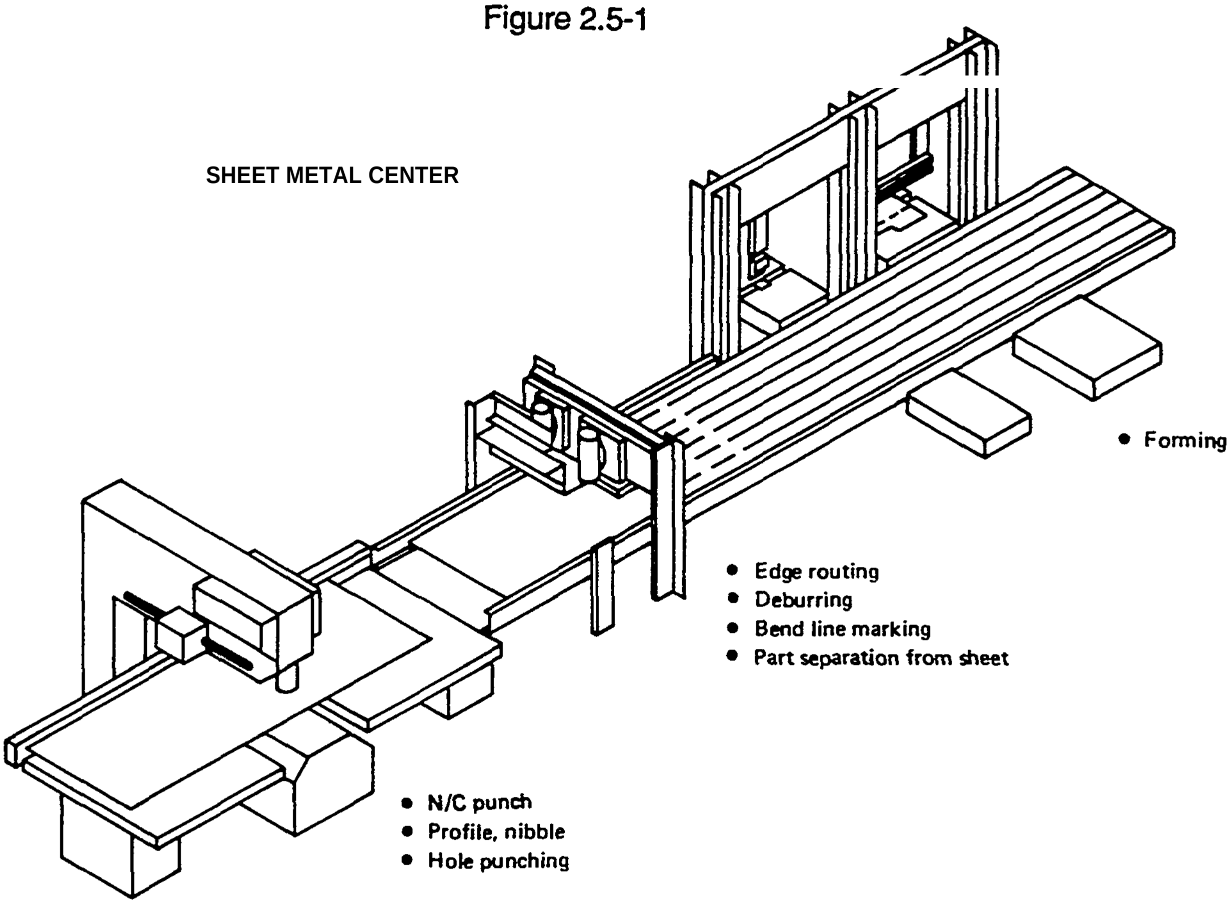


Figure 12. An Analysis of the Shape Characteristics, Dimensions, and Frequency of Occurrence, Using the BUCCS-1 Raw Material and BUCCS-3 Piece Part Classifications, Was Used in Developing the Specifications for and Automated Sheet Metal Fabrication Center

An important function of a classification system is that it provides the basis for a complete analysis of a piece parts population so that any engineering or manufacturing decision can be made on prior knowledge of the product.

The foregoing discussion describes the extent to which Boeing's Classification and Coding and Group Technology efforts progressed prior to integration of classification concepts into the explosive applications of computer aided design and manufacturing in the period since 1975.

"GENERATIVE" COMPUTER AIDED DESIGN AND MANUFACTURING

The application of classification and coding techniques in Computer Aided, Design and Manufacturing at Boeing came about with the realization that:

1. Hierarchical classification structures could be defined in decision tree logic.
2. A unique path through a decision tree could be represented as a specific code character.
3. Acombination of unique decision tree paths could identify a specific engineering or manufacturing decision.
4. Characteristic codes could be used as a shorthand to define acombination of paths which lead to a prescribed optimum design or manufacturing decision.

Figure 2.5-1

This concept was initially proposed to the Boeing Company by Professor Dell K. Allen and Mr. Ronald P. Millett of Brigham Young University who worked with the Company to demonstrate the applications of the foregoing concepts in a demonstration of generative process planning.

GENERATIVE PROCESS PLANNING

The purpose of the generative planning system model is to demonstrate that uniform manufacturing process plans could be generated directly from engineering design information. Sheet metal piece parts were selected for the demonstration. This type of part comprises about 75% of the total designed piece part count in airframe manufacture. The fabrication processes are of moderate complexity, averaging about 12-16 operations per part type.

A. GROUND RULES

The basic ground rules adopted for this system demonstration include the following:

1. Process plans must be generated from objective data.
2. All required information should be commonly associated with an engineering drawing.
3. Generated process plans must be uniform and consistent for each similar part/material group.
4. The system is targeted for approximately 80% effectiveness. This decision is based on the conclusion that attempting to generate process plans for rare, one-of-a-kind configurations would not be cost effective.

B. SYSTEM DESCRIPTION

The system concept involves the interrelations of several logic elements and a text file within a software package to form a truly unique generative planning system. The total system consists of:

1. Classification logic for part shape (BUCCS-3) and raw material (BUCCS-1);
2. Process parameters such as tolerance and finish;
3. Manufacturing decision logic that relates drawing derived shape, material and special characteristics to manufacturing equipment and process capabilities;
4. An operations narrative file which describes each potential manufacturing operation that the factory can perform with the available manufacturing equipment and processes;
5. Sequencing decision logic which arranges the selected operations in the proper order;
6. A plan preparation segment to output a process plan in the desired format.

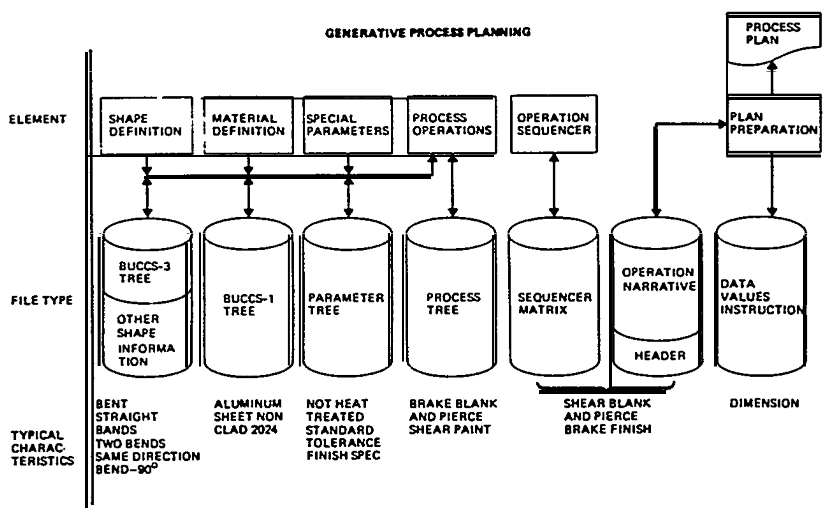


Figure 13. This Concept for a Generative Process Planning System Covers Sheet Metal Airframe Parts

Figure 2.5-1

The logic elements and text file are interrelated through computer sensible internal codes that identify these interrelationships. The key portions of the system are illustrated in Figure 13, and are more fully defined below.

1. CLASSIFICATION LOGIC ELEMENTS

The classification logic consists of two basic elements: shape and material. The information contained in each element is derived from the engineering drawing and requires no individual interpretation. The drawing characteristics for each element are identified and captured in a code. This code can be used to either retrieve information related to that element, or as the logic input for making manufacturing process selections. Because these codes are internal to the computer, the system user need only identify the element characteristics and not the code. Under this concept the generated codes and certain additional objective engineering data automatically supply answers to the manufacturing decision logic element.

2. SPECIAL PARAMETRIC ELEMENTS

This portion of the logic deals with product characteristics that are not normally attributes of shape or raw material, but do form a part of the design process decision logic. These elements are inherent characteristics of the design for a part, and include such typical items as finish and tolerance. They also include characteristics that are associated with the product, such as ‘appearance” for commercial aircraft passenger accommodations. These special parameters can vary to a greater degree than the more static shape and material characteristics. However, they are nonetheless objective in nature, and are required to generate optimal manufacturing process decisions.

3. MANUFACTURING DECISION LOGIC ELEMENTS

The manufacturing decision logic element contains the identification and relationship of design information to correctly identify optimum processes within the factory. The system is limited in application only by the manufacturing processes that it considers. The manufacturing decision logic begins with the most general characteristics and proceeds to the more specific until the type of shop (sheet metal, machine shop, gear line, etc.) can be identified. Those independent, primary operations (i.e., forming and machining), that dictate other operations are next identified from the design characteristics. Upon the identification of additional characteristics, the next level of operations can be identified (i.e., deburring, decreasing, part marking). This process continues until all operations required to manufacture a part with a specific mix of capital equipment and labor skills (i.e., factory) are identified.

4. OPERATIONS NARRATIVE FILE

The Operations Narrative File is comprised of detailed verbal statements that describe the manufacturing process being performed on the raw material. Within certain statements, blank spaces have been provided for the user to add specific data, such as dimension, specific number of holes, etc. Each of the narrative statements are indexed by an operation code. This operation code is used by the sequencing logic element to place the operations on the generated process plan in the proper order.

5. SEQUENCING LOGIC

The sequencing routine utilizes the operation code to resequence the operations into the proper order through a “truth table”. The concept of “truth table” logic is illustrated in Figure 14.

6. PLAN PREPARATION

The final element of the generative planning system is the preparation of a properly sequenced listing of operations for manufacturing an article having a defined combination of shape, material, and special parameters, interrelated with the manufacturing processes available.

As each selected operation is listed in its proper order, the system requests the input of discrete dimensional data (hole location, hole diameter, length of feature, ***etc.)*** which uniquely identifies the process plan to the piece part it covers. The output is in the prescribed format of the organization which will perform the work.

	SHEAR	STACK ROUT	PREP SAW	PIERCE	PUNCH	BLANK	BRAKE	JOGGLE	HYDRO	STRETCH	ROLL	HAMMER	DRILL	DRILL AFTER	PIERCE AFTER	SHAPE	PIN ROUT	SAW	INSPECT	FINISH
SHEAR																				
STACK ROUT	0																			
PREP SAW	0	0																		
PIERCE	2	0	0																	
PUNCH	2	0	0	1																
BLANK	2	0	0	0	0															
BRAKE	2	2	2	1	1	2														
JOGGLE	2	2	2	4	4	0	2													
HYDRO	2	2	2	0	0	0	4	0												
STRETCH	2	2	2	0	0	0	2	0	0											
ROLL	2	2	2	0	0	0	2	5	0	5										
HAMMER	2	2	2	0	0	0	5	0	1	0	0									
DRILL	2	2	2	2	1	1	5	5	5	5	5	5								
DRILL AFTER	2	2	2	2	2	2	2	2	2	2	2	2	2							
PIERCE AFTER	2	2	2	2	2	2	2	2	2	2	2	2	2	5						
SHAPE	2	2	2	2	0	0	2	2	2	2	2	2	2	4	2					
PIN ROUT	2	2	2	0	0	2	1	2	2	2	2	2	2	1	2	5				
SAW	2	2	2	1	4	2	2	2	0	2	2	2	2	2	2	5	2			
INSPECT	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2		
FINISH	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	

0 ISEQUENCE NOT IMPORTANT
1 PREFER COLUMN THEN ROW
2 MUST BE COLUMN THEN ROW
3 MUST HAVE COLUMN THEN ROW ADJACENT
4 PREFER ROW THEN COLUMN
5 MUST BE ROW THEN COLUMN
6 MUST HAVE ROW THEN COLUMN ADJACENT

Figure 14. ***The Operation Sequencing Table Determines the Appropriate Relationship Between the Current, the Preceding, and the Succeeding Operation from One of Seven Choices as Shown in the Table***

Figure 2.5-1

GENERATIVE DESIGN

The generative concept defined in the above paragraphs underlies all of the applications for classfication and coding theory within the Boeing Company.

It is universally accepted that classification benefits are potentially greatest when they are implemented in the design process. Only in this manner can the advantages from a classification system cover the whole business spectrum.

The Computer Aided Design Retrieval - Extrusions (CADRE) system currently under development at Boeing is intended to demonstrate the potential value of utilizing generative techniques for design. This concept is illustrated in Figure 15.

The logic upon which this system is based is similar to Generative Process Planning except that specific geometry for a design requirement is utilized.

A. SYSTEM DESCRIPTION

This system concept deals with the interrelationships between geometry, material, and analysis to produce a finished piece art definition. It includes:

1. Classification logic for part shape (BUCCS-3) and raw material (BUCCS-1).
2. Geometry interface routines which allow shape characteristic data to be refined into specific geometry.
3. Interface with engineering analysis routines to calculate part mass properties and loads.
4. Drawing decision logic covering drawing notes and annotations.
5. Interface with graphics systems to produce finished drawing data.

The logic elements are interrelated in the same manner as used for Generative Process Planning. The system will utilize a graphics terminal in which the user will communicate interactively with all elements of the system.

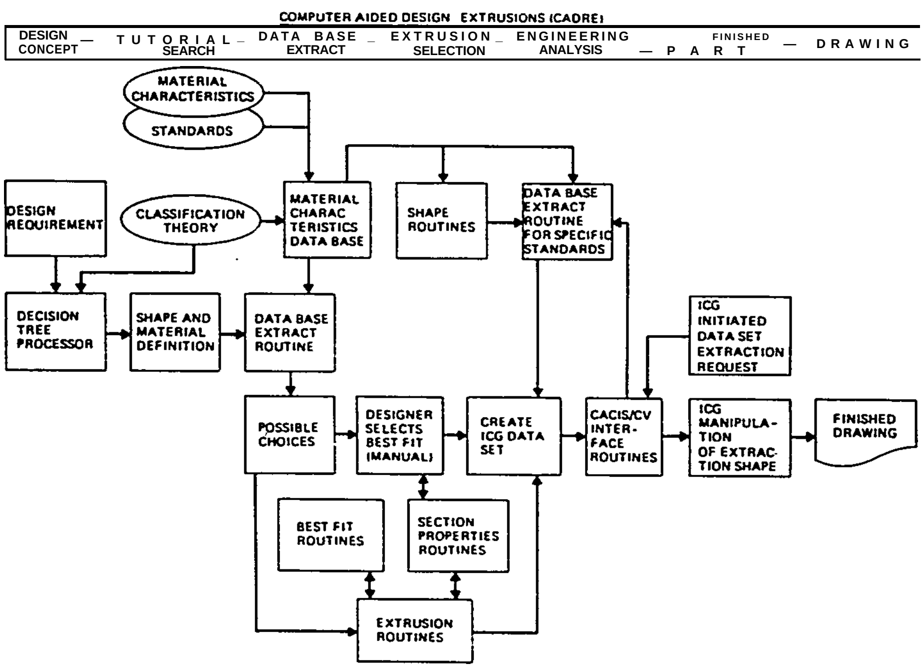


Figure 15. This System Used Classification and Decision Tree Logic to Identify and Extract the Preferred Solution to a Design Problem

Figure 2.5-1

B. SYSTEM OPERATION

The elements of the CADRE system and their interrelationships are shown in Fgure 16.

When a design requirement has been established, the engineer will interrogate the system to derive a range of possible extruded cross section solutions to the design requirement. The choices will be extracted from a database containing shape and material definitions from a library of all available extrusion standard designs.

From the list of choices, the engineer will apply a set of best-fit routines including the application of section properties analyses.

These data will be optimized to create an interactive computer graphics data set for the prescribed cross section. The design will then be manipulated to complete the longitudinal geometry for the part from additional stored shape routines.

Decision logic for assigning engineering notes and references will be applied. Engineering analysis routines will calculate mass properties and loads.

The result of the foregoing logic interrelationships will be a complete drawing dataset.

Conjoining a generative drawing with a generative process planning system can result in the automation of the total production function.

Other generative design concepts for which research is being conducted include electrical circuit design and hydraulic tubing system design.

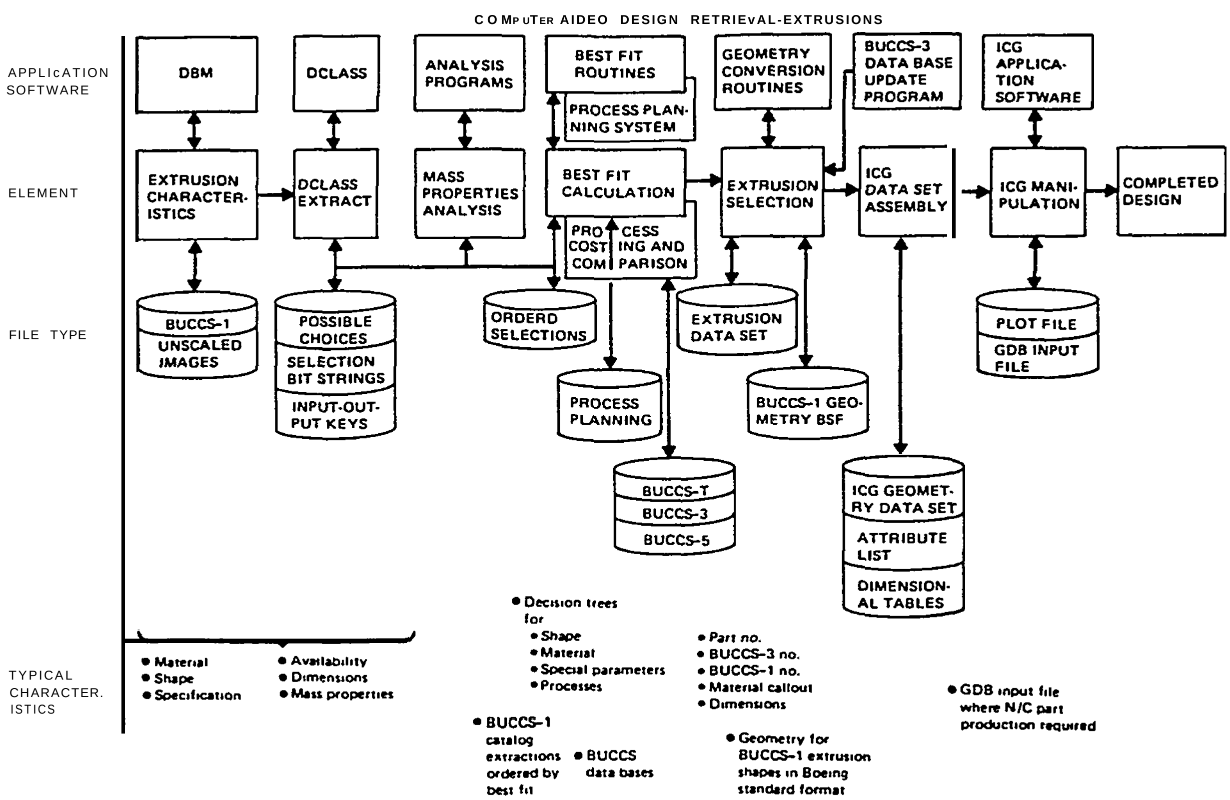


Figure 16. The Concept for Generative Design Follows the Same Basic Logic as Generative Process Planning

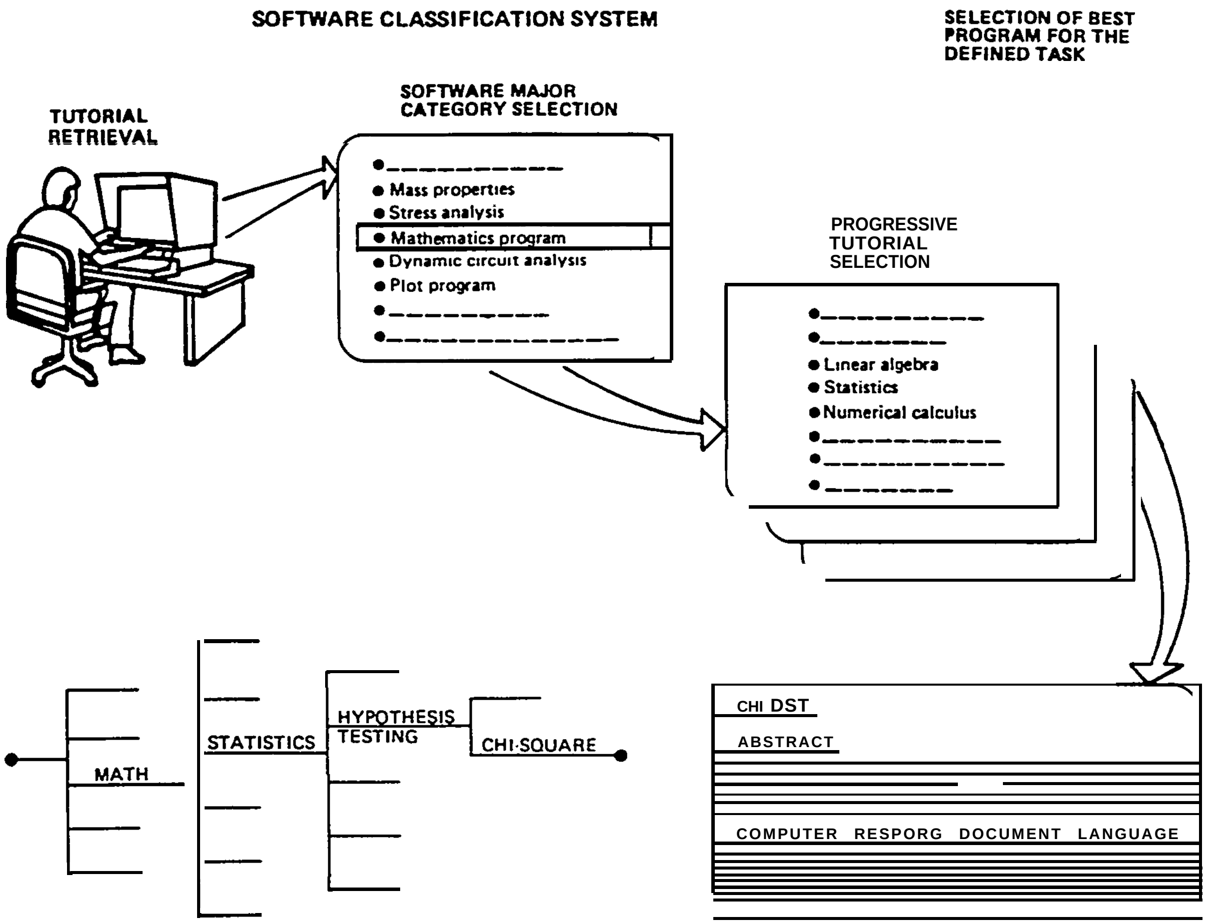


Figure 17. This System Permits a Programmer to Quickly Retrieve Information Covering Existing Software Modules

SOFTWARE CLASSIFICATION

Classification techniques have also been successfully used to store and retrieve computing software.

The demonstration project is for the retrieval of frequently used mathematical programs. The procedure utilizes decision tree logic and tutorial retrieval.

In this concept, which is illustrated in Figure 17, the user selects, from a menu, the type of software he wishes to retrieve and from the basic inquiry he is led by a logic path to the optimum solution for the problem at hand.

In this system, the user is provided with a current abstract for each mathematical routine together with information concerning the appropriate computer documentation, etc.

Like all of the retrieval systems being developed at Boeing, this system uses a "keyword" concept which leads directly to the terminal node, or interim node, of a decision tree. When the user is acquainted with key characteristics of the item he is searching, the keyword greatly shortens the search time by by-passing many stored logic elements.

Figure 2.5-1

Figure 2.5-1

CONCLUSION

All systems described above are based on the group technology principle that classifying items by their similarities opens the way for efficiently handling design and production processes in a uniform, consistent manner. This concept becomes abundantly clear when advanced computing techniques are employed.

It is practical and economical for perhaps the first time to manage complex product design and manufacturing in a way that assures optimum consistent solutions *to* all production requirements. The potential benefits from using these techniques afford one of the greatest productivity improvement opportunities for industry in the foreseeable future.

-A cautionary note is in order The cost of implementing systems of the type described above is not in the computing software. By far the greater cost is associated with the development of the classification and decision logic which uniquely describes each company's product and processes. No major benefits can be realized from these techniques without the dedication of significant resources to evaluate the current method of operation, determine optimum or preferred solutions, and construct logical, hierarchical statements of those decisions.

These concepts cannot replace the intuitive judgment of senior managers, designers and technicians. They can capture the best available solution to recurring problems, and assure that each will be resolved in the same, preferred manner as it occurs.

Figure 2.5-1

APPENDIX A

BOEING COMPANY TAXONOMY CLASSES

CLASS DESCRIPTION

BUCCS-1 Raw Materials used to produce tooling and product.
BUCCS-2 Purchased Items (Commodities) used in the product, designed by others.
BUCCS-3 Piece Parts designed by Boeing.
BUCCS-4 Assembled Parts and Commodities.
BUCCS-5 Fabrication and Assembly Tools
BUCCS-6 Capital Equipment
BUCCS-7 Non-Production Items, including shop supplies and spares.
BUCCS-9 Computer Software.

In addition to the above, special purpose classifications can be developed, of which the two below are examples:

BUCCS-C Non-Metallics Classification for FAA certified materials.
BUCCS-T Time Standards to support production and maintenance management functions.

SECTION 3
Product Work Classification and Coding

Section Three traces the development presents the configuration, and explains the function of the classiffication and coding system in a manual and computer aided manner.

SECTION CONTENTS

3.1 *INTRODUCTION*

This study was given the task of exploring group technology with the intent of developing an application of classification and coding for the shipbuilding industry. This section of the manual will

- Trace the development of the application in terms of the approach that was used, the scope that was defined and the requirements that it had to meet
- Define the logic that led to the selection of attributes and code formate, and present the classification and coding system in the form of a code book,
- Discuss manual and computer-aided classification and coding, and
- Present art example of product work classification and coding and interim product sorting.

3.2 *DEVELOPMENT*

This study began as a very "open minded" endeavor. Its goals were to develop an application of classification and coding that

- met the technological needs of the shipbuilding industry, circa 1983, and
- took the greatest advantage of the state of group technology utilization available in the same time period.

3.2.1 Approach

To meet these goals, a two part approach was used.

First a survey was mailed to domestic shipyards. This survey was structured to determine

1. The level of importance each yard assigned to the utilization of group technology in shipbuilding,
2. The areas of need which they felt this.study should address, and
3. Any resources or experience from which this study could benefit

Second an effort was begun to define the current state of group technology utilization. This was done to insure that this study took advantage of all potential resources and did not duplicate any existing work. This effort involved

1. Sending the above mentioned shipyard survey to various universities, institutions and individuals known to be involved in either group technology or shipbuilding,
2. Visiting companies known to have had success implementing group technology, and
3. Attending seminars presented by various professional organizations concerning group technology.

The respondents to the shipyard survey provided valuable insights into the needs of the shipbuilding industry. A summary of the most common responses revealed

1. The shipbuilding industry was very interested in expanding its utilization of group technology. Seventy percent of the major new construction shipyards that responded assigned either critical or major importance to the goals of the study.

2. Many shipbuilders felt this study would be valuable if it developed a classification and coding system that addressed the interim products that result from a "Product Work Breakdown Structure" or "zone oriented" approach to shipbuilding.

3. Many shipbuilders were interested in a computer based classification and coding system that could eventually be integrated with CAD/CAM, CAPP (Computer-Aided Process Planning), and CIM (Computer Integrated Manufacturing).

4. Several respondents expressed concern that results of this study be compatible with existing production management methods. Of particular concern were customer mandated methods such as SWBS (Ship Work Breakdown System) and existing methods that involved electronic hardware in which rhey had substantial capitol invested

5. Several respondents stressed that the classification and coding system must serve many shipyards which, when combined, had a broad product mix, e.g. Naval, commercial nuclear, non-nuclear, combatant and auxiliary.

6. Several respondents stressed that the successful implementation of any application would be partially dependent on its ease of use.

Many good ideas and helpful suggestions were received in the shipyard survey. Unfortunately, all of them could not be incorporated into the scope of this project From this survey, the project derived the following direction for its study.

1. It would pursue the development of a classiification and coding system that addressed ship fabrication and assembly work as defined in the National Shipbuilding Research Program Publication, "Product Work Breakdown Structure". Because many shipyards were currently implementing the methods defined in this book the study felt this direction would ***best*** complement the work and systems that were either already in place or being developed.

2. It would attempt to develop both a manual and a computer-aided classification and coding system.

3. It would attempt to develop a classification and coding system that would be easy to use.

4. During the development of the classification and coding "system the study would try to anticipate future uses and configure it with them in mind.

The effort to define the current state of group technology utilization revealed many things that had a bearing on the direction of this study. Among them were several possible directions which the study considered but did not pursue. A summary of these is provided below.

1. A purchased pares catalog organized in accordance with group technology concepts was not considered appropriate because many either existed or were being developed by individual shipyards. Since part catalogs are highly dependent on product mix, i.e., the type of ships built it was concluded that the independent shipyard was indeed the best place for this development to occur and not a viable end product of this study.

2. Pipe price, sheet metal piece and machined part fabrication operations were considered to be very strong candidates for organization by group technology concepts. Further investigation revealed however, that group technology classification and coding systems for these operations were currently available from a small variety of vendors. (See Resources, Appendix\A). Indeed virtually all of the systems in use by other industries were the standard product or hybrid products of these vendors. It was decided that to include these applications in the manual would be to duplicate a product that was already available to the shipbuilding industry.

The rejection of these group technology applications does not imply a lack of significance or value, only that they were not considered suitable topics for this manual.

The effort to define the current state of group technology utilization also produced many findings which put the goals of the study in perspective with what had been done in other industries. A summary of these findings is given below.

1. The majority of work that had been done concerned classification and coding of parts, particularly machined parts, to support part fabrication operations. Virtually no work had been done to classify or code part assembly operations. It became apparent that in its effort to develop an application of classification and coding for assembly work this study was, to a large degree, plowing ***new ground.***

2. The utilization of computers in classification and coding was suficiently advanced to enable the study to pursue its goals in this area. The small number of vendors however, might hamper the studies desire to develop an application that would be compatible with a variety of hardware types.

3.2.2 scope

The results of this two-part approach were reported to the SP-4 Panel. A specification was then prepared to define the scope of the classification and coding system and the contents of a manual that would present it to the shipbuilding community. This specification, in part, stated

1. The manual shall describe a classification and coding system that addresses:

   A. Hull block construction (to include piece part fabrication and assembly).

   B. Zone outfitting.

   C. Zone painting.

2. The classification and ceding system shall be usable in a computer-aided manner and if possible serve as a foundation for a computer-aided prccess planning system to be developed by a separate project

3. The manual shall incorporate an example, utilizing an existing ship, to demonstrate the use of the classification and coding system. The example shall be evaluated to determine the advantages and disadvantages of the system.

4. The manual shall provide a discussion of other aspects of shipbuilding indirectly affected by the use of the classification and coding system.

3.3 *THE APPLICATION*

Once the scope of the project was clearly defined, work began that would lead to the development of the classification and coding system. To ensure that the system met the needs dictated by the specification, five (5) requirements were defined.

1. It must sort interim products which occur during hull construction, zone outfitting and zone painting into the groups established by Product Work Breakdown Structure (PWBS)

2. It must identify PWBS groups with a code string in a simple, efficient manner.

3. It must be concise and not permit ambiguity in group or code assignment.

4. It must minimize the potential for coding errors.

5. It must anticipate and capture the product data needed to drive a computer aided process planning systerm

The development of the classification and coding system involved two (2) primary areas of work.

1. Selection and structuring of attributes.

2. Selection of code format and characters.

3.3.1 Selection and *Structuring of Attributes*

PWBS sorts interim products into groups according to attributes which reflect similarities in production problems. Ideally, these groups contain interim products which require similar labor skills, labor quantities, tools, facilities and materials. To meet these criteria and the requirements defined in the previous section, two kinds of attributes were needed.

1. Attributes for interim product description, and

2. Attributes for interim product control.

Attributes for interim product description capture information that enable interim products to be sorted according to production problems that are related to physical characteristics. Listed below are several examples of attributes which could be used for interim product description.

- size
- Shape
- Weight
- Configuration
- Position
- Location
- Skill requirements
- Labor type
- Labor quantity
- Material type
- Material quantity

Attributes for interim product control capture information that enable interim products to be sorted according to their position in the overall manufacturing sequence of the ship or their position in any portion of the manufacturing sequence of the ship. Listed below are examples of attributes which could be used for interim product control.

- Procurement characteristics
- Fabrication characteristics
- Assembly characteristics
- Erection characteristics
- Test characteristics

Product Work Breakdown Structure uses both attributes for interim product description and attributes for interim product control. It uses these attributes alone and in combinations which can vary between different interim product groups. To establish order among the many attributes used in Product Work Breakdown Structure, interim products are classified according to five characteristics.

1. Work Type - A characteristic of an interim product which uses attributes for interim product description to differentiate between interim products possessing dissimilar work requirerments.

2. Manufacturing Level - A characteristic of an interim product which uses attributes for interim product control to differentiate between ***interim products at*** different points in the work sequence for a particular work type.

3. Zone Type - A characteristic of an interim product which uses attributes for interim product description to differentiate between interim products with dissimilar production objectives within a particular manufacturing level.

4. Problem Area - A characteristic of an interim product which uses attributes for interim product description to differentiate between interim products with dissimilar work requirements within a particular zone type.

5. Stage - A characteristic of an interim product which ***uses*** attributes for interim product control to differentiate between interim products at different points in the work sequence for a particular problem area.

The attributes used by each characteristic may change from group to group according to the descriptive requirements of the work breakdown structure. These five characteristics however, remain constant throughout the classification and coding system.

The organizational structure of characteristics, implied in their definitions, is hierarchical Within each work type are specific manufacturing levels and within each manufacturing level are specific zone, problem area and stage attributes. The attributes available in any characteristic depend upon those previously selected. This hierarchical tree structure is shown in Figure 3.3-1.

The complete classification of attributes is presented in Figure 3.2. Please note that the changes were made in the arrangement of the tree structure to enable it to fit on a singl page. The logic however, remains unchanged.

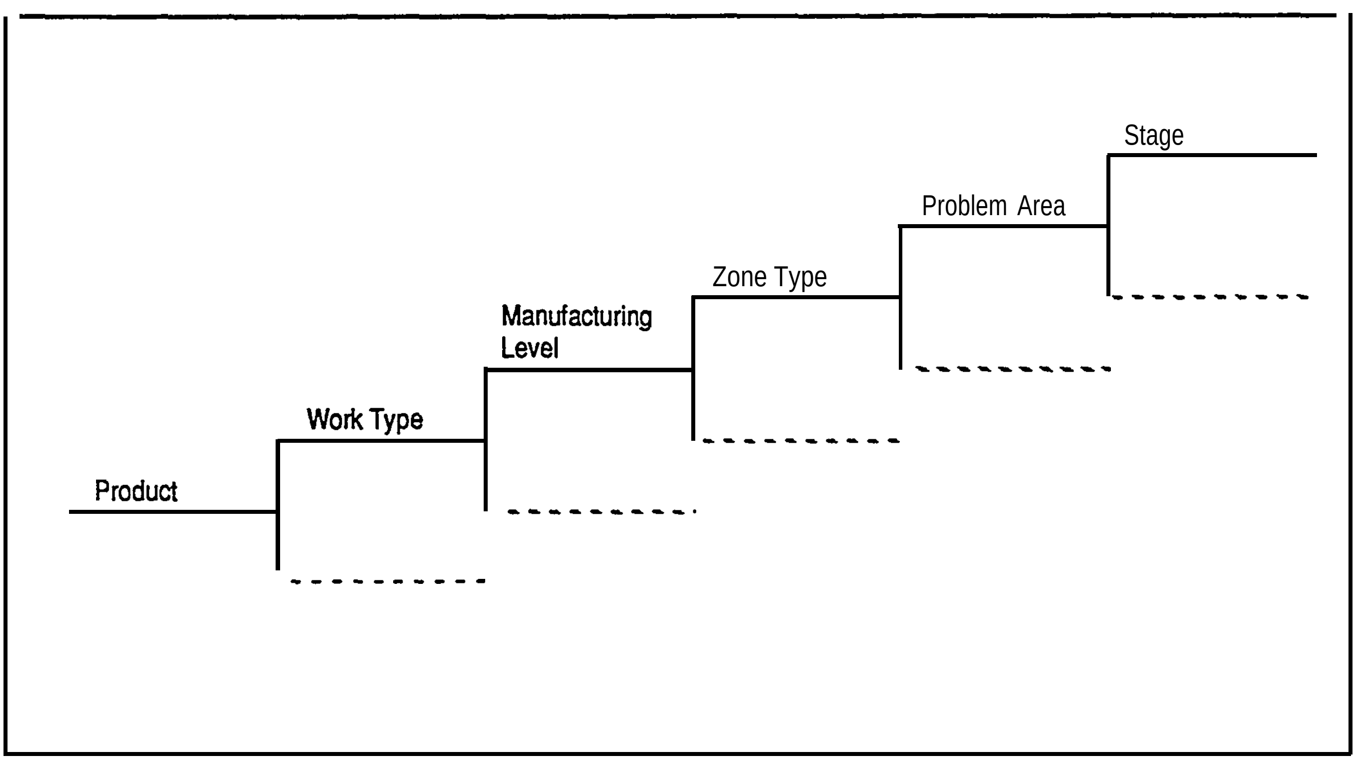


Figure 3.3-1
Hierarchy of Characteristics

3.3.2 *Selection of Code Format and Characters*

The selection of code format and characters had a significant impact on many of the goals of the study and the requirements of the classification and coding system. The code format had to perform several functions, some of which were difficult to reconcile because of their opposing nature. For example

1. The code format had to be long enough to accommodate all of the required information.

2. Research revealed that the code would be more easily used if each digit represented a specific characteristic. This tended to lengthen the code format

3. The potential for ceding error increased with the number digits in the code.

4. The code could not be so long that it became unwieldly and difficult to use.

Several formats were tried and evaluated. Ultimately, a compromise was found that met the requirements of the system and minimized as many negative aspects as possible. The selected format contains six digits which represent the following characteristics.

Digit	Attribute
1	Work Type
2	Manufacturing Level
3	Zone
4	Problem Area
5	Problem Area
6	Stage

The selected code characters are both numeric and alphabetic. Alphabetic characters are used to define work type attributes because they are few in number and can be easily recognized by a key letter from the attribute name. Numerals are used for all other atttributes.

3.3.3 *PWBS Classfication and Coding Book*

The classification and waling system developed by this study is,presented in Figure 3.3-3, PWBS Classification and Coding Book. After much experimentation, this code book format was found to be the most easily use, manual method, for performing classification and coding. The PWBS classification and coding book and instructions for its use were published as a figure, independent of the text of this manual, to enable it to be easily reproduced and used as a separate entity. Please note that the page numbering of the PWBS classification and coding book is independent of the pagination of this manual. An example illustrating classification and coding of portions of an actual ship using the code book is presented in Section 3.6.

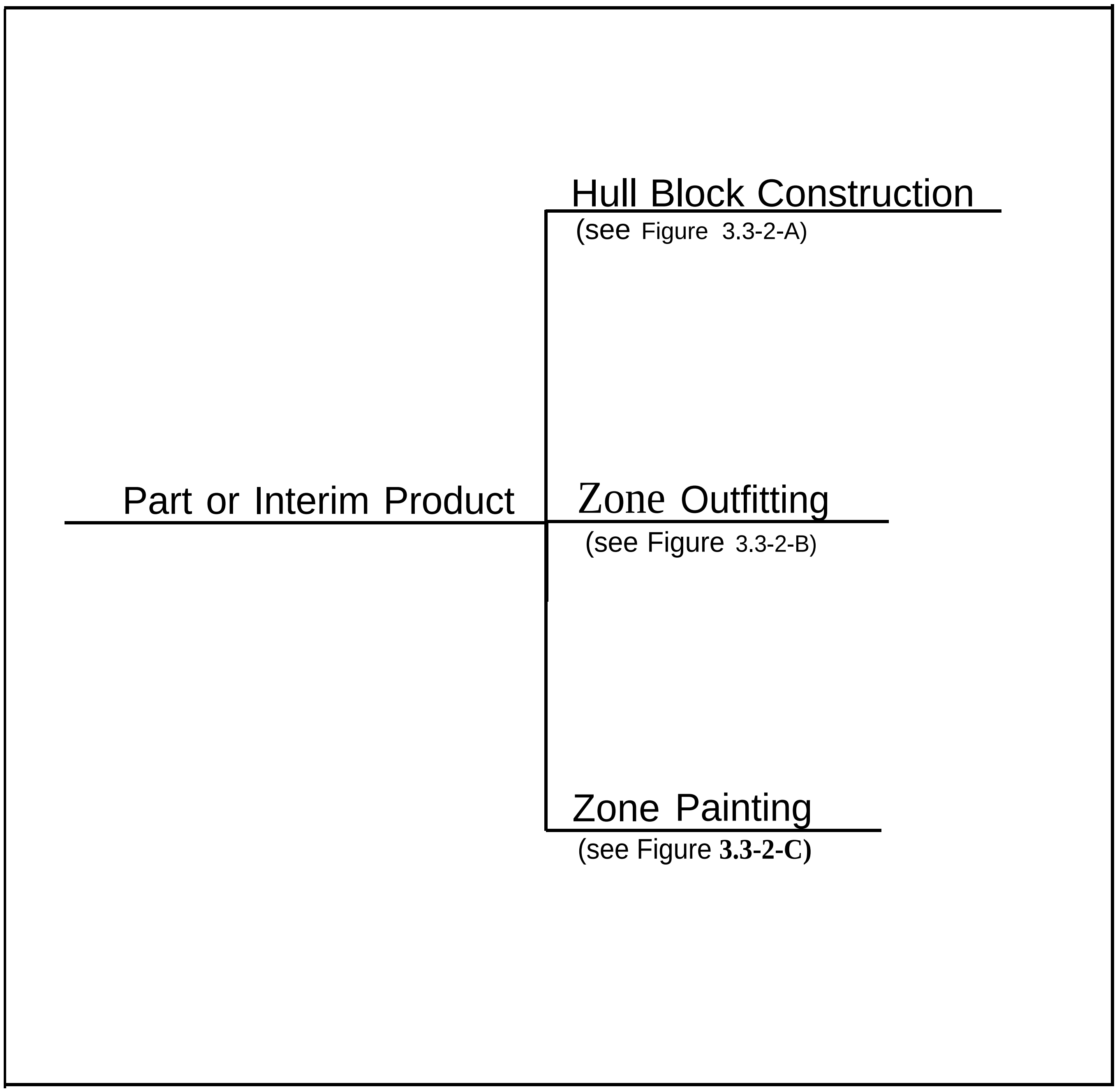


Figure 3.3-2
P.W.B.S. Classification Tree

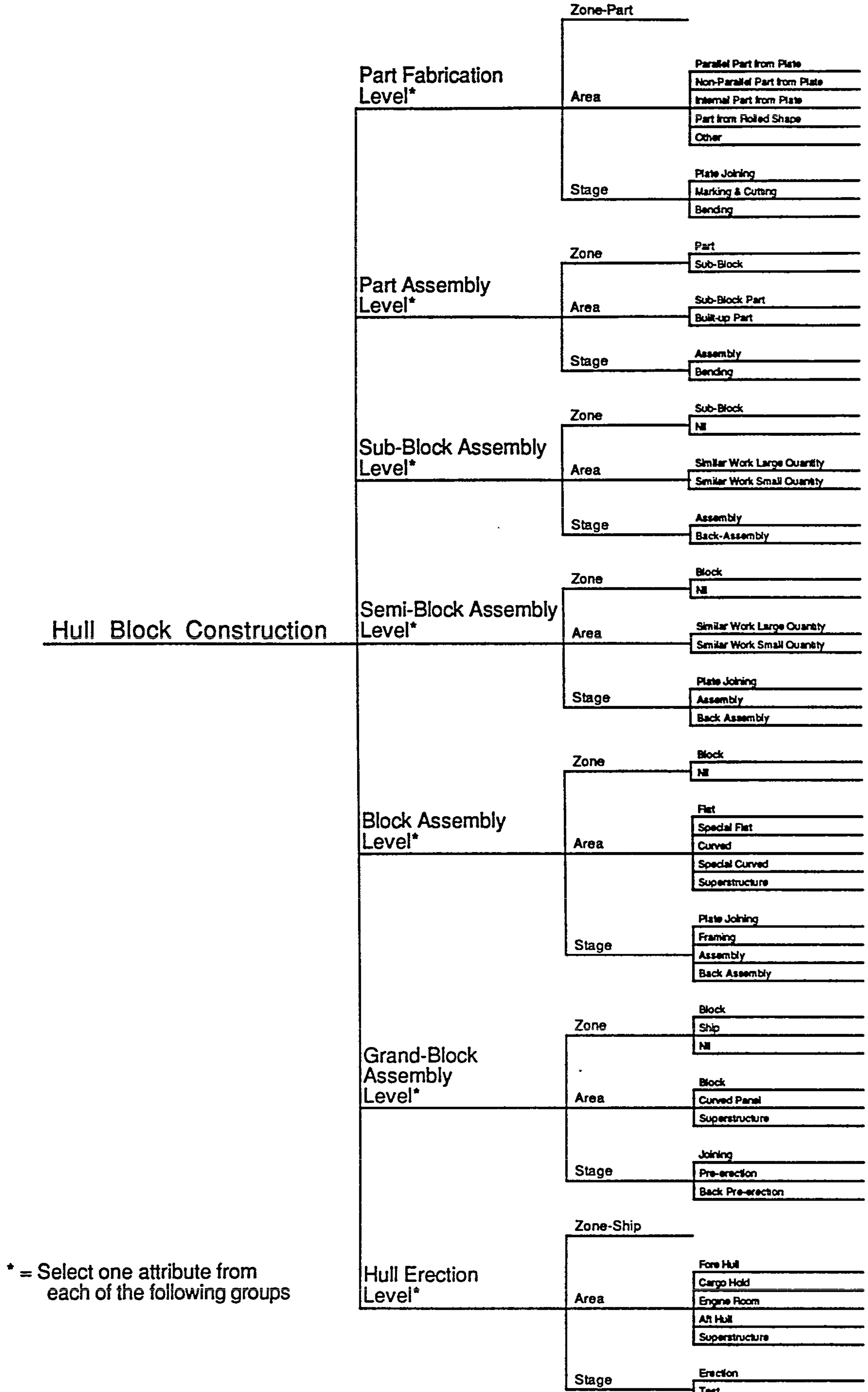
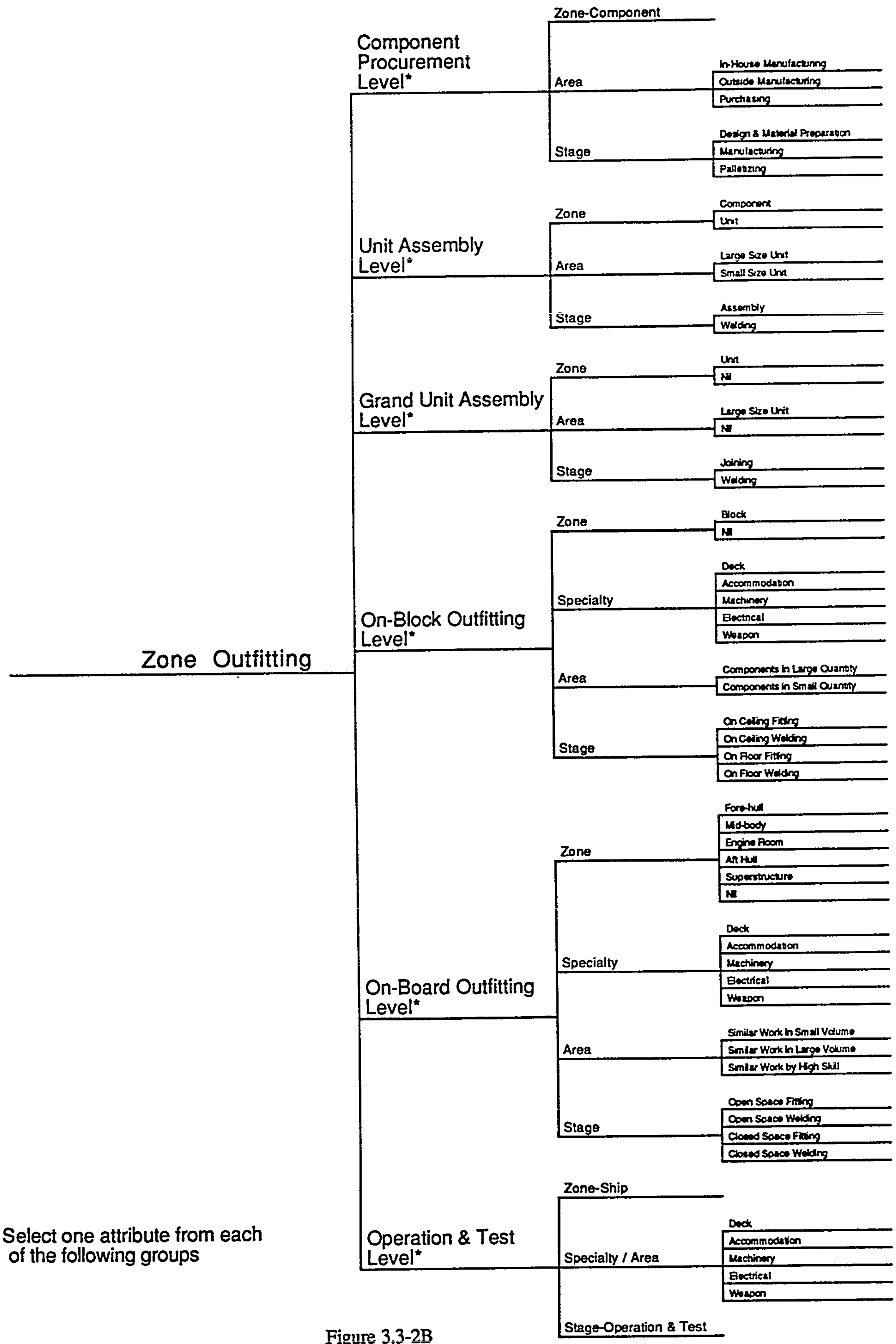

Hull Block Construction
Part Fabrication Level*
Zone-Part
Area
Parallel Part from Plate
Non-Parallel Part from Plate
Internal Part from Plate
Part from Rolled Shape
Other
Stage
Plate Joining
Marking & Cutting
Bending
Part Assembly Level*
Zone
Part
Sub-Block
Area
Sub-Block Part
Built-up Part
Stage
Assembly
Bending
Sub-Block Assembly Level*
Zone
Sub-Block
Nil
Area
Similar Work Large Quantity
Similar Work Small Quantity
Stage
Assembly
Back-Assembly
Semi-Block Assembly Level*
Zone
Block
Nil
Area
Similar Work Large Quantity
Similar Work Small Quantity
Stage
Plate Joining
Assembly
Back Assembly
Block Assembly Level*
Zone
Block
Nil
Area
Flat
Special Flat
Curved
Special Curved
Superstructure
Stage
Plate Joining
Framing
Assembly
Back Assembly
Grand-Block Assembly Level*
Zone
Block
Ship
Nil
Area
Block
Curved Panel
Superstructure
Stage
Joining
Pre-erection
Back Pre-erection
Hull Erection Level*
Zone-Ship
Area
Fore Hull
Cargo Hold
Engine Room
Aft Hull
Superstructure
Stage
Erection
Test
* = Select one attribute from each of the following groups

Figure 3.3-2A



* = Select one attribute from each of the following groups

Figure 3.3-2B

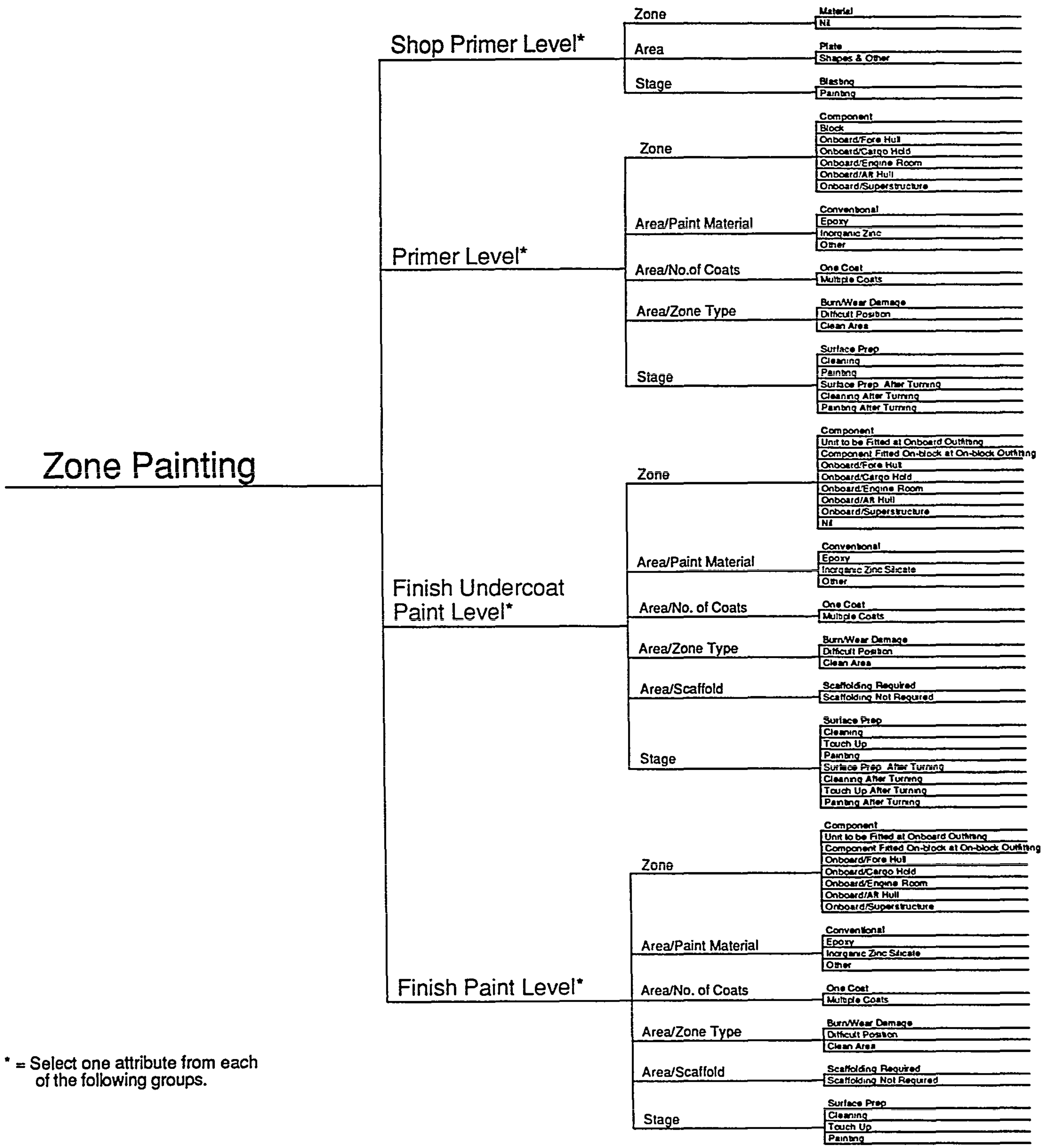

Zone Painting
Shop Primer Level*
Zone
Material
Nil
Area
Plate
Shapes & Other
Stage
Blasting
Painting
Primer Level*
Zone
Component
Block
Onboard/Fore Hull
Onboard/Cargo Hold
Onboard/Engine Room
Onboard/Aft Hull
Onboard/Superstructure
Area/Paint Material
Conventional
Epoxy
Inorganic Zinc
Other
Area/No.of Coats
One Coat
Multiple Coats
Area/Zone Type
Burn/Wear Damage
Difficult Position
Clean Area
Stage
Surface Prep
Cleaning
Painting
Surface Prep After Turning
Cleaning After Turning
Painting After Turning
Finish Undercoat Paint Level*
Zone
Component
Unit to be Fitted at Onboard Outfitting
Component Fitted On-block at On-block Outfitting
Onboard/Fore Hull
Onboard/Cargo Hold
Onboard/Engine Room
Onboard/Aft Hull
Onboard/Superstructure
Nil
Area/Paint Material
Conventional
Epoxy
Inorganic Zinc Silicate
Other
Area/No. of Coats
One Coat
Multiple Coats
Area/Zone Type
Burn/Wear Damage
Difficult Position
Clean Area
Area/Scaffold
Scaffolding Required
Scaffolding Not Required
Stage
Surface Prep
Cleaning
Touch Up
Painting
Surface Prep After Turning
Cleaning After Turning
Touch Up After Turning
Painting After Turning
Finish Paint Level*
Zone
Component
Unit to be Fitted at Onboard Outfitting
Component Fitted On-block at On-block Outfitting
Onboard/Fore Hull
Onboard/Cargo Hold
Onboard/Engine Room
Onboard/Aft Hull
Onboard/Superstructure
Area/Paint Material
Conventional
Epoxy
Inorganic Zinc Silicate
Other
Area/No. of Coats
One Coat
Multiple Coats
Area/Zone Type
Burn/Wear Damage
Difficult Position
Clean Area
Area/Scaffold
Scaffolding Required
Scaffolding Not Required
Stage
Surface Prep
Cleaning
Touch Up
Painting
* = Select one attribute from each of the following groups.

Figure 3.3-2C

PWBS CLASSIFICATION AND CODING BOOK

FIGURE 3.3-3

PWBS CLASSIFICATION AND CODING BOOK

GENERAL INFORMATION

1. The system uses a six-digit code string to describe interim products. The digits define

DIGIT	DEFINES
1	Work Type
2	Manufacturing Level
3	Zone
4	Problem Area
5	Problem Area
6	Stage

2. The code sheets are read from left to rightj and then from top to bottom. Once your choice is found the code is obtained from the horizontal row of numbers only. The numbers in the vertical column indicate the column in which the code number is placed.

3. In the upper left comer of each code sheet is a reminder of the previous selection and coding which led to that page.

4. No more than three pages are required to classify and code any interim product.

INSTRUCTIONS

1. All classification and coding begins on Page 1 with the selection of work type attributes.

2. Below each work type attribute, in parentheses, is the page number on which the corresponding manufacturing level attributes are selected.

3. Below each manufacturing level attribute, in parentheses, is the page number on which the corresponding zone, problem area and stage attributes are selected.

An Example: P35513

P = Zone Painting Work Type (Page 1)
3 = Finish Undercoat Paint Manufacturing Level (Page 17)
5 = Zone - On board, Engine Room (Page 20)
5 = Scaffold Required, Epoxy Paint (Page 20)
1 = Single Coat, Positional Difficulies (Page 20)
3 = Painting Stage (Page 20)

NONE

PREVIOUS CODING

P.W.B.S. CLASSIFICATION & CODING

COLUMN		CODE	H	Z	P							
	1	**WORK TYPE**	HULL BLOCK CONST. (2)	ZONE OUTFIT. (10)	ZONE PAINTING (17)							
	2	**MANUFACTURING LEVEL**										
	3	**ZONE**										
	4	**AREA**										
	5	**AREA**										
	6	**STAGE**										

HULL BLOCK
CONSTRUCTION

H					

PREVIOUS
CODING

P.W.B.S. CLASSIFICATION & CODING

COLUMN	CODE		0	1	2	3	4	5	6	7	8	9
	1	**WORK TYPE**										
	2	**MANUFACTURING LEVEL**		PART FAB. (3)	PART ASSY. (4)	SUB BLOCK ASSY. (5)	SEMI BLOCK ASSY. (6)	BLOCK ASSY. (7)	GRAND BLOCK JOINING (8)	HULL ERECTION (9)		
	3	**ZONE**										
	4	**AREA**										
	5	**AREA**										
	6	**STAGE**										

PART FABRICATION LEVEL

P.W.B.S. CLASSIFICATION & CODING

H	I				

PREVIOUS CODING

COLUMN		CODE	0	1	2	3	4	5	6	7	8	9
	1	**WORK TYPE**										
	2	**MANUFACTURING LEVEL**										
	3	**ZONE**	PART									
	4	**AREA**	E	N	T	E	R		Z	E	R	O
	5	**AREA**	PARALLEL PART FROM PLATE	NON PARALLEL PART FROM PLATE	INTERNAL PART FROM PLATE	PART FROM ROLLED SHAPE	OTHER					
	6	**STAGE**	PLATE JOINING	MARKING & CUTTING	BENDING							

PART ASSEMBLY LEVEL

P.W.B.S. CLASSIFICATION & CODING

H	2				

PREVIOUS CODING

COLUMN		CODE	0	1	2	3	4	5	6	7	8	9
	1	**WORK TYPE**										
	2	**MANUFACTURING LEVEL**										
	3	**ZONE**	PART	SUB BLOCK								
	4	**AREA**	E	N	T	E	R		Z	E	R	O
	5	**AREA**	SUB BLOCK PART	BUILT UP PART								
	6	**STAGE**	ASS'Y	BENDING								

SUB-BLOCK
ASSEMBLY LEVEL

P.W.B.S. CLASSIFICATION & CODING

H	3				

PREVIOUS CODING

COLUMN		CODE	0	1	2	3	4	5	6	7	8	9
	1	**WORK TYPE**										
	2	**MANUFACTURING LEVEL**										
	3	**ZONE**	SUB BLOCK	NIL								
	4	**AREA**	E	N	T	E	R		Z	E	R	O
	5	**AREA**	SIMILAR WORK LARGE QUANTITY	SIMILAR WORK SMALL QUANTITY								
	6	**STAGE**	ASS'Y	BACK ASS'Y								

SEMI-BLOCK
ASSEMBLY LEVEL

H	4			.	

PREVIOUS
CODING

P.W.B.S.
CLASSIFICATION
&
CODING

COLUMN	CODE		0	1	2	3	4	5	6	7	8	9
	1	**WORK TYPE**										
	2	**MANUFACTURING LEVEL**										
	3	**ZONE**	BLOCK	NIL								
	4	**AREA**	E	N	T	E	R		Z	E	R	O
	5	**AREA**	SIMILAR WORK LARGE QUANTITY	SIMILAR WORK SMALL QUANTITY								
	6	**STAGE**	PLATE JOINING	ASS'Y	BACK ASS'Y							

BLOCK ASSEMBLY

PREVIOUS CODING

P. W.B.S. CLASSIFICATION & CODING

COLUMN		CODE	0	1	2	3	4	5	6	7	8	9
	1	**WORK TYPE**										
	2	**MANUFACTURING LEVEL**										
	3	ZONE	BLOCK	NIL								
	4	AREA	E	N	T	E	R		z	E	R	O
	5	AREA	FLAT	SPECIAL FLAT	CURVED	SPECIAL CURVED	SUPER-STRUCTURE					
	6	STAGE	PLATE JOINING	FRAMING	ASS'Y	BACK ASS'Y						

GRAND BLOCK
JOINING LEVEL

P.W.B.S.
CLASSIFICATION
&
CODING

H	6				

PREVIOUS
CODING

COLUMN	CODE		0	1	2	3	4	5	6	7	8	9
	1	**WORK TYPE**										
	2	**MANUFACTURING LEVEL**										
	3	**ZONE**	BLOCK	SHIP	NIL							
	4	**AREA**	E	N	T	E	R		Z	E	R	O
	5	**AREA**	FLAT PANEL	CURVED PANEL	SUPER-STRUCTURE							
	6	**STAGE**	JOINING	PRE-ERECTION	BACK PRE-ERECTION							

HULL
ERECTION LEVEL

H	7				

PREVIOUS CODING

P.W.B.S. CLASSIFICATION & CODING

COLUMN		CODE	0	1	2	3	4	5	6	7	8	9
	1	**WORK TYPE**										
	2	**MANUFACTURING LEVEL**										
	3	**ZONE**	SHIP									
	4	**AREA**	E	N	T	E	R		Z	E	R	O
	5	**AREA**	FORE HULL	CARGO HOLD	ENGINE ROOM	AFT HULL	SUPER-STRUCTURE					
	6	**STAGE**	ERECTION	TEST								

ZONE OUTFITTING

P.W.B.S. CLASSIFICATION & CODING

Z						

PREVIOUS CODING

COLUMN	CODE		0	1	2	3	4	5	6	7	8	9
	1	**WORK TYPE**										
	2	**MANUFACTURING LEVEL**		COMPO-NENT PROCURE (11)	UNIT ASS'Y (12)	GRAND UNIT JOINING (13)	ON BLOCK OUTFIT. (14)	ON BOARD OUTFIT. (15)	OPERATION & TEST (16)			
	3	**ZONE**										
	4	**AREA**										
	5	**AREA**										
	6	**STAGE**										

COMPONENT
PROCUREMENT LEVEL

Z	1				

PREVIOUS
CODING

P.W.B.S. CLASSIFICATION & CODING

COLUMN	CODE		0	1	2	3	4	5	6	7	8	9
	1	WORK TYPE										
	2	MANUFACTURING LEVEL										
	3	ZONE	COMPO-NENT									
	4	AREA	E	N	T	E	R		Z	E	R	O
	5	AREA	MANUFACTURING: IN HOUSE	MANUFACTURING: OUT SIDE	PURCHASE							
	6	STAGE	DESIGN & MAT'L PREP.	MANUF.	PALLETIZE							

UNIT ASSEMBLY LEVEL

P.W.B.S. CLASSIFICATION & CODING

Z	2				

PREVIOUS CODING

COLUMN	CODE		0	1	2	3	4	5	6	7	8	9
	1	**WORK TYPE**										
	2	**MANUFACTURING LEVEL**										
	3	**ZONE**	COMPO-NENT	UNIT								
	4	**AREA**	E	N	T	E	R		Z	E	R	O
	5	**AREA**	LARGE SIZE UNIT	SMALL SIZE UNIT								
	6	**STAGE**	ASS'Y	WELDING								

FINISH UNDERCOAT
PAINT LEVEL

P.W.B.S. CLASSIFICATION & CODING

P	3				

PREVIOUS CODING

COLUMN	CODE	0	1	2	3	4	5	6	7	8	9
1	WORK TYPE										
2	MANUFACTURING LEVEL										
3	ZONE				ON BOARD						
		COMPONENT	UNIT TO BE FITTED AT ON-BOARD OUTFITTING	COMPONENT FITTED ON BLOCK @ ON-BLOCK OUTFITTING	FORE HULL	CARGO HOLD	ENGINE ROOM	AFT HULL	SUPER-STRUCTURE	NIL	
4	AREA/ PAINT MAT'L/ SCOFFOLD	NO SCAFFOLD REQUIRED				SCAFFOLD REQUIRED					
		CONV. PAINT	EPOXY	INORG. ZINC SILICATE	OTHER	CONV. PAINT	EPOXY	INORG. ZINC SILICATE	OTHER		
5	AREA/ NO. OF COATS	SINGLE COAT				MULTIPLE COATS					
		NOMINAL AREA	POSITIONAL DIFFICULTIES	POST PAINT BURN/WELD DAMAGE	NEED TO MAINTAIN APPEARANCE	NOMINAL AREA	POSITIONAL DIFFICULTIES	POST PAINT BURN/WELD DAMAGE	NEED TO MAINTAIN APPEARANCE		
6	STAGE					AFTER TURNING					
		SURFACE PREP.	CLEANING	TOUCH UP	PAINTING	SURFACE PREP.	CLEANING	TOUCH UP	PAINTING		

ON-BLOCK
OUTFIITING LEVEL

P. W.B.S.
CLASSIFICATION

Z	4

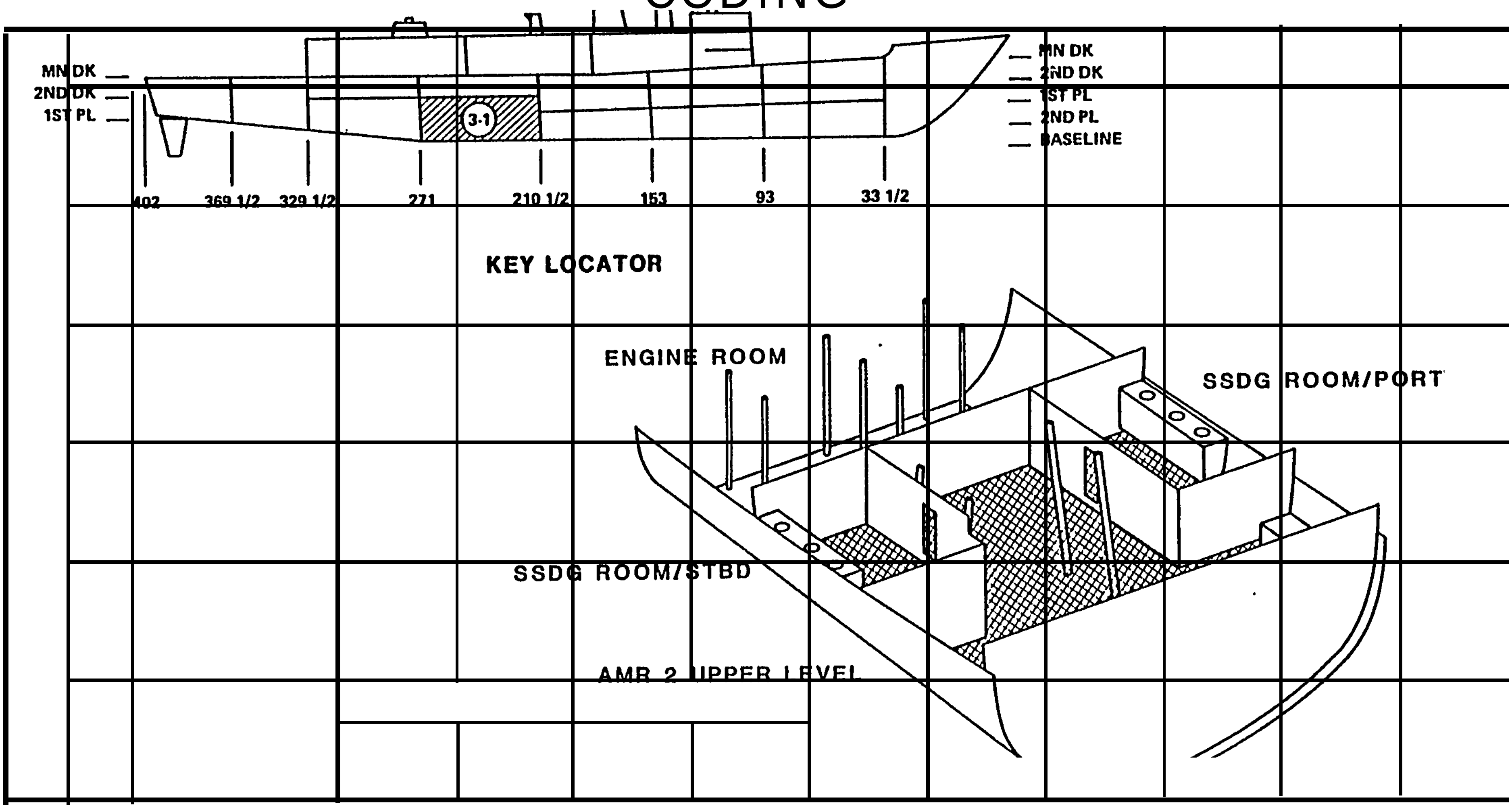
PREVIOUS
CODING

COLUMN		CODE	0	1	2	3	4	5	6	7	8	9
C	1	WORK TYPE							tine in ent the			
O	2	MANUFACTURING LEVEL							with			
L	3	ZONE	BLOCK	NIL								
u	4	AREA/ SPECIALTY	DECK	ACCOM.	MACH.	ELEC.	WEAPON					
M	5	AREA	COMPS. IN LARGE QUANTITY	COMPS. IN SMALL QUANTITY								
N	6	STAGE	ON CEILING		ON FLOOR							
			FITTING	WELDING	FITTING	WELDING						

ON-BOARD
OUTFITTING LEVEL

Z 4

P.W.B.S. CLASSIFICATION & CODING



OPERATION AND TEST LEVEL

P.W.B.S. CLASSIFICATION & CODING

Z	6				

PREVIOUS CODING

COLUMN		CODE	0	1	2	3	4	5	6	7	8	9
	1	**WORK TYPE**										
	2	**MANUFACTURING LEVEL**										
	3	**ZONE**	SHIP									
	4	**AREA/ SPECIALTY**	DECK	ACCOM.	MACH.	ELEC.	WEAPON					
	5	**AREA**	E	N	T	E	R		Z	E	R	O
	6	**STAGE**	OPERATION & TEST									

ZONE PAINTING

P.W.B.S. CLASSIFICATION & CODING

P						

PREVIOUS CODING

COLUMN		CODE	0	1	2	3	4	5	6	7	8	9
	1	WORK TYPE										
	2	MANUFACTURING LEVEL		SHOP PRIMER (18)	PRIMER (19)	FINISH UNDER COAT (20)	FINISH PAINT (21)					
	3	ZONE										
	4	AREA										
	5	AREA										
	6	STAGE										

SHOP PRIMER
LEVEL

P.W.B.S. CLASSIFICATION & CODING

P	1				

PREVIOUS CODING

COLUMN	CODE		0	1	2	3	4	5	6	7	8	9
	1	**WORK TYPE**										
	2	**MANUFACTURING LEVEL**										
	3	**ZONE**	MATERIAL	NIL								
	4	**AREA**	E	N	T	E	R		Z	E	R	O
	5	**AREA**	PLATE	SHAPES & OTHER								
	6	**STAGE**	BLASTING	PAINTING								

PRIMER
LEVEL

P	2				

PREVIOUS
CODING

P.W.B.S.
CLASSIFICATION
&
CODING

COLUMN		CODE	0	1	2	3	4	5	6	7	8	9
	1	**WORK TYPE**										
	2	**MANUFACTURING LEVEL**										
	3	**ZONE**			ON BOARD							
			COMPO-NENT	BLOCK	FORE HULL	CARGO HOLD	ENGINE ROOM	AFT HULL	SUPER-STRUCTURE			
	4	**AREA/ PAINT MAT'L**	CONV. PAINT	EPOXY	INORG. ZINC SILICATE	OTHER						
	5	**AREA/ NO. OF COATS**	SINGLE COAT				MULTIPLE COATS					
			NOMINAL AREA	POSI-TIONAL DIFFICUL-TIES	POST PAINT BURN/WELD DAMAGE	NEED TO MAINTAIN APPEAR-ANCE	NOMINAL AREA	POSI-TIONAL DIFFICUL-TIES	POST PAINT BURN/WELD DAMAGE	NEED TO MAINTAIN APPEAR-ANCE		
	6	**STAGE**				AFTER TURNING						
			SURFACE PREP.	CLEANING	PAINTING	SURFACE PREP.	CLEANING	PAINTING				

FINISH UNDERCOAT
PAINT LEVEL

P	3				

PREVIOUS CODING

P.W.B.S. CLASSIFICATION & CODING

COLUMN	CODE	0	1	2	3	4	5	6	7	8	9
1	**WORK TYPE**										
2	**MANUFACTURING LEVEL**										
3	**ZONE**				ON BOARD						
		COMPONENT	UNIT TO BE FITTED AT ON-BOARD OUTFITTING	COMPONENT FITTED ON BLOCK @ ON-BLOCK OUTFITTING	FORE HULL	CARGO HOLD	ENGINE ROOM	AFT HULL	SUPER-STRUCTURE	NIL	
4	**AREA/ PAINT MAT'L/ SCOFFOLD**	NO SCAFFOLD REQUIRED				SCAFFOLD REQUIRED					
		CONV. PAINT	EPOXY	INORG. ZINC SILICATE	OTHER	CONV. PAINT	EPOXY	INORG. ZINC SILICATE	OTHER		
5	**AREA/ NO. OF COATS**	SINGLE COAT				MULTIPLE COATS					
		NOMINAL AREA	POSITIONAL DIFFICULTIES	POST PAINT BURN/WELD DAMAGE	NEED TO MAINTAIN APPEARANCE	NOMINAL AREA	POSITIONAL DIFFICULTIES	POST PAINT BURN/WELD DAMAGE	NEED TO MAINTAIN APPEARANCE		
6	**STAGE**					AFTER TURNING					
		SURFACE PREP.	CLEANING	TOUCH UP	PAINTING	SURFACE PREP.	CLEANING	TOUCH UP	PAINTING		

FINISH PAINT
LEVEL

P	4				

PREVIOUS
CODING

P.W.B.S.
CLASSIFICATION
&
CODING

COLUMN		CODE	0	1	2	3	4	5	6	7	8	9
	1	**WORK TYPE**										
	2	**MANUFACTURING LEVEL**										
	3	**ZONE**				ON BOARD						
			COMPO-NENT	UNIT TO BE FITTED AT ON-BOARD OUTFITTING	COMPO-NENT FITTED ON BLOCK @ ON-BLOCK OUTFITTING	FORE HULL	CARGO HOLD	ENGINE ROOM	AFT HULL	SUPER-STRUCTURE	NIL	
	4	**AREA/ PAINT MAT'L/ SCOFFOLD**	NO SCAFFOLD REQUIRED				SCAFFOLD REQUIRED					
			CONV. PAINT	EPOXY	INORG. ZINC SILICATE	OTHER	CONV. PAINT	EPOXY	INORG. ZINC SILICATE	OTHER		
	5	**AREA/ NO. OF COATS**	SINGLE COAT				MULTIPLE COATS					
			NOMINAL AREA	POSI-TIONAL DIFFICUL-TIES	POST PAINT BURN/WELD DAMAGE	NEED TO MAINTAIN APPEAR-ANCE	NOMINAL AREA	POSI-TIONAL DIFFICUL-TIES	POST PAINT BURN/WELD DAMAGE	NEED TO MAINTAIN APPEAR-ANCE		
	6	**STAGE**	SURFACE PREP.	CLEANING	TOUCH UP	PAINTING						

3.4 MANUAL CL4SSIFICATI0N AND CODING

Manual classification and coding comprises generating the coding for an interim product manually, using the PWBS Classification and Coding Book. Experimentation revealed that this method worked very well and posed no problem other than the potential for misread or misplaced code characters. This method did, however, require further consideration once coding was complete. The example discussed in Section 3.6 revealed that the amount of data that resulted from even a single block was so great that further manual manipulation of it either by indexed cards or file folder was impractical. Post coding data manipulation then emerged as one factor shipyards should consider when implementing this system.

The most efficient means of using the classification and coding system manually seemed to be using the PWBS Classification and Coding Book in conjunction with data base management software and a computer with adequate memory capacity. Research indicated this to be well within the capability of current technology. This approach to implementing the classification and coding system is discussed in the example in Section 3.6 and in Section 3.7, Conclusions.

3.5 COMPUTER AIDED CLASSIFICATION AND CODING

Computer aided classification and coding comprises not only generation of the interim product coding, but the capture and manipulation of all associated data by interaction with a computer.

As this study progressed it became apparent that the most effective applications of group technology utilized computer aided classification and coding. This assumption was supported by the effort to define the current level of group technology utilization, by visits to companies using group technology and by the opinions expressed by shipbuilders in the industry survey.

To develop a computer aided version of the classification and coding systeM, the study team contacted vendors known to offer products of this nature. They were provided with a summary of the study's goals and the classification trees shown in Figure 3.3-2.

Of those contacted only one vendor responded The Brigham Young University CAM Software Research Center (BYU CAM Center). Follow-up telephone conversations to the other vendors revealed they generally did not respond because their product was not well suited to the structure of the classification and coding system.

Subsequent discussions wifh the BYU CAM Center, and review of information they provided revealed their product, D-CLASS,

1. could accommodate all aspects of the classification and coding system,

2. *was* compatible with a variety of computer hardware types, and

3. was being used by many large manufacturing companies to perform classification and coding and computer aided process planning.

The study team concluded that D-CLASS was the only commercially available means of using the classification and coding system it had developed in a computer aided manner. An arrangement was then made whereby the BYU CAM Center enabled the study to use D-CLASS software and its computer for a demonstration project.

Appendix B - DCLASS Information, contains a variety of literature provided by the BYU CAM Center. Further information can be obtained by contacting the CAM center directly.

Work then began that eventually led to the classification and coding system being used in a computer aided manner. Before describing this work however, the reader should be advised that the BYU CAM Center agreed, at the time this work was completd to retain on their computer, the classification and coding system and the example data that was used to test it for review by interested shipbuilders. Review of the computer aided product work classification and coding system is discussed in Appendix C-1. Access to a modum equipped terminal is required.

3.6 USING THE SYSTEM - AN EXAMPLE

Because this project was attempting, in part, to develop a prototype shipbuilding tool, its sponsors required an example be provided that

1. illustrated its use, and

2. tested its capability.

This example classifies and codes an erection block of an FFG-7 class guided missile frigate of the United States Navy. The block comprises an auxiliary machinery room and a portion of the engine room. It was selected for use because of its variety of work and complexity of outfitting. While all of the interim products of this block were classified and coded, only a representative portion are shown here. A representative listing of 1074 interim products, from the more than 4200 developed by this example, is presented in appendix C-example data.

Before reviewing the example, the reader should be aware of certain conditions which limited its effectiveness in illustrating and testing the system.

1. Because the ship used in this example was not designed to take full advantage of a prcduct work breakdown structure, a few of the manufacturing levels - on unit outfitting in particular - were difficult to apply.

2. Because this example was limited to the interim products of a single block the on board manufacturing levels were not used.

3. Because this example portrays the first attempt to use the system, it represents a learning experience which may or may not make the most effective use of interim product designation and code assignment.

4. Because the classification and coding shown here was done by a particular shipbuilder, it contains decisions which reflect production characteristics at a particular shipyard and may not apply to other facilities.

The example demonstrated the systems potential as a tool for creating work packages. To perform this function effectively, however, a means of specifying the location of an interim product within the ship was needed. The interim product designation scheme discussed in Section 4.5 was developed to meet this need. It is recommended that the reader review this section before studying the example.

Through experimentation, the project team found using the system to be a four step process.

Step 1 A zone directory was developed which defined the zones and sub-zones contained in the block.

Step 2 Interim products were identified designated and classified and coded..

Step 3 Interim products were experimentally sorted into work packages to determine optimum productivity value.

Step 4 Interim products were assigned to a work package and given a number to represent this decision.

Steps 1 through 4 are discussed below as they apply to manual and computer aided classification and coding.

Step 1- Zone Directory

Before classification and coding could begin the manufacturing sequence of the block had to be planned. This plan defined the zones and sub-zones that would be used to geographically divide work and, in a general way, established the sequence of assembly for major structural components. The zone directory for the example block is shown in Figure 3.6-1. Step 1 is performed in the same manner for both manual and computer aided classification and coding.

Step 2- Interim Product Classification and Coding

Once the zone and sub-zone arrangements were defined, interim products were designated by their zone and sub-zone and then classified and coded.

This was done by compiling lists of interim products from drawings similar to those in Figure 3.6-2 (due to space considerations these lists are not complete and present only a portion of the interim products for the zone shown. A complete list of interim products is contained in Appendix C-3). Manually, interim products were added to the Iist, then coded using the code book presented in Figure 3.3-3. Instructions for using the code book are contained in Figure 3.3-3. When coding is complete, the data would be entered into a data base management program as discussed in Section 3.4, Manual Classification and Coding. This example did not expend the effort to enter this data into a data base management program because the function and performance of these programs are generally understood and well documented. For this reason, Steps 3 and 4 only discuss interim product sorting using D-CLASS. It was assumed that sorting with a data base management program would be conceptually similar though significantly less functional.

In a computer aided manner, interim product coding was accomplished interactively with D-CLASS by responding to the inquiries displayed on the terminal. An example of these interactions is shown in Figure 3.6-3 with annotation to explain what is being done.

This example illustrates the classification and coding of the web portions of the web frames at Frames 220 and 228 shown in the sketch of zone 11 figure 3.6-2. These four pieces are treated as a single interim product because they are identical and all occur within the same zone. They could also be treated as individual interim products, at the discretion of the shipyard.

Step 3- Sorting Interim Products

Step 3 initiates the sorting of interim products into groups that will eventually become work packages.

The system performs sorting according to the variables used in interim product designation,

- Hull No.
- Block No.
- Zone No.
- Sub-Zone No.

and, by the PWBS Code in any progressive combination of the six digits which represent

- Work type
- Manufacturing level
- Zone type
- Problem area
- Problem area, and
- Stage

The goal of the sorting process was to create work packages which possessed optimum productivity value (PV)*. The factors T, N and Q* were considered in each sorting experiment and the resulting group of interim products was modified until optimum PV was attained.

*see "Product Work Breakdown Structure", Section 1.3.

It should e noted that T, N and Q are subjective variables and will differ with production process and facility. Their values, reflected in these sorting experiments and in final work package assignment reflect conditions at the yard in which this Ship was built.

The sorting experiments shown in Figure 3.6-4 were performed using DCLASS and are annotated to denote what is being done. The goal of this particular sorting experiment was to create a work package for the steel parts fabrication shop from the small tanks and sea chest located on the shell in block 31. The reader should remember that the data base used in think example only contained interim products from a single block. The variables, hull no. and block no., shown here therefore produce no sorting results. The need for these variables could only be demonstrated if the data base contained interim products from several ships. They are included in this example to indicate their potential use.

Step 4- Work Package Assignment

Step Four concludes the classification and coding of interim products by capturing the information developed in Step Three pertaining to work package assignment.

In DCLASS, Step Four involves changing the work package variable from the previously entered “99” to the appropriate work package number. Step Four is illustrated in Figure 3.64 in which the interim products sorted in Figure 3.6-3 are designated as work package 10.

3.7 CONCLUSIONS AND RECOMMENDATIONS

As is often the case with research and development work, this project raised as many, if not more, new questions as it answered old. Before discussing new questions however, the answers to the old should be reviewed.

Any attempt to analyze the results of this project must consider

- its goal stated in Section 1.1, Introduction,
- its scope specification stated in Section 3.2.2, Scope, and
- the requirements defined in Section 3.3, The Application.

The goal of t.his project was to explore group technology with the intent of developing an application of classification and coding for the shipbuilding industry. Within the limited scope of the example, the effectiveness of this classification and coding system was demonstrated in Section 3.6.

The ultimate value of this c!assificat.ion and ceding system will not be known until it is used in the building of one or several ships and its performance weighed against the information needs of work planners and schedulers. This project did not have the resources to classify and code the estimated forty thousand interim products of the complete frigate, nor could it simulate the complex flow of information that occurs in the building of a ship. However, based upon the information that the project team was able to produce within the scope of the example, the following conclusions can be drawn.

1. The classification and coding system will perform sorting of interim products by work content and shipboard location. This capability should enable work planners to develop work packages for specific hull block construction, zone outfitting and zone painting processes, and for specific periods of time based on a block oriented build schedule.

2. The system captures interim product work content through classification and coding in a relatively simple, concise, and unambiguous manner. Most of the project team members who experimented with the system found it easy to use both in a manual and computer aided manner.

   A few coding errors did, of course, occur. The example revealed that errors might be reduced if the stage attributes within each problem area were arranged, where possible, to reflect the sequence of work. Because this sequence may vary from yard to yard, this modification should be done by individual shipyards using the system.

   The most significant issue to arise from the example concerned attribute ambiguity. Questions arose concerning the meaning of a particular attribute or the relative meanings of attributes within a group, for exarnple, the difference between a large unit and a small unit, or between a flat block and a special flat block. Research revealed that beyond the definitions offered in “Product Work Breakdown Structure”, the meanings of various attributes were subject to methods of production and could vary significantly between shipyards. As a result, it is recommended that individual shipyards develop a standard definition for each attribute and provide training to their users.

   The potential exists, in the current configuration of the system, for the user to commit logic errors. For example, in the part fabrication level of hull block construction, it is possible for the user to select the “part from rolled shape” problem area and then select the “plate joining” stage attribute which is clearly illogical. Adequate user training should prevent this error and it was not deemed mandatory to unnecessary complicate the classification tress and code sheets.

3. Using DCLASS, the system will operate in a computer aided environment and be compatible with a variety of hardware types. Also, in its computer aided form the system could serve as a foundation for a computer aided process planning system provided a decision tree approach was used. (See Section 4.7). It should be noted that the classiilcation and coding system used only a small portion of DCLASS' decision tree processing capability. The project team recommends that shipbuilders review the example data left on the BYU CAM Center computer to aquaint themselves with this capability. Shipbuilders interested in developing their own example or pilot project should be aware that DCLASS is available in a micro-computer based version (type C licence) for a relatively small fee.

4. The example brought out the important relationship between work organization concepts and attribute selection. The attributes currently in the system adequately described all interim products contained in the subject block. It conceivable though, that some shipbuilders may wish to add attributes to the system. This process is discussed in Section 4.3. For example, in the component procurement level of zone outfitting, a shipyard could add attributes to expand the definition capability under in-house manufacturing to include those prccesses it maintains in-house. Possible attributes could be pipe piece manufacturing, vent piece manufacturing, electrical piece manufacturing, and machined piece manufacturing.

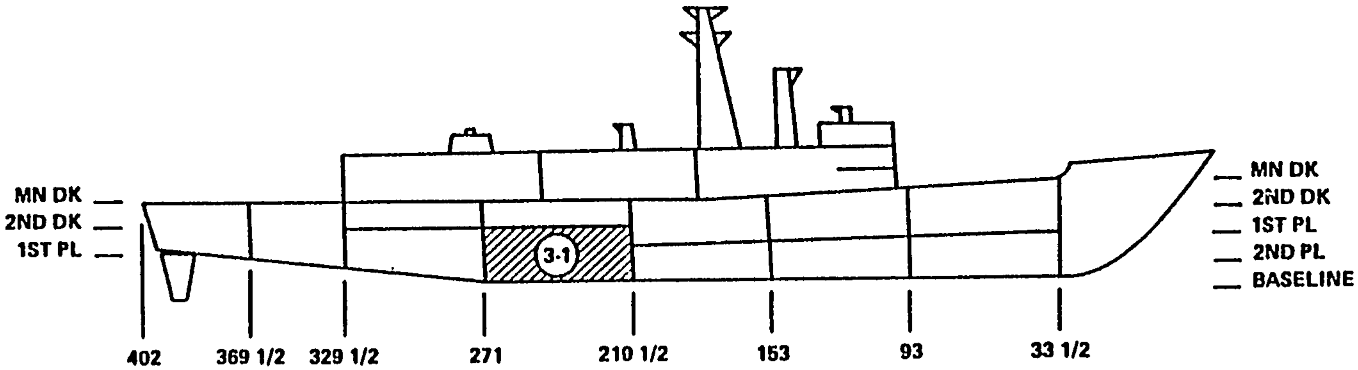
During the course of this study, several questions arose which were interesting but beyond the scope of this project They are mentioned here as suggestions for further investigation by individual shipyards and the National Shipbuilding Research Program.

1. The feasibility of developing attributes which address productivity value should be investigated. In "Product Work Breakdown Structure", Section 1.3, Productivity Value (PV) is expressed as a function of process time (T), resource quantity (N), and quality of work cimurnstance (Q). To derive a value for PV is within the capability of DCLASS. The decision trees, i.e. attributes and tree structure, will require a significant amount of research to develop.

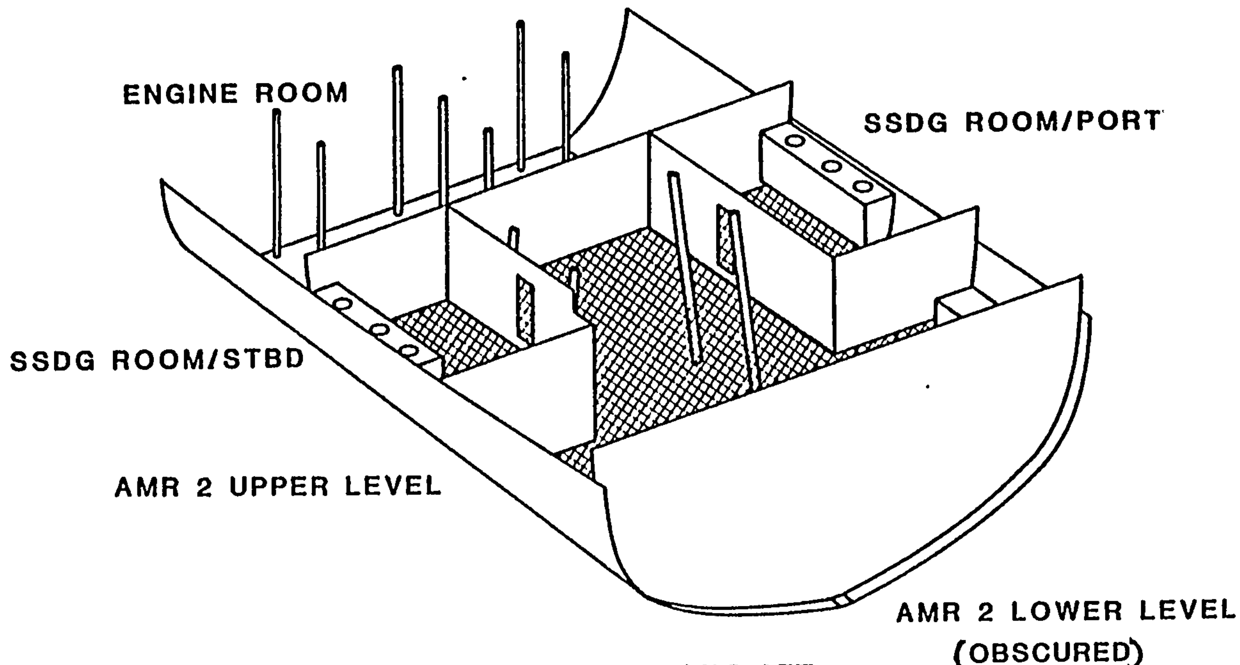
2. The feasibility of using DCLASS as a sub-routine in a larger manufacturing information management system should be investigated. This is within the capability of DCLASS.

3. The feasibility of integrating the DCLASS interactive classification and coding process with interim product graphics generated from a CAD/CAM data base should be investigated.

4. The feasibility of developing decision trees which identify interim products for flexible manufacturing work cells and robotic work stations should be investigated.



KEY LOCATOR



UNIT 3-1 STBD LKG AFT

Figure 3.6-1
31 Block
Zone Directory

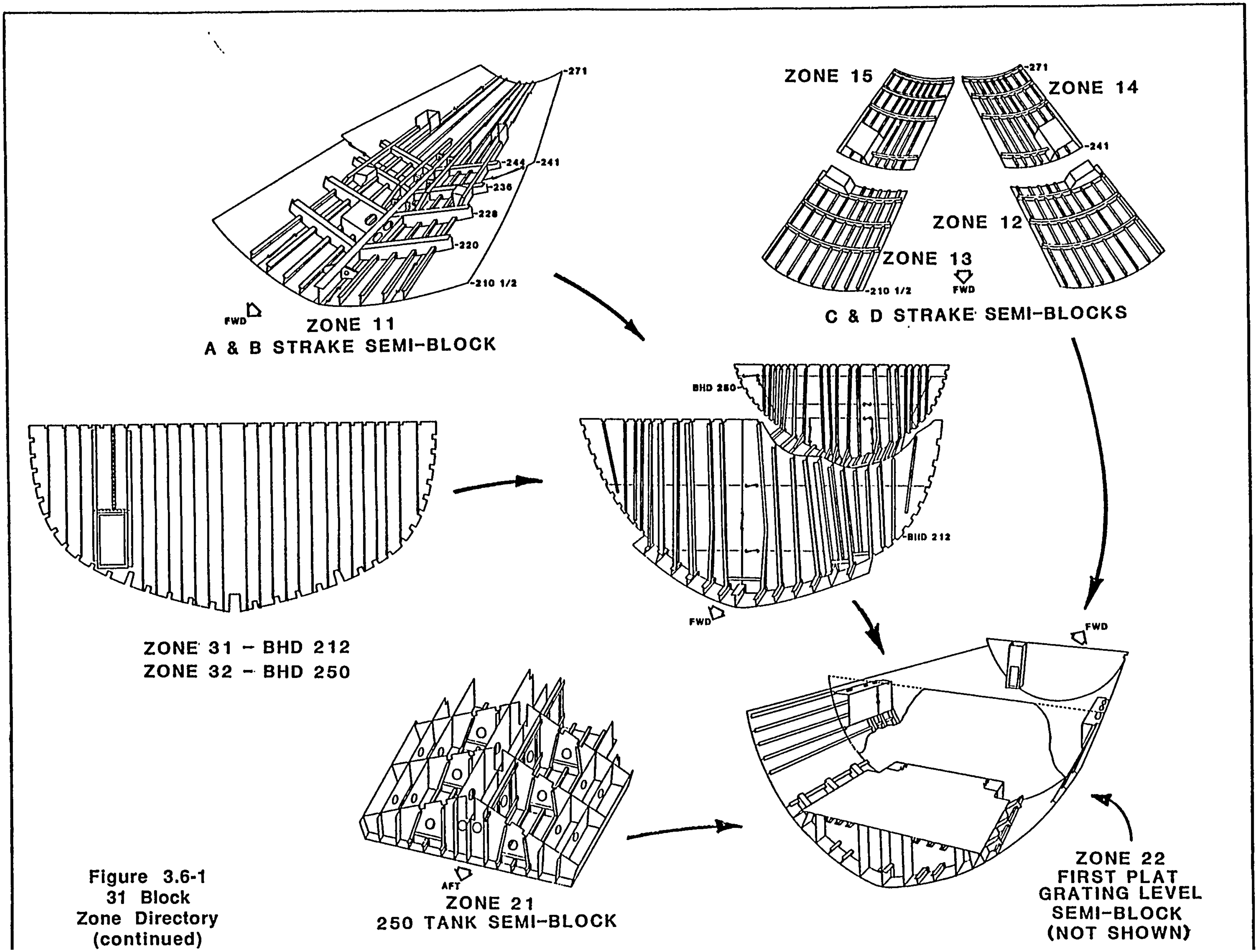


Figure 3.6-1
31 Block
Zone Directory
(continued)

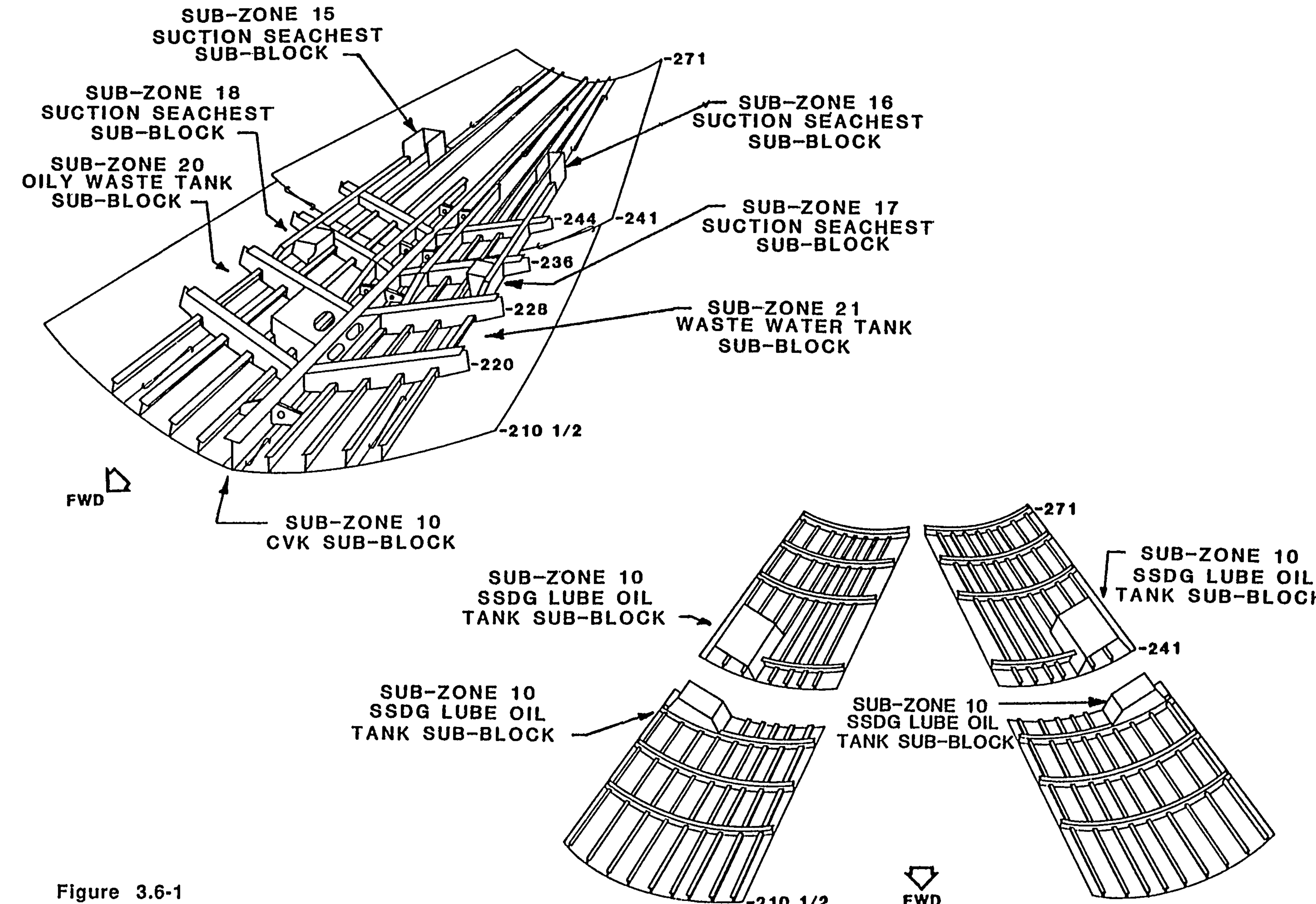
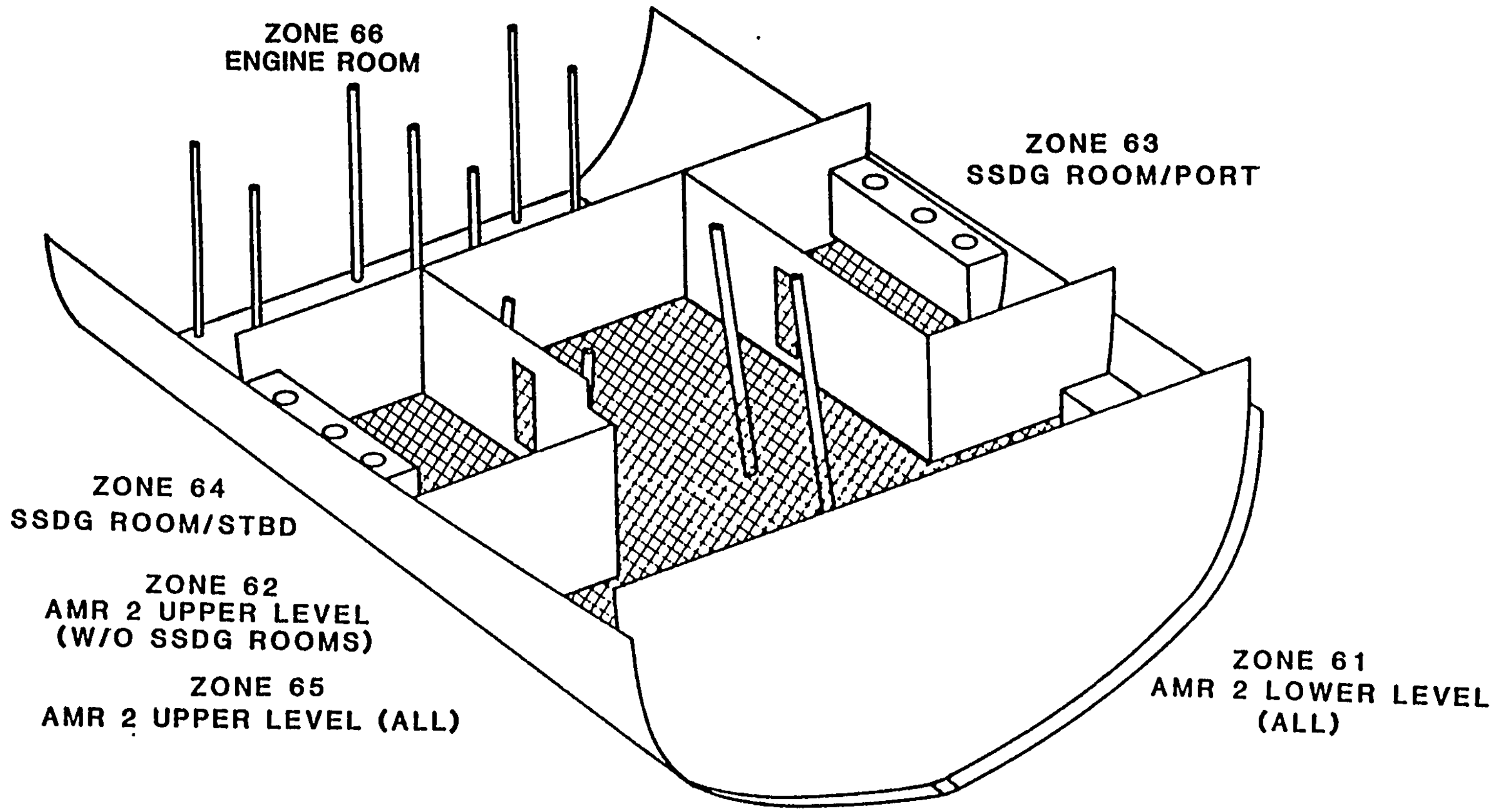
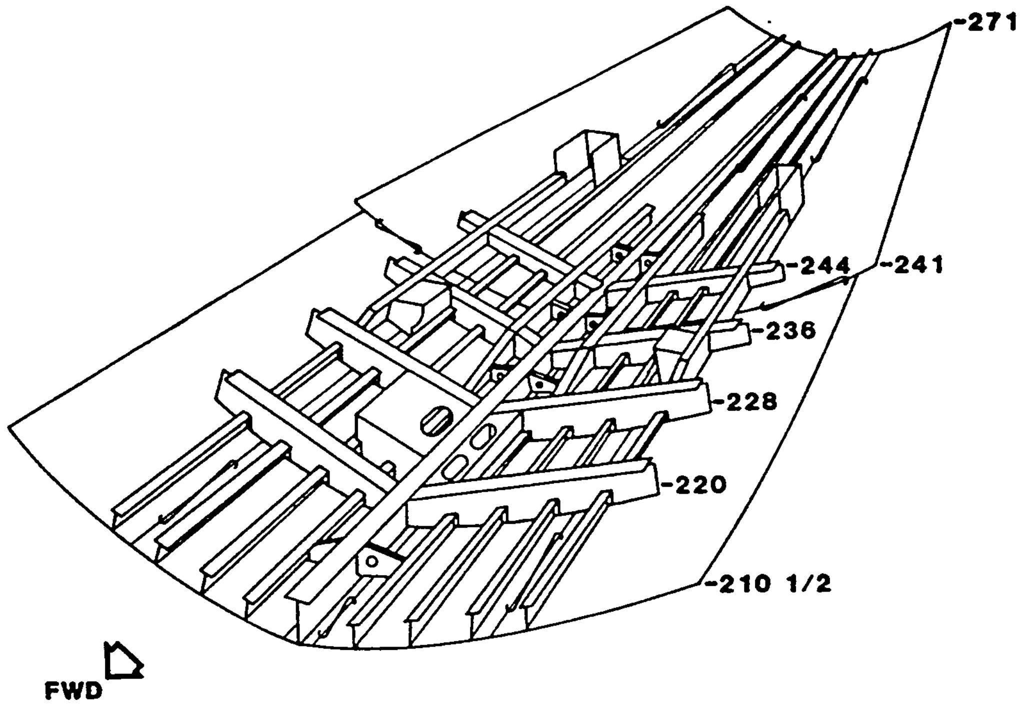


Figure 3.6-1
31 Block
Zone Directory
(continued)



UNIT 3-1 STBD LKG AFT

Figure 3.6-1
31 Block
Zone Directory
(continued)



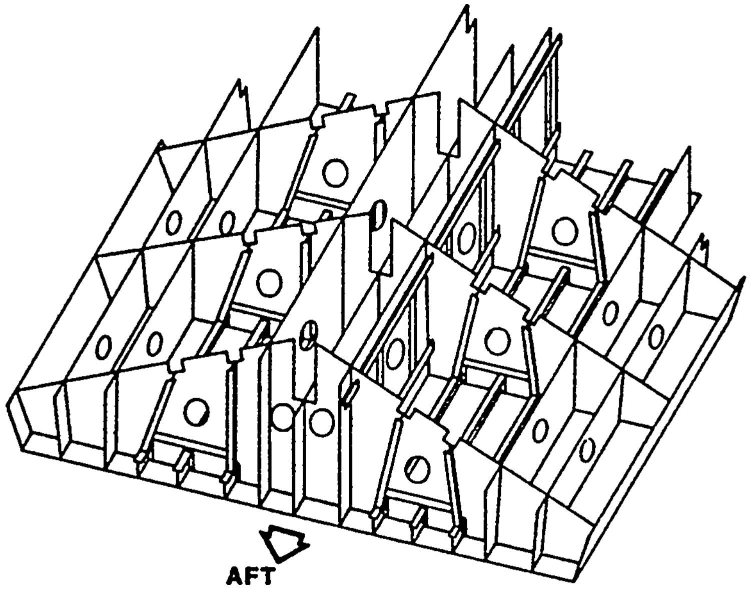
ID#	DESCRIPTION	INTERIM PRODUCT DESIGNATION					CODE*
		WP#	HULL#	BLOCK#	ZONE#	SUB ZONE#	
001	31 SHELL A&B PLT CUT	99	61	31	11	99	H 1 0 0 0 1
002	31 SHELL A&B PLT ROLL					99	H 1 0 0 0 2
003	31 SHELL A&B PLT ASSY					99	H 5 0 0 3 0
004	31 SHELL LONG'L CUT					99	H 1 0 0 3 1
006	31 SHELL A&B LONG'L ASSY					99	H 5 0 0 3 1
007	31 CVK VERT PLT CUT					10	H 1 0 0 2 1
008	31 CVK FACE PLT CUT					10	H 1 0 0 0 1
009	31 CVK BRKT VERT PLT CUT					10	H 1 0 0 2 1
010	31 CVKX BRKT FACE PLT CUT					10	H 1 0 0 0 1
011	31 CVK FACE PLT ASSY					10	H 2 0 0 1 0
012	31 CVK BRKT FACE PLT ASSY					10	H 2 0 0 1 0
013	31 CVK ASSY					10	H 3 0 0 0 0
014	31 SHELL GIRDER VERT PLT CUT					99	H 1 0 0 2 1
015	31 SHELL GIRDER FACE PLT CUT					99	H 1 0 0 0 1
016	31 SHELL GIRDER FACE PLT CUT					99	H 2 0 0 1 0
017	31 SHEL;L GIRDER BKT VERT PLT CUT	↓	↓	↓	↓	99	H 1 0 0 2 1

*The code column would be used only in manual classification and coding.

Figure 3.6-2
Interim Product List

ID#	DESCRIPTION	INTERIM PRODUCT DESIGNATION					CODE*
		WP#	HULL#	BLOCK#	ZONE#	SUB ZONE#	
018	31 SHELL GIRDER BRKT FACE PLT CUT	99	61	31	11	99	H 1 0 0 0 1
019	31 SHELL GIRDER BRKT FACE PLT ASSY					99	H 2 0 0 1 0
020	31 SHELL GIRDER ASSY					99	H 2 0 0 1 0
005	31 SHELL LONG'L BEND					99	H 1 0 0 3 2
021	31 CVK SHELL ASSY					99	H 5 0 0 3 1
022	31 SHELL GIRDER SHELL ASSY					99	H 5 0 0 3 1
024	31 DOCK BRKT PLATE CUT					99	H 1 0 0 2 1
025	31 A&B SHELL WEBFACE PLT CUT					99	H 1 0 0 3 1
026	31 DOCK BRKT FACE PLT CUT					99	H 1 0 0 3 1
027	31 A&B SHELL WEB SELF ASSY					99	H 2 0 0 1 0
028	31 DOCK BRKT SELF ASSY					99	H 2 0 0 1 0
029	31 A&B SHELL WEB SHELL ASSY					99	H 5 0 0 3 1
030	31 DOCK BRKT SHELL ASSY					99	H 5 0 0 3 1
031	31 A&B SHELL WEB BRKT CUT					99	H 1 0 0 2 1
032	31 A&B SHELL WEB COLLAR CUT					99	H 1 0 0 2 1
033	31 A&B SHELL TANK PLATE CUT					20	H 1 0 0 1 1
034	31 SEA CHEST PLATE CUT					15	H 1 0 0 2 1
035	31 A&B SHELL TANK STIFFENER CUT					20	H 1 0 0 3 1
036	31 A&B SHELL TANK STIFFENER ASSY					20	H 3 0 0 0 1
037	31 A&B SHELL TANK ASSY					20	H 3 0 0 1 0
038	31 SEA CHEST STIFFENER CUT					15	H 1 0 0 3 1
039	31 SEA CHEST STIFFENER ASSY					15	H 3 0 0 0 0
040	31 SEA CHEST ASSY					15	H 3 0 0 1 0
041	31 A&B SHELL TANK SHELL ASSY					20	H 5 0 0 3 1
042	31 SEA CHEST SHELL ASSY					15	H 5 0 0 3 1
043	31SEA CHEST BAFFLE CUT					15	H 1 0 0 3 1
044	31 SEA CHEST BAFFLE BEND					15	H 1 0 0 3 2
045	31 SEA CHEST BAFFLE ASSY					15	H 3 0 0 1 0
046	31 SEA CHEST BAFFLE INST					15	Z 4 0 2 1 0
085	31 A&B SHELL WEB FACE PLT ROLL					99	H 1 0 0 3 2
086	31 DOCK BRKT FACE PLT ROLL					99	H 1 0 0 3 2
094	31 A&B SHELL WEB COLLAR ASY					99	H 5 0 0 3 1

Figure 3.6-2
Interim Product List
(continued)



250 **TANK**

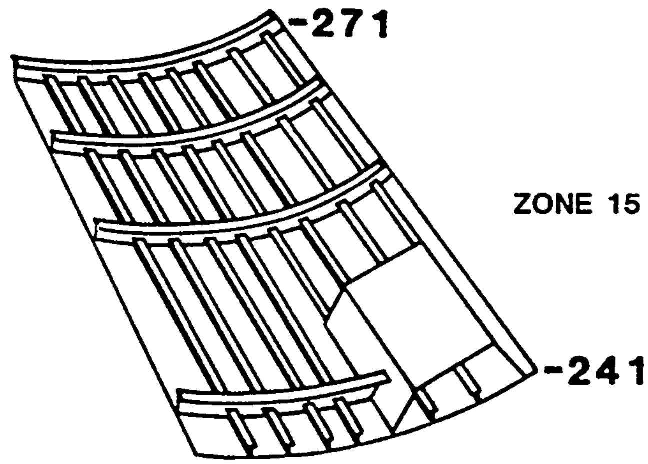
ZONE 21

ID#	DESCRIPTION	INTERIM PRODUCT DESIGNATION WP#	HULL#	BLOCK#	ZONE#	SUB ZONE#	CODE*
103	31 250 TANK A/2 PLT CUT	99	61	31	21	99	H100O01
104	31 250 TANK A/1 PLT CUT						H10011
105	31 250 TANK CL BHD CUT						H10001
l06	31 250 TANK XVERSEEUT						H10021
107	31 250 TANK GIRDER CUT						H10321
109	31 250 TANK STIFFENER CUT						H10031
109	31 250 TANK COHP, SLY, CUT						H10031
110	31 250 TANK CORP.SLV BEND						H10032
111	31 250 TANK A/1 7 A/2 PLT ASSY						H40000
112	31 250 TANK TANNK FRAMING						H40001
116	31 250 TANK STANCHION CUT						H10031
117	31 250 TANK STANCICHION ASSY						H20100
l18	31 250 TANK STANCHION ASSY						H50032
119	31 250 TANK INSTALLATION						H50032
120	31 250 TANK HEADER CUT						H10021
121	31 250 TANK GUSSETS CUT						H10021

*The code column would be used only in manual classification and coding.

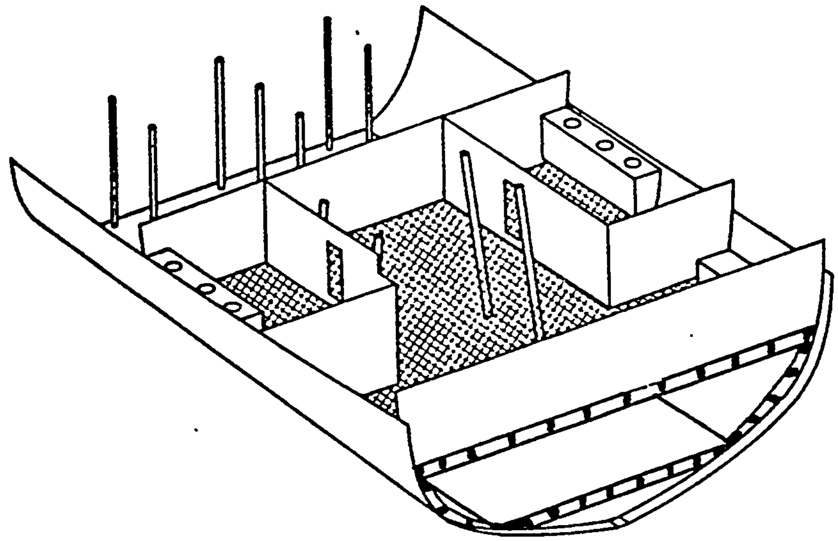
Figure 3.6-2
Interim Product List
(continued)

ID#	DESCRIPTION	INTERIM PRODUCT DESIGNATION					CODE*
		WP#	HULL#	BLOCK#	ZONE#	SUB ZONE#	
122	31 250 TANK BRKTS CUT	99	61	31	21	99	H 1 0 0 2 1
123	31 250 TANK COLLAR CUT					99	H 1 0 0 2 1
124	31 250 TANK HEADER ASSY					99	H 4 0 0 0 2
125	31 250 TANK GUSSET ASSY					99	H 4 0 0 0 2
126	31X 250 TANK BRKT ASSY					99	H 4 0 0 0 2
127	31 250 TANK COLLAR INST.					99	H 5 0 0 3 2



ID#	DESCRIPTION	INTERIM PRODUCT DESIGNATION					CODE*
		WP#	HULL#	BLOCK#	ZONE#	SUB ZONE#	
200	31 C&D SHELL WEB PLATE CUT	99	61	31	15	99	H 1 0 0 2 1
201	31 C&D SHELL WEB FACE PLT CUT					99	H 1 0 0 3 1
202	31 C&D SHELL WEB SELF ASSY					99	H 3 0 0 0 0
203	31 C&D SHELL WEB SHELL ASSY					99	H 4 0 0 0 1
204	31 C&D SHELL WEB COLLAR CUT					99	H 1 0 0 2 1
205	31 C&D SHELL WEB COLLAR ASSY					99	H 4 0 0 0 1
206	31 C&D SHELL WEB BRKT CUT					99	H 1 0 0 2 1
207	31 C&D SHELL TANK PLATE CUT					10	H 1 0 0 1 1
208	31 C&D SHELL TANK STIFFENER CUT					10	H 1 0 0 3 1
209	31 C&D SHELL TANK STIFFENER ASSY					10	H 3 0 0 0 1
210	31 C&D SHELL TANK ASSY					10	H 3 0 0 1 0
211	31 C&D SHELL TANK SHELL ASSY					10	H 4 0 0 1 1
212	31 C&D SHELL TANK COLLAR CUT					10	H 1 0 0 2 1
213	31 SHELL C&D STRAKE ASSY					99	H 5 0 0 3 2

Figure 3.6-2
Interim Product List
(continued)



UNIT 3-1 STBD LKG AFT

ZONE 61

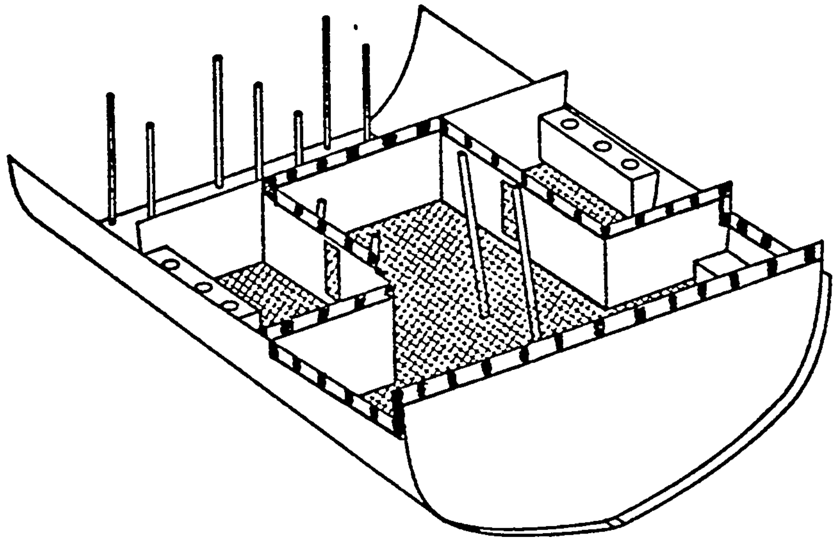
ID#	DESCRIPTION	INTERIM PRODUCT DESIGNATION					CODE*
		WP#	HULL#	BLOCK#	ZONE#	SUB ZONE#	
231	31 GRTG ACCESS HANDLE CUT	99	61	31	61	99	H 1 0 0 3 1
232	31 GRTG ACCESS HANDLE BEND						H 1 0 0 3 2
233	31 GRTG ACCESS LATCH PTS 20, 20 & 23						Z 1 0 0 1 0
234	31 GRTG ACCESS HINGES						Z 1 0 0 1 0
235	31 GRTG ACCESS LATCH PTS 22 &24						H 1 0 0 2 1
236	31 GRTG ASCCESS LATCH PT ASSY						H 2 0 0 0 0
237	31 GRTG ACCESS ASSY						H 2 0 0 1 1
238	31 GRTG ACCESS INSTALL						H 4 0 0 0 1
239	31 DK GRTG MATL PROCUREMENT						Z 1 0 0 1 1
240	31 DK GRTG CUT						H 2 0 0 0 0
241	31 DK PLATE CUT						H 1 0 0 3 1
242	31 DK PLATE DRILLING						H 1 0 0 3 1
251	31 DK GRTG PT 205 CUT						H 1 0 0 3 1
252	31 DK GRTG PT 205 ASSM						H 2 0 0 1 0
253	31 DK GRTG PT 206 CUT						H 1 0 0 3 1
254	31 DK GRTG PT 2106 BEND						H 1 0 0 3 2

*The code column would be used only in manual classification and coding.

Figure 3.6-2
Interim Product List
(continued)

ID#	DESCRIPTION	INTERIM PRODUCT DESIGNATION					CODE*
		WP#	HULL#	BLOCK#	ZONE#	SUB ZONE#	
255	31 DK GRTG PT 19 PROCUREMENT	99	61	31	61	99	Z 1 0 0 2 1
256	31 DK GRTG INSTALL						Z 4 0 0 0 2
257	31 DK PLATE INSTALL						Z 4 0 0 0 2
318	SPECIAL TOOL STWG -STO CAB INST CABINET						Z 4 0 0 1 2
319	SPECIAL TOOL STWG -STO CAB PRIME MAT'L						P 2 0 2 2 2
320	SPECIAL TOOL STWG-STO CAB PREP FDN						P 3 2 1 5 0
321	SPECIAL TOOL STWG -STO CAB PAINT FDN						P 3 2 1 5 3
322	SPECIAL TOOL STWG-STO CAB PAINT CABINET						P 2 0 1 3 2
330	SSDG FUEL PRIMING PMP STWG CUT FDN PCS						H 1 0 0 3 1
331	SSDG FUEL PRIMING PMP STWG ASSM FDN PCS						H 2 0 0 0 0
332	SSDG FUEL PRIMING PMP STWG INST FDN						H 5 0 0 3 2
333	SSDG FUEL PRIMING PMP STWG STRP PROCUREMENT						Z 1 0 0 1 1
334	SSDG FUEL PRIMING PMP STWG TOOL BOX PROCUREMENT						Z 1 0 0 2 1
335	SSDG FUEL PRIMING PMP STWG INST TOOL BOX						Z 4 0 0 1 2
336	SSDG FUEL PRIMING PMP STWG PRIME MAT'L						P 2 0 2 2 2
337	SSDG FUEL PRIMING PMP STWG PREP FDN						P 3 2 1 5 0
338	SSDG FUEL PRIMING PMP STOW PAINT FDN						P 3 2 1 5 3
339	SSDG FUEL PRIMING PMP STWG PAINT TOOL BOX						P 4 1 0 3 2
340	FUEL OIL PURIFIER CUT FDN PCS						H 1 0 0 3 1
341	FUEL OILPURIFIER BEND FDN PCS						H 1 0 0 3 2
342	FUEL OIL PURIFIER ASSM FDN PCS						H 2 0 0 1 1
343	FUEL OIL PURIFIER HARDWARE PROCUREMENT						Z 1 0 0 2 2
344	FUEL OIL PURIFIER -PURIFIER PROCUREMENT						Z 1 0 0 2 2
345	FUEL OIL PURIFIER INST FDN						H 5 0 0 3 2
346	FUEL OIL PURIFIER PRIME FDN PCS						P 2 0 2 2 2
347	FUEL OIP PURIFIER PREP FDN						P 3 2 1 5 0
348	FUEL OIL PURIFIER PAINT FDN						P 3 2 1 4 3
349	FUEL OIL PURIFIER INST PURIFIER						Z 6 0 0 C 2
370	(43) DRY CHEM FIRE EXT STWG CUT FDN PC						H 1 0 0 3 1
371	(4) DRY CHEM FIRE EXT STWG PR ME PC						P 2 0 2 2 2
372	(4) DRY CHEM FIRE EXT STWG INST FDN						H 5 0 0 3 2
373	(4) DRY CHEM FIRE EXT STWG PREP FDN						P 3 2 1 4 0

Figure 3.6-2
Interim Product List
(continued)



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ZONE 62

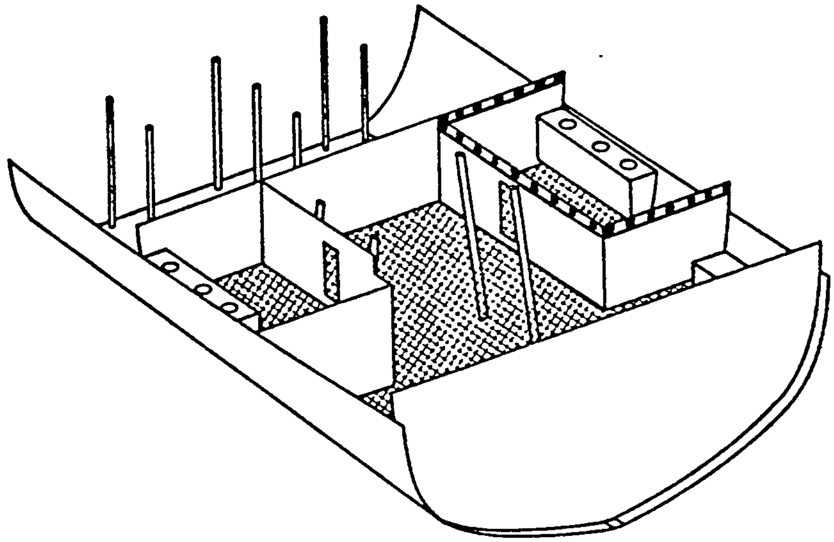
ID#	DESCRIPTION	INTERIM PRODUCT DESIGNATION					CODE*
		WP#	HULL#	BLOCK#	ZONE#	SUB ZONE#	
388	CAS PWR CABLE RACK CUT PCS	99	61	31	62	99	H10031
389	CAS PWR CABLE RACK BEND PCS 1 & 7						H10032
390	CAS PWR CABLE RACK ASSM PCS 1 & 3						H30010
391	CAS PWR CABLE RACK PRIME PCS						P20222
392	CAS PWR CABLE RACK INST HDRS						H40012
393	CAS PWR CABLE RACK INST RACK						H40011
394	CAS PWR CABLE RACK PREPPCS						P32000
395	CAS PWR CABLE RACK PAINT RACK						P42003
396	CAS PWR CABLE RACK INST CABLE						Z60003
446	CAS POWER CABVLE RACK CUT PCS						H10031
447	CAS POWER CABVLE RACK BEND PCS 1 & 7						H10032
448	CAS POWER CABLE RACK ASSM PCS 1 & 3						H30010
449	CAS POWER CABLE RACK PRIME PCS						P20222
450	CAS POWER CABLE RACK INST HDRS						H40012
451	CAS POWER CABLE RACK INST RACK						H40011
452	CAS POWER CABLE RACK PREP PCS						P32000

*The code column would be used only in manual classification and coding.

Figure 3.6-2
Interim Product List
(continued)

ID#	DESCRIPTION	INTERIM PRODUCT DESIGNATION					CODE*
		WP#	HULL#	BLOCK#	ZONE#	SUB ZONE#	
453	CAS POWER CABLE RACK PAINT RACK	99	61	31	62	99	P 4 2 0 0 3
454	CAS POWER CABLE RACK INST CABLE						Z 6 0 0 0 3
484	(4) CO2 FIRE EXT STWGS CUT PCS						H 1 0 0 3 1
485	(4) CO2 FIRE EXT STWGS BEND PC 55						H 1 0 0 3 2
486	(4) CO2 FIRE EXT STWGS PROCURE HARDWARE						Z 1 0 0 2 2
487	(4) CO2 FIRE EXT STWGS ASSM FDN						H 3 0 0 1 0
488	(4) CO2 FIRE EXT STWGS PRIME PARTS						P 2 0 2 2 2
489	(4) CO2 FIE EXT STWGS INST FDN						H 5 0 0 3 2
490	(4) CO2 FIRE EXT STWGS BOTTLF PROCUREMENT						Z 1 0 0 2 2
491	(4) CO2 FIRE EXT STWGSINST BOTTLE						Z 6 0 0 0 2
492	(4) CO2 FIRE EXT STWGS CLEAN FDN						P 3 2 0 2 0
493	(4) CO2 FIRE EXT STWGS PAIONT FDN						P 3 2 0 2 2
494	(4) CO2 FIRE EXT STWGS FINAL PAINT FDN						P 4 2 0 3 3
532	(4) CO2 FIRE EXT STWGS CUT PCS						H 1 0 0 3 1
533	(4) CO2 FIRE EXT STWGS BEND PC 55						H 1 0 0 3 2
534	(4) CO2 FIRE EXT STWGS PROCURE HARDWARE						Z 1 0 0 2 2
535	(4) CO2 FIRE EXT STWGS ASSM FDN						H 3 0 0 1 0
536	(4) CO2 FIRE EXT STWGS PRIME PARTTS						P 2 0 2 2 2
537	(4) CO2 FIRE EXT STWGS INST FDN						H 5 0 0 3 2
538	(4) CO2 FIRE EXT STWGS BOTTLE PROCUREMENT						Z 1 0 0 2 2
539	(4) CO2 FIRE EXT STWGS INST BOTTLE						Z 6 0 0 0 2
540	(4) CO2 FIRE EXT STWGS CLEAN FDN						P 3 2 0 2 0
541	(4) CO2 FIRE EXT STWGS PAINT FDN						P 3 2 0 2 2
542	(4) CO2 FIRE EXT STWGS FINAL PAINT FDN						P 4 2 0 3 3
590	TEE (#380) WRENCH STWG CUT PCS						H 1 0 0 2 1
591	TEE (#380) WRENCH STWG BEND PC 63						H 1 0 0 2 2
592	TEE (#380) WRENCH STWG ASSM PCS						H 3 0 0 1 0
593	TEE (#380) WRENCH STWG INST STWG						H 4 0 0 1 1
594	TEE (#380) WRENCH STWG PRIME STWG						P 2 0 2 2 2
595	TEE (#380) WRENCH STWG PREP STWG						P 2 0 1 0 0
596	TEE (#380) WRENCH STWG PAINT STWG						P 2 0 1 0 2
597	TEE (#380) WRENCH STWG FINAL PAINT STWG						P 4 1 1 3 3

Figure 3.6-2
Interim Product List
(continued)



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ZONE 63

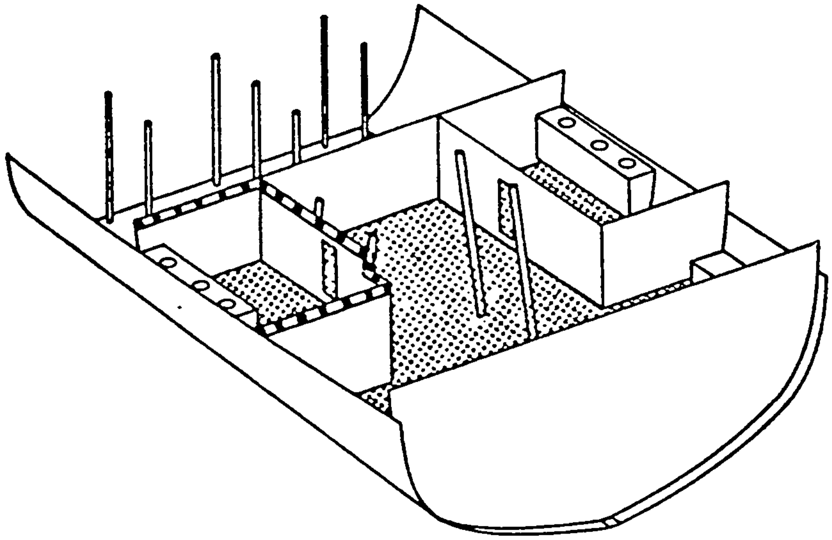
ID#	DESCRIPTION	INTERIM PRODUCT DESIGNATION					CODE*
		WP#	HULL#	BLOCK#	ZONE#	SUB ZONE#	
555	2 LO SAMPLE BOTTLE RACK CUT PCS	99	61	31	63	99	H 1 0 0 3 1
556	2 LO SAMPLE BOTTLE RACK BEND PC 968					99	H 1 0 0 3 2
557	2 LO SAMPLE BOTTLE RACK PROCURE HARDWARE					99	Z 1 0 0 2 1
558	2 LO SAMPLE BOTTLE RACK ASSM PARTS					99	H 3 0 0 0 0
559	2LO SAMPLE BOTTLE RACK PRIME FDN					99	P 2 0 2 2 2
560	2LO SAMPLE BOTTLE RACK INST UPPER FDN					99	H 4 0 0 1 2
561	2 LO SAMPLE BOTTLE RACK INST LWR FDN					99	H 5 0 0 3 2
562	2 LO SAMPLE BOTTLE RACK PREP FDNS					99	P 3 2 2 1 0
563	2 LO SAMPLE BOTTLE RACK PAINT FDNS					99	P 3 2 2 1 2
564	2 LO SAMPLE FINAL PAINT FDNS					99	P 4 2 0 1 3
565	2 LO SAMPLE BOTTLE RACK PROCURE BOTTLES					99	Z 1 0 0 2 2
566	2 LO SAMPLE BOTTLE RACK INST BOTTLES					99	Z 6 0 0 0 0
640	WRENCH (#51) STWG CUT PCS					10	H 1 0 0 2 1
641	WRENCH (#51) STWG BEND PC 59					10	H 1 0 0 2 2
642	WRENCH (#51) STWG ASSM PCS					10	H 3 0 0 1 0
643	WRENCH (#51) STWG INST STWG					10	H 4 0 0 1 1

*The code column would be used only in manual classification and coding.

Figure 3.6-2
Interim Product List
(continued)

ID#	DESCRIPTION	INTERIM PRODUCT DESIGNATION					CODE*
		WP#	HULL#	BLOCK#	ZONE#	SUB ZONE#	
644	WRENCH (#51) STWG PRIME STWG	99	61	31	63	10	P 2 0 2 2 2
645	WRENCH (#51) STWG PREP STWG					10	P 2 0 1 0 0
646	WRENCH (#51) STWG PAINT STWG					10	P 2 0 1 0 2
647	WRENCH (#51) STWG FINAL PAINT STWG					10	P 4 1 1 3 3
648	WRENCH (#51) STWG PROCURE WRENCH					10	Z 1 0 0 2 2
790	(2) SSDG ENCL DK CHNL &FRMG (LWR) CUT PCS					99	H 1 0 0 0 1
791	(2) SSDG ENCL DK CHNL & FRMG (LWR) BEND PCS						H 1 0 0 0 2
792	(2) SSDG ENCL DK CHNL &FRMG (LWR) ASSM/INST DK PCS						H 5 0 0 3 1
793	(2) SSDG ENCL DK CHNL & FRMG (LWR) PRIME PCS						P 2 0 2 0 2
794	(2) SSDG ENCL DK CHNL & FRMG (LWR) PREP/DK CHANNEL						P 3 2 1 7 0
795	(2) SSDG ENCL DK CHNL & FRMG (LWR) PAINT/DECK CHANNEL						P 3 2 1 7 3
796	(2) SSDG ENCL DK CHNL & FRMG (LWR) FINAL PAINT/DK CHANN						P 4 5 1 3 3
797	(2) SSDG ENCL DK CHNL & FRMG (LWR) PROCURE HARDWARE						Z 1 0 0 2 1
798	(2) SSDG ENCL DK CHNL & FRMG (LWR) ASSM /INST OVHD PCS						H 4 0 0 0 2
799	(2) SSDG ENCL DK CHNL & FRMG (LWR) PREP/OVHD PCS						P 3 2 1 3 0
800	(2) SSDG ENCL DK CHNL & FRMG (LWR) PAINT/OVHD PCS						P 3 2 1 3 3
801	(2) SSDG ENCL DK CHNL & FRMG (LWR) INST "H" BEAM						H 5 0 0 3 2
802	(2) SSDG ENCL DK CHNL & FRMG (UPPER) CUT PCS						H 1 0 0 0 1
803	(2) SSDG ENCL DK CHNL & FRMG (UPPER) BEND PCS						H 1 0 0 0 2
804	(2) SSDG ENCL DK CHNL & FRMG (UPPER) ASSM/INST DK PCS						H 4 0 0 0 1
805	(2) SSDG ENCL DK CHNL & FRMG (UPPER) PRIME PCS						P 2 0 2 0 2
806	(2) SSDG ENCL DK CHNL & FRMG(UPPER) PREP /DK CHANNEL						P 3 2 1 3 0
807	(2) SSDG ENCL DK CHANNEL & FRMG (UPPER) PAINT/DK CHvANNL						P 3 2 1 3 3
809	(2) SSDG ENCL DK CHNL & FRMG (UPPER) INST/CURTAIN PLTS						H 7 0 0 2 0
810	(2) SSDG ENCL DK CHNL & FRMG (UPPER) INST "H" BEAM						H 7 0 0 2 0
811	(2) SSDG ENCL DK CHNL & FRMG (UPPER) FINAL PAINT						P 4 5 1 3 3
886	MISC STRL CLOSE PLTS -UP LVL P/S CUT PLTS						H 1 0 0 2 1
887	MISC STRL CLOSE PLTS -UP LV P/S CUT SHAPES						H 1 0 0 3 1
888	MISC STRL CLOSE PLTS -UP LVL P/S PRIME MAT'L						P 2 0 1 0 2
889	MISC STRL CLOSE PLTS -UP LV P/S INST PCS						H 7 0 0 2 0
890	MISC STRL CLOSE PLTS -UP LVL P/S PREP PCS						P 3 1 5 2 0
891	MISC STRL CLOSE PLTS -UP LVL P/S PAINT PCS						P 3 1 5 3 3

Figure 3.6-2
Interim Product List
(continued)



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ZONE 64

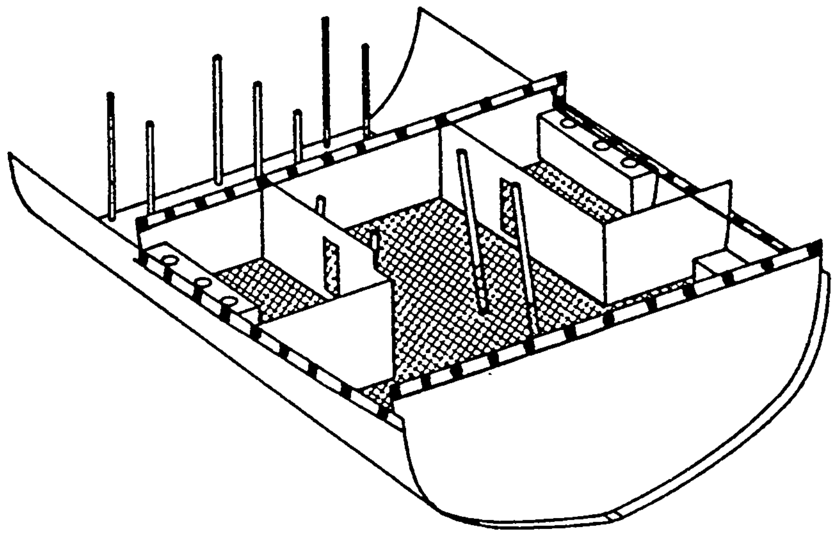
ID#	DESCRIPTION	INTERIM PRODUCT DESIGNATION					CODE*
		WP#	HULL#	BLOCK#	ZONE#	SUB ZONE#	
610	WRENCH (#50) STWG CUT PCS	99	61	31	64	10	H 1 0 0 2 1
611	WRENCH (#50) STWG BEND PC 59					10	H 1 0 0 2 2
612	WRENCH (#50) STWG ASSM PCS					10	H 3 0 0 1 0
613	WRENCH (#50) STWG INST STWG					10	H 4 0 0 1 1
614	WRENCH (#50) STWG PRIME STWG					10	P 2 0 2 2 2
615	WRENCH (#50) STWG PREP STWG					10	P 2 0 1 0 0
616	WRENCH (#50) STWG PAINT STWG					10	P 2 0 1 0 2
617	WRENCH (#50) STWG FINAL PAINT STWG					10	P 4 1 1 3 3
618	WRENCH (#50) STWG PROCURE WRENCH					10	Z 1 0 0 2 2
619	WRNCH (#50) STWG INST WRENCH					10	Z 6 0 0 0 2
778	(2) SSDG ENCL DK CHNL & FRMG (LWR) CUT PCS					99	H 1 0 0 0 1
779	(2) SSDG ENCL DK CHNL &FRMG (LWR) BEND PCS					99	H 1 0 0 0 2
780	(2) SSDG ENCL DK CHNL & FRMG (LWR) ASSM/INST DK PCW					99	H 5 0 0 3 1
781	(2) SSDG ENCL DK CHNL &FRMG (LWR) PRIME PCS					99	P 2 0 2 0 2
782	(2) SSDG ENCL DK CHNL &FRMG (LWR) PREP/DK CHANNEL					99	P 3 2 1 7 0
783	(2) SSDG ENCL DK CHNL 7 FRMG (LWR) PAINT/DK CHANNEL					99	P 3 2 1 7 3

*The code column would be used only in manual classification and coding.

Figure 3.6-2
Interim Product List
(continued)

ID#	DESCRIPTION	INTERIM PRODUCT DESIGNATION					CODE*
		WP#	HULL#	BLOCK#	ZONE#	SUB ZONE#	
784	(2) SSDG ENCL DK CHNL & FRMG (LWR) FINAL PAINT/DK CHAi	99	61	31	64	99	P45133
785	(2) SSDG ENCL DK CHNL &FRMG (LWR) PROCURE HARDWARE						Z10021
786	(2) SSDG ENCL DK CHNL & FRMG (LWR) ASSM/INST OVHD PCS						H40002
787	(2) SSDG ENCL DK CHNL & FRMG (LWR) PREP/OVHD PCS						P32130
788	(2) SSDG ENCL DK CHNL &FRMG (LWR) PINT/OVHD PCS						P32133
789	(2) SSDG ENCL DK CHNL & FRMG (LWR) INST "H" BEAM						H50032
838	(2) SSDG ENCL DK CHNL & FRMG (UPPER) CUT PCS						H10001
839	(2) SSDG ENCL DK CHNL &FRMG (UPPER) BEND PCS						H10002
840	(2) SSDG ENCL DK CHNL & FRMG (UPPER) ASSM/INST DK PCS						H40001
841	(2) SSDG ENCL DK CHNL &FRMG (UPPER) PRIME PCS						P20202
845	(2) SSDG ENCL DK CHNL & FRMG (UPPER) INST/CURTAIN PLTS						H70020
844	(2) SSDG ENCL DK CHNL & FRMG (UPPER) PROCURE HARDWARE						Z10021
843	(2) SSDG ENCL DK CHNL & FRMG (UPPER) PAINT/DK CHANNEL						P32133
842	(2) SSDG ENCL DK CHANNEL & FRMG (UPPER) PREP/DK CHANNN						P32130
846	(2) SSDG ENCL DK CHNL & FRMG (UPPER) INST "H" BEAMS						H70020
847	(2) SSDG ENCL DK CHNL & FRMG (UPPER) FINAL PAINT						P45133
848	MISC STRL CLOSE PLTS -UP LVL P/S CUT PLTS						H10021
849	MISC STRL CLOSE PLTS -UP LVL P/S CUT SHAPES						H10031
850	MISC STRL CLOSE PLTS-UP LVL PS PRIME MAT'L						P20102
851	MISC STRL CLOSE PLTS -UP LVL P/S INST PCS						H70020
852	MISC STRL CLOSE PLTS -UP LVL P/S-PREP PCS						P31520
853	MISC STRL CLOSE PLTS -UP LVL P/S PAINT PCS						P31533
854	MISC STRL CLOSE PLTS -UP LVL PS- FINAL PAINT						P45533
863	SSDG DSECONDARY FUEL FILTER ENCL (2) CUT PLTS						H10021
864	SSDG SECONDARY FUEL FILTER ENCL (2) CUT SHAPES						H10031
865	SSDG SECONDARY FUEL FILTER ENCL (2) BEND PLTS						H10022
866	SSDG DECONDARY FUEL FILTER ENCL (2) PROCURE MTG & SHIELD PNLS						Z10010
867	SSDG SECONDARY FUEL FILTER ENCL (2) PROCURE HARDWARE						Z10021
868	SSDG SECONDARY FUEL FILTER ENCL (2) ASSMEBLE ENCLOSURE						Z20110
869	SSDG SECONDARY FUEL FILTER ENCL (2) PREP ENCL						P20110
870	SSDG SECONDARY FUEL FILTER ENCL (2) PAINT ENCL						P20112
871	SSDG SECONDARY FUEL FILTER ENCL (2) INSTALL ENCLOSURES						Z52201

Figure 3.6-2
Interim Product List
(continued)



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ZONE 65

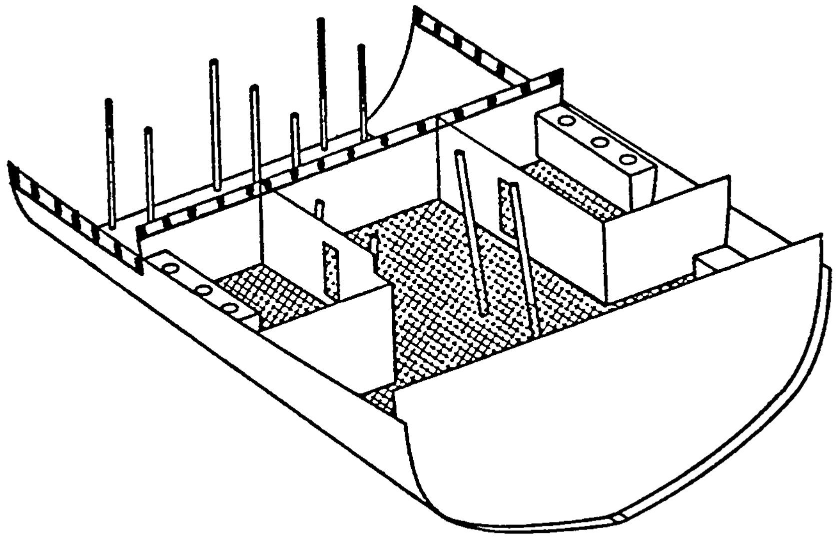
ID#	DESCRIPTION	INTERIM PRODUCT DESIGNATION					CODE*
		WP#	HULL#	BLOCK#	ZONE#	SUB ZONE#	
128	31 ER TRUNKS BHD PLATE CUT	99	61	31	65	99	H 1 0 0 1 1
129	31 ER TRUNKS BHD PLAT BEND						H 1 0 0 1 2
130	31 ER TRUNKS STIFFENER CUT						H 1 0 0 3 1
131	31 ER TRUNKS FDN CUT						H 1 0 0 3 1
133	31 ER TRUNKS FDN BRKT CUT						H 1 0 0 2 1
134	31 ER TRUNKS BRKT CUT						H 1 0 0 2 1
135	31 ER TRUNKS PLATE JOINING						H 4 0 0 1 0
136	31 ER TRUNKS STIFFENER INST						H 4 0 0 1 2
137	31 ER TRUNKS BRKT INST						H 4 0 0 1 2
138	31 ER TRUNKS FDN INST						H 4 0 0 1 1
139	31 ER TRUNKS INSTALL						H 7 0 0 2 0
132	31 ER TRUNKS FDN ASSY						H 3 0 0 0 0
323	EMER PITCH HND PUMP CUT FDN PCS						H 1 0 0 3 1
324	EMER PITCH HAND PUMP ASSM FDN PCS						H 3 0 0 0 0
325	EMER PITCH HAND PUMP INST FDN						H 5 0 0 3 2
326	EMER PITCH HAND PUMP PRIME MAT'L						P 2 0 2 2 2

*The code column would be used only in manual classification and coding.

Figure 3.6-2
Interim Product List
(continued)

ID#	DESCRIPTION	INTERIM PRODUCT DESIGNATION					CODE*
		WP#	HULL#	BLOCK#	ZONE#	SUB ZONE#	
327	EMER PITCH HAND PUMP PREP FDN	99	61	31	65	99	P 3 2 1 5 0
328	EMER PITCH HAND PUMP PAINT FDN						P 3 2 1 5 3
329	EMER PITCH HAND PUMP INST PUMP						Z 4 0 2 1 2
350	TEE (#386) WRENCH STOW CUT PCS						H 1 0 0 2 1
351	TEE (#386) WRENCH STOW BEND PC 63						H 1 0 0 2 2
352	TEE (#386) WRENCH STOW ASSEM PCS						H 3 0 0 1 0
353	TEE (#386) WRENCH STOW INST STOWAGE						H 4 0 0 1 1
354	TEE (#386) WRENCH STOW PRIME STOWAGE						P 2 0 2 2 2
355	TEE (#386) WRENCH STOW PREP STOWAGE						P 2 0 1 0 0
356	TEE (#386) WRENCH STOW PAINT STOWAGE						P 2 0 1 0 2
357	TEE (#8386) WRENCH STOW FINAL PAINT STOWAGE						P 4 1 1 3 3
358	TEE (#386) WRENCH STOW WRENCH PROCUREMENT						Z 1 0 0 2 2
359	TEE (#386) WRENCH STOW INST WRENCH						Z 6 0 0 0 2
360	WRENCH (#54) STOWAGE CUT PCS						H 1 0 0 2 1
361	WRENCH (#54) STOWAGE BEND PC 59						H 1 0 0 2 2
362	WRENCH (#54) STOWAGE ASSM PCS						H 3 0 0 1 0
363	WRENCH (#54) STOWAGE INST STOWAGE						H 4 0 0 1 1
364	WRENCH (#54) STOWAGE PRIME STOWAGE						P 2 0 2 2 2
365	WRENCH (#54) STOWAGE PREP STOWAGE						P 2 0 1 0 0
366	WRENCH (#54) STOWAGE PAINT STOWAGE						P 2 0 1 0 2
367	WRENCH (#54) STOWAGE FINAL PAINT STOWAGE						P 4 1 1 3 3
368	WRENCH (#54) STOWAGE WRENCH PROCURMENT						Z 1 0 0 2 2
379	GTRB SPECIAL TOOLS STWG ASSM FDN PCS						H 3 0 0 0 0
380	GTRB SPECIAL TOOLS STWG INST FDNS						H 5 0 0 3 2
381	GTRB SPECIAL TOOLS STWG STRAP PROCUREMENT						Z 1 0 0 1 1
382	GTRB SPECIAL TOOLS STWG TOOL BOX PROCUREMENT						Z 1 0 0 2 1
383	GTRB SPECIAL TOOLS STWG INST TOOL BOX						Z 4 0 0 1 2
384	GTRB SPECIAL TOOLS STWG PRIME MAT'L						P 2 0 2 2 2
385	GTRB SPECIAL TOOLS STWG PREP FDNS						P 3 2 1 5 0
386	GTRB SPECIAL TOOLS STWG PAINT FDNS						P 3 2 1 5 3

Figure 3.6-2
Interim Product List
(continued)



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ZONE 66

ID#	DESCRIPTION	INTERIM PRODUCT DESIGNATION					CODE*
		WP#	HULL#	BLOCK#	ZONE#	SUB ZONE#	
698	GTRB SPECIAL TOOLS STWG CUT LKR PCS	99	61	31	66	99	H 1 0 0 1 1
699	GTRB SPECIAL TOOLS STWG BEND LKR PCSA						H 1 0 0 1 2
700	GTRB SPECIAL TOOLS STWG PROCURE HARDWARE						Z 1 0 0 2 1
701	GTRB SPECIAL TOOLS STWG ASSM LKR						Z 3 0 0 1 0
702	GTRB SPECIAL TOOLS STWG CUT MOUNTING PCS						H 1 0 0 3 1
703	GTRB SPECIAL TOOLS STWG ASSM MTG PCS TO LKR						Z 3 0 0 1 0
704	GTRB SPECIOAL TOOLS STWG INST LKR						Z 4 0 0 1 2
705	GTRB SPECIAL TOOLS STWG PROCURE TOOL BOXES						Z 1 0 0 2 2
706	GTRB SPECIAL TOOLS STWG PROCURE STRAPS						Z 1 0 0 2 2
707	GTRB SPECIAL TOOLS STWG PRIME LKR						P 2 0 2 2 2
708	GTRB SPECIAL TOOLS STWG PREP LKR						P 3 2 0 3 0
709	GTRB SPECIAL TOOLS STWG PAINT LKR						P 3 2 0 3 2
710	GTRB SPECIAL TOOLS STWG INST TOOL BOXES						Z 6 0 0 0 2
739	GTRB-FIXTURE LIFT BAR INLET STWG CUT PCS						H 1 0 0 3 1
740	GTRB-FIXTURE LIFT BAR INLET STWG BEND PCS						H 1 0 0 3 2
741	GTRB-FIXTURE LIFT BAR INLET STWG DRILL HOLES						Z 2 0 0 1 0

*The code column would be used only in manual classification and coding.

Figure 3.6-2
Interim Product List
(continued)

ID#	DESCRIPTION	INTERIM PRODUCT DESIGNATION					CODE*
		WP#	HULL#	BLOCK#	ZONE#	SUB ZONE#	
742	GTRB-FIXTURE LIFT BAR INLET STWG PRIME PCS	99	61	31	66	99	P 2 0 2 0 2
743	GTREB-FIXTURE LIFT BAR INLET STWG INST STWGS						H 4 0 0 1 1
744	GTRB-FIXTURE LIFT BARINLET STWG PREP STWGS						P 3 2 1 2 0
745	GTRB-FIXTURE LIFT BAR INLET STWG PAINT STWGS						P 3 2 1 2 2
746	GTRB-FIXTURE LIFT BAR INLET STWG PROCURE LIFT BARS						Z 1 0 0 2 2
747	GTRB-FIXTURE LIFT BAR INLET STWG INSTALL LIFT BARS						Z 6 0 0 0 2
748	GTRB-FIXTURE LIFT BAR INLET STWG PROCURE HARDWARE						Z 1 0 0 2 1
749	MN RDGR SPCL TOOLS STWG CUT PCS						H 1 0 0 3 1
750	MN RDGR SPCL TOOLS STWG ASSM STWG						H 3 0 0 0 0
751	MN RDCR SPCL TOOLS STWG PRIME STWG						P 2 0 2 2 2
752	MN RDGR SPC TOOLS STWG INST HEADERS						H 4 0 0 1 2
753	MN RDGR SPCL TOOLS STWG INST STWG						H 4 0 0 1 1
754	MN RDGR SPCL TOOLS STWG PROCURE STRAPS						Z 1 0 0 1 1
755	MN RDGR SPCL TOOLS STWG PROCURE TOOL BOXES						Z 1 0 0 2 2
756	MN RDGR SPCL TOOLS STWG INSTALL TOOL BOXES AND STRAPS						Z 6 0 0 0 2
757	MN RDGR SPCL TOOLS STWG PREP HDRS						P 3 2 1 0 0
758	MN RDGR SPCL TOOLS STWG PAINT HEADERS						P 3 2 1 0 2
759	MN RDGR SPCL TOOLS STWG PREP STWG						P 3 2 1 1 0
760	MN RDGR SPCL TOOLS STWG PAINT STWG						P 3 2 1 1 2
761	MN RDGR SPCL TOOLS STWG FINAL PAINT STWG						P 4 5 1 3 3
762	GTRB EMER MNL CONT CABLE RACK CUT PCS						H 1 0 0 3 1
763	GTRB EMER MNL CONT CABLE RACK BEND PCS 53 & 55						H 1 0 0 3 2
764	GTRB EMER MNL CONT CABLE RACK ASS PCS 53. 54 & 57						H 3 0 0 1 0
765	GTRB EMER MNL CONT CABLE RACK PRIME PCS						P 2 0 2 2 2
766	GTRB EMER MNL CONT CABLE RACK INST RACK						H 4 0 0 1 2
767	GTRB EMER MNL CONT CABLE RACK PREP RACK						P 3 2 0 0 0
768	GTRB EMER MNL CONT CABLE RACK PAINT RACK						P 3 2 0 0 2
770	GTRB EMER MNL CONT CABLE RACK INST CABLE						Z 6 0 0 0 3
769	GTRB EMER MNL CONT CABLERACK PROCURE LASHING						Z 1 0 0 2 2
812	CLAY CONTAINER STWG CUT PCS						H 1 0 0 3 1
813	CLAY CONTAINER STWG PRIME PCS						P 2 0 2 2 2
814	CLAY CONTAINER STWG PROCURE HARDWARE						Z 1 0 0 2 2

Figure 3.6-2
Interim Product List
(continued)

DCLASS INPUT/OUTPUT

*** HAIN MENU ***

CHOOSE OPTION:
4. Tree Processing
Select and Display ID #5
User Defined System
Data Base Statistics
Select New Tree
Stop

The
tool fo
an interim pro
product designation scheme discus
developed to meet this need. It i
reader review this section before stu

ne syst
- ENTER HULL NO.
Q >>31
- ENTER BLOCK NO.
- ENTER ZONE NO.
>>11
- ENTER SUB - ZONE NO.
:>>99

PRODUCT ASPECTS BY WORK TYPE
1 - MULL BLOCK CONSTRUCTIONi
2 -- ZONE (OUTFITTING
3 - ZONE PAINTING

teps 1 through 4 are discu
al and computer aided clas

p 1 - Zone Directory

Before classification and co
nufacturing sequence of the h

Step 2 - Interim Product Classification

Once the zone and sub-zone arrang
nterim products were designated by th

ANNOTATION

This is the MAIN MENU which appears after loggin9 on to the system. Classification and coding is performed in option No. 1, Tree Processing.

DCLASS request the Interim Product ID No.

The user enters “023”.

DCLASS request an interim product description.

The user enters “FR 220 & 228 SHELL WEB PLT CUT”.

DCLASS request interim product designation variables.

The user inputs the appropriate values. Note that “99” is entered for work package numder because this value will not be known until after sorting. “99” is also entered for sub-zone No. to demonstrate its use as an insignificant or Nil designation. In this case, there is no sub-zone designation.

DCLASS presents the "WORK TYPE” menu.

The user selects option No. 1, Hull Block Construction.

DCLASS presents the “MANUFACTURING LEVEL” mene for Hull Block Construction.

The user selects option No. 1, “Part Fabrication level.”

Note - At this point the zone menu would normally appear, however since this manufacturing level has only one zone type option, DCLASS automatically assumes its selection, assigns the code digit, and proceedes to the next menu.

DCLASS presents the “AREA” menu.

The user selects option No. 3.

Figure 3.6-3
DCLASS **Classification and Coding** Interaction

DCLASS INPUT/OUTPUT	ANNOTATION
STAGE 1 - PLATE JOINING 2 - MARKING & CUTTING 3 - BENDING **>2	DCLASS presents the "STAGE" menu- The user selects option No. 2.
Choose Option: 1 - Review Choices 2 - Continue ◊==>2	Classification and coding is now complete. The user can elect to review the previous choices or continue. The user elects to continue.
NEW Entry: 023 Choose Option: 1 - Store ID # 2 - Change ID Name 3 - NO Store ◊==>1	DCLASS repeats the ID No. and queries the user concerning its disposition. The user **elects to store** the ID No.
*** ID # STORED: 023 Code=H 1 0 0 2 1 *** MAIN MENU *** CHOOSE OPTION: 1 - Tree Processing 2 - Select and Display ID #s 3 - User Defined System 4 - Data Base Statistics 5 - Select New Tree 6 - Help Information 10 - DCLASS Manager 11 - Stop ==>	DCLASS repeats the ID No., and displays its code, stores the ID No., code and variables, and returns to the NAIN NENU.

Figure 3.6-3
DCLASS Classification and Coding Interaction
(continued)

DCIASS INPUT\OUTPUT	ANNOTATION
*** MAIN MENU*** CHOOSE OPTION: 1 - Tree Processing 2- Select and Display ID #s 3- User Defined System 4 - Data Base Statistics 5- Select New Tree 6- Help Information 10- DCLASS lfanaga- 11- stop =>2	Sorting begins at the MAIN NENU by selecting option No. 2.
***** RETRIVEL AND DISPLAY ***** CHOOSE OPTION: 1. Display/List ID #5 2-Select Group froa Data 3- DCLASS Bit Comparison 4- Change Defaults 5- Mass ID # Update 12 - Exit	To sort Interim Products, the user must first form a group from the Data Base by selecting option No. 2 from the "RETRIEVAL AND DISPLAY" menu. . .
*** ID #S IN GROUP= 0 **** SELECT GROUP FROM DATA -- 1- Select ID #5 fros Data Base 2- Refine Group 3- Display Group 4- Restore Previous Group 5- Initialize Group 12- Exit	.. And option No. 1 from the "ID #s IN GROUP" menu.
SELECT ID #s froa Ddta Base 1 - BY CODE 2 -by variable 3 - by key 4 -by Description 5 - Exit	ID #s may be selected by any of the characteristics shown here. The user wants only those from Hull No. 61 (avariable) so option No. 2 is selected.
- Enter -Low Valus >>hl' Enter High Value >>61 2	The Hull No. variable (hull) is entered and since only one Hull NO. is needed "61" is entered for both the low and high search values.
1070 NEE ID #s ADDED TO GROUP *** 0 DUplicate ID #s Already Selected 1070 TOTAL ID #s Selected 1070 TOTAL ID #s for this Main Tree 1070 TOTAL ID *s in Data Base	DCLASS forms a group of all those ID #s With the Hull NO. 61.

Figure 3.6-4
DCLASS Sorting Example

DCLASS INPUT\OUTPUT	ANNOTATION
SELECT ID #s from Data Base 1 - by Code 2 - by Variable 3 - by Key 4 - by Description 5 - Exit ==>5	The user wishes to refine this group to include only those ID #s in Block No. 31 and so exits the "SELECT ID#S FROM DATA BASE" menu, and selects option No. 2 from the "SELECT GROUP FROM DATA BASE" menu.
*** ID #s IN GROUP = 1070 *** SELECT GROUP FROM DATA BASE 1 - Select ID #s from Data Base 2 - Refine Group 3 - Display Group 4 - Restore Previous Group 5 - Initialize Group 12 - Exit ==>2	
REFINE Selected Group 1- by KEEPING Matching Group 2- by DELETING Matching Group 3- Exit ==>1	The user wishes to keep only those ID #s in Block 31 and so selects option No. 1.
KEEP Matching Group 1 - by Code 2 - by Variable 3 - by Key 4 - by Description 5 - Exit ==>2	Block No. is a variable so option No. 2 is selected
Enter Variable Name >>BLK	The Block No. variable (BLK) is entered.
Enter Low Value >>31 Enter High Value >>31	The value "31" is entered for low and high search value.
*** O ID #s DELETED FROM GROUP *** 1070 TOTAL ID #s Selected	DCLASS refines the group to include only those ID #s in Block No. 31.
REFINE Selected Group 1 - by KEEPING Matching Group 2 - by DELETING Matching Group 3 - Exit ==>1	The user wishes to keep only those ID #s in Zone No. 11 and so elects to further refine the group.
KEEP Matching Group 1 - by Code 2 - by Variable 3 - by Key 4 - by Description 5 - Exit ==>2	Zone No. is a variable so option No. 2 is selected

Figure 3.6-4
DCLASS Sorting Example
(continued)

DCLASS INPUT\OUTPUT	ANNOTATION
Enter Variable Name	The Zone No. variable (zON) is entered-
Enter Low Value >>11	The value 11 is entered.
Enter High Value >>11 e	
*** 962 ID #s DELETED FROM GROUP *** 108 TOTAL ID#s Selected	DCLASS refines the group to include only those ID #s in Zone 11.
	The user wishes to keep only those ID #s in Sub-Zones 15,16,17,&18, (the suction sea chest) and so elects to refine the group further.
 	Sub-Zone No. is a variable so option No. 2 is selected.
Enter Variable Name >>SZN	The Sub-Zone No. variable (SZN) is entered.
Enter Low Value >>15	The value "15" is entered for low value.
Enter High Value	The value "18" is entered for high value.
*** 72 ID#s DELETED FROM GROUP 36 TOTAL ID#s Selected	DCLASS refines the group to include only those ID #s in Sub-Zones 15 through 18.
REFINE Selected GroucI 1 - by KEEPING Hatching Group 2 - by DELETING Matching Group 3 - Exit	The user wishes to keep only those ID #s which contain Hull block, part fabrication work (code Hl).
Zone Direct (continued	The user selects option No. 1, by code.
=>1	
Choose Option: 1- Enter Code 2 - Get Code by Traversing Tree	
==>1	

Figure 3.6-4
DCLASS Sorting Example
(continued)

DCLASS INPUT\OUTPUT	ANNOTATION
Enter Code >>H1	The code "Hl is entered.
*** 20 ID #s DELETED FROM GROUP*** 16 TOTAL ID #s Selected	DCLASS refines the group to include only those ID #s with the first two code digits of Hl.
REFINE Selected Group 1 - by KEEPING Matching Group 2 - by DELETING Matching Group 3 - Exit ==>3	The user wishes to view the ID #s in the group so exits the "REFINE SELECTED GROUP" menu-..
*** ID #s IN GROUP = 16 *** SELECT GROUP FROM DATA BASE 1 - Select ID #s from Data Base 2 - Refine Group 3 - Display Group 4 - Restore Previous Group 5 - Initialize Group 12 - Exit ==>3	... and selects option No. 3 to display the group.
DISPLAY Selected Group 1 - ID #s & Code 2 - ID #s 2 Code & 3 Variables 3 - ID #s & Description 4- ID #s & Codes, Keys, Variables 5- ID #s & Paths 12 - Exit ==>3	The user only needs to see the description so selects option No. 3.
*** ENTER EXIT TO TERMINATE DISPLAY ***	DCLASS displays the ID #s, descriptions and codes of the group.

034 31 SEA CHEST PLATE CUT	TA	H1OO21
038 31 SEA CHEST STIFFENER CUT	TA	H1OO31
043 31SEA CHEST BAFFLE CUT	TA	H1OO31
044 31 SEA CHEST BAFFLE BEND	TA	H1OO32
141 31 SEA CHEST PLATE CUT	TA	H1OO21
145 31 SEA CHEST STIFFEHER CUT	TA	H10031
150 31 SEA CHEST BAFFLE CUT	TA	H1OO31
151 31 SEA CHEST BAFFLE BEND	TA	H1OO32

-RETURN- to Continue
>>

154 31 SEA CHEST PLATE CUT	TA	H1OO21
155 41 SEA CHEST - STIFFENER CUT	TA	H1OO31
159 31 SEA CHEST BAFFLE CUT	TA	H1OO31
160 31 SEA CHEST BAFFLE BEND	TA	H1OO32
163 31 SEA CHEST PLATE CUT	TA	H1OO21
164 31 SE4 CHEST STIFFENER CUT	TA	H1OO31
162 31SEA CHEST BAFFLE CUT	TA	H1OO31
169 31 SEA CHEST BAFFLE BEND	1A	HIO032

-RETURN- to Continue

Figure 3.6-4
DCLASS Sorting Example
(continued)

DCLASS INPUT/OUTPUT

ANNOTATION

DISPLAY Selected Group

4-
5-
12
=>12

The user decides there are too many ID #s for a single work package so elects to refine the group to include only those which contain the marking and cuttinq of parts from rolled shapes (code H10031).

The user exits the display menu...

"Refine qroup" is selected...

ID#

..."By code " is selected. . .

Choose Option:
1 - Enter Code
- Get Ccde by Traversing Tree
3-Exit

..."Enter *code" is* selected...

Enter Code
>>H10031

...The code "H1O031" is entered.

*** 8 ID #S DELETED FROM GROUP ***
8 TOTAL ID #s Selected

DCLASS refines the group.

563	2 LO SAMPLE BOTTLE RA
564	2 LO SAMPLE FINAL PAI

*** ID #s IN GROUP = 8 ***

640	WRENCH (#51) STWG CUT
641	WRENCH (#51) STWG BEND
642	WRENCH (#51) STWG ASSM
643	WRENCH (#51) STWG INST

The user selects "Display group"...

Figure 3.6-4
OCLASS Sorting Example
(continued)

DCLASS INPUT\OUTPUT

ANNOTATION

```
DISPLAY Selected Group
 1 - ID #s & Code
 2 - ID #s & Code & 3 Variables
 3 - ID #s & Description
 4 - ID #s & Codes, Keys, Variables
 5 - ID #s & Paths
12 - Exit
==>3
```

..."BY ID #s and Description".

```
*** ENTER EXIT TO TERMINATE DISPLAY ***

038  31 SEA CHE5T STIFFENER CUT     TA   H1OO31
043  31SEA CHEST BAFFLE CUT         TA   H1OO31
145  31 SEA CHEST STIFFENR CUT      TA   H1OO31
150  31 SEA CHEST BAFFLE CUT        TA   H1OO31
155  31 SEA CHEST STIFFENER CUT     TA   H1OO31
159  31 SEA CHEST BAFFLE CUT        TA   H1OO31
164  31 SEA CHEST STIFFENER CUT     TA   H1OO31
168  31SEA CHEST BAFFLE CUT         TA   H1OO31

 -RETURN- to Continue
>>
```

DCLASS displays the group.

```
DISPLAY Selected Group
 1 - ID #s & Code
 2 - ID #s & Code & 3 Variables
 3 - ID #s & Description
 4 - ID #s & Codes, Keys, Variables
 5 - ID #s & Paths
12 - Exit
==>
```

Figure 3.6-4
DCLASS Sorting Example
(continued)

DCLASS INPUT/OUTPUT	ANNOTATION
*** MAIN MENU *** CHOOSE OPTION: 1 - Tree Processing 2 - Select and Display ID #s 3 - User Defined System 4 - Data Base Statistics 5 - Select New Tree 6 - Help Information 10 - DCLASS Manager 11 - Stop 0==>1	Step 4 begins at the MAIN MENU by selecting option No. 1, Tree Processing.
Enter ID # 0 >>038	The user enters the ID No. of the interim product to be assigned to Work Package No. 10.
Enter Description: 31 SEA CHEST STIFFENER CUT >>	DCLASS displays the current description and prompts the user for a revision. The user does not wish to revise the description and so depresses the enter key.
- ENTER WORK PACKAGE NUMBER Value = 99 >>10	DCLASS displays the current Work Package No. and prompts the user for a revision. The user enters the revised value "10"
- ENTER HULL NO. Value = 61 >> - ENTER BLOCK NO. Value = 31 >> - ENTER ZONE NO. Value = 11 >> - ENTER SUB - ZONE NO. Value = 15 >>	DCLASS displays the current Hull, Block, and Sub-Zone numbers in turn, each time prompting the user for a revision. The user depresses the enter key in each case.
PRODUCT ASPECTS BY WORK TYPE * 1 - HULL BLOCK CONSTRUCTION 2 - ZONE OUTFITTING 3 - ZONE PAINTING **>SA	DCLASS displays the "PRODUCT ASPECT BY WORK TYPE' menu with an asterisk to indicate the current selection and prompts the user for a revision. The user enters the command "SA" to indicate the code will remain the same.
Choose Option: 1 - Review Choices 2 - Continue ==>2	DCLASS bypasses the remaining code menus and proceeds to the ID disposition menus.
*** OLD Entry: 038 TA	
Choose Option: 1 - Store ID # 2 - Change ID Name 3 - NO Store ==>1	The user elects to store the ID with its new Worl Package No.
*** ID # STORED: 038 Code=H 1 0 0 3 1	DCLASS confirms the storage and returns to the MAIN MENU.
*** MAIN MENU *** CHOOSE OPTION: 1 - Tree Processing 2 - Select and Display ID #s 3 - User Defined System 4 - Data Base Statistics 5 - Select New Tree 6 - Help Information 10 - DCLASS Manager 11 - Stop ==>	

Figure 3.6-5
DCLASS Work Package Assignment

SECTION 4
Related Subjects

Section Four briefly familiarizes the reader with several aspects of shipbuilding impacted by the use of a PWBS classification and coding system.

SECTION CONTENTS

4.1 *INTRODUCTI0N*

In 1984 the Society of Manufacturing Engineers described group technology as a synergistic tool,meaning its total effect on a company is greater than the sum of its individual effects. What this means to a company as large and complex as a shipyard is that the introduction of PWBS classification and coding will have a significant effect on the organization of the shipyard and change the way that many things are done.

Included in this section are brief discussions of topics which this study found to be significant either during the transition from traditional shipbuilding to PWBS methods or those which will become important as further modernization is pursued. The PWBS classification and coding system presented in this manual was configured to provide a foundation for modernization that should enable a shipyard to consider many of the "high-tech" manufacturing technologies that have little application to traditional shipbuilding.

4.2 SETTING *UP A STORAGE AND RETRIEVAL SYSTEM*

During the course of its research, this study visited several companies that were using classification and coding systems for storage and retrieval of part information. It became apparent that the organizational considerations involved in setting up such a system were complex and perhaps a good candidate for a separate, follow-on study. In any event a complete technical discussion of this subject was clearly beyond the time and budget parameters of this effort. This study is, however, responsible for reporting what it witnessed to the shipbuilding community. The following paragraphs summarize what this study learned concerning setting up a storage and retrieval system.

1. Manual vs. Computer

A few of the companies were using a manual storage and retrieval system which typically took the form of part sketches or part information sheets being stored in filing cabinets in numerical sequence according their group assignment The majority of companies, however, used computers for part storage and retrieval. The key factor which divided the manual users from the computer based users was the scope of the application. The manual users typically used classification and coding as a means of organizing small purchased and fabricated parts. The computer based users were using classitlcation and coding to organize purchased and fabricated parts, but in many cases they had tied the information available from their parts classification and coding system into computer based material requirements planning systems, process planning systems and automated purchasing systems. Interestingly, most of the companies using manual systems had plans to convert to a computer based system once they had assimilated the organization changes made when they implemented group technology.

2. Using Consultants

Many of the group technology users visited had used the services of a consultant during the implementation of their classification and coding system. Many of these users stressed the importance of having their employees work closely with the consultants to ensure:

1. The system is carefully structured to meet the needs of the company, and

2. A complete understanding of the system is retained by the company

3. Management

Many of the group technology users visited recommended that a separate departrnent section or group of individuals be formed which would be responsible for

- Implementing the system
- Providing system training
- Adding to or deleting parts from the system
- Controlling access to the system
- Maintaining the system and
- Expanding the capability of the system.

In relatively large applications, a key person with special knowledge was also recommended in each department which had access to the system.

43 *TAILORING THE CLASSIFICATION AND CODING SYSTEM TO A PARTICULAR SHIPYARD*

This study developed a classification and coding system which is capable of defining the work content of an interim product to a level which was determined by two considerations.

1. This study was funded by a panel made up of representatives from many shipyards using money provided, in part, by the Government. It was therefore required to develop a classification and coding system which wouId be usable by many shipyards and was not unique to any one in particular. To a small degree, this requirement affected the scope of interim product definition provided by the attributes.

2. Classification and coding systems traditionally are derived from a detailed census of work passing through a manufacturing facility in a given period of time. Because most domestic shipyards are in a transitional stage between system oriented and product work oriented work methods, no such census was available to this study. It therefore relied heavily upon previous publications of the National Shipbuilding Research Program for attribute selectionj which also affected its scope of interim product definition.

A particular shipyard can, however, expand the system's capability to define the work content of an interim product to .suit its own requirements. This should be attempted only after considerable use of the system in its present configuration has revealed the need for greater definitive capability. Prior to adding new attributes, the following questions should be considered.

1. Do the new attributes reflect differences in interim products which are significant to production i.e., will the new attributes reflect a distinction in work station assignment?

2. Do the new attributes fit into the five characteristics discussed in-section 3.3.1? If not an additional digit may have to be added to the code format Note In many of the manufacturing levels the fourth digit is not used and is available for other attributes.

An example is presented below to illustrate how the classification and coding could be expanded to satisfy the need of a hypothetical shipyard to further define the work content of its interim products.

The Problem - After becoming familiar with the classification and ceding systern Nonesuch Shipyard found that it needed to add attributes which distinguished between interim products which contained steel welding and those which contained aluminum welding. Their work load was very heavy, and almost evenly divided between aluminum ships and steel ships. Experience had shown that it was more productive to maintain separate work centers for aluminum and steel welding. It was necessary, then, to reflect this distinction in the classification and coding system.

The Solution - This could be accomplished in several ways. The distinction between aluminum and steel welding constitutes a difference in problem area. To maintain the integrity of the terminology of the system, this distinction should occur in either the fourth or fifth digits of the code format which represent problem areas.

If the distinction is only significant to the hull block construction manufacturing levels then the distinction could be made in the fourth digit as shown in Figure 4.3-1 within the block assembly manufacturing level.

If the distinction is significant to a manufacturing level which uses the fourth digit, as the on block outfitting manufacturing level does, the distinction could be made in the fifth digit as shown in Figure 4.3-2.

This example was included to illustrate a method for expanding the classification and coding system and should not be interpreted as a recommendation that the system be revised to include attributes which distinguish between aluminum and steel welding.

The classification and coding example included in Section 3.6 was performed in part to test the descriptive capability of the system. The results of this example, discussed in Section 3.7, should be reviewed prior to expanding the system.

4.4 *Traditional Systems*

During its work, this project became aware of and in some cases reviewed shipbuilding classification and coding systems which could best be called transitional systems, i.e., systems that were neither wholly system oriented nor product work oriented but rather a little of each.

BLOCK ASSEMBLY LEVEL

P . W . B . S .

C L A S S I F I C A T I O N

&

C O D I N G

H	5				

PREVIOUS CODING

COLUMN		CODE	o	1	2	3	4	5	6	7	8	9
	1	**WORK TYPE**										
	2	**MANUFACTURING LEVEL**										
	3	**ZONE**	BLOCK	NIL								
	4	**AREA/ /MATERIAL**	ALUMINUM	STEEL								
	5	**AREA**	FLAT	SPECIAL FLAT	CURVED	SPECIAL CURVED	SUPER-STRUCTURE					
	6	**STAGE**	PLATE JOINING	FRAMING	ASS'Y	BACK ASS'Y						

Figure 4.3-1
P.W.B.S. Classification and Coding

ON-BLOCK
OUTFITTING LEVEL

P.W.B.S. CLASSIFICATION & CODING

Z	4					

PREVIOUS CODING

COLUMN		CODE	0	1	2	3	4	5	6	7	8	9
	1	**WORK TYPE**										
	2	**MANUFACTURING LEVEL**										
	3	**ZONE**	BLOCK	NIL								
	4	**AREA/ SPECIALTY**	DECK	ACCOM.	MACH.	ELEC.	WEAPON					
	5	**AREA**	ALUMINUM		STEEL							
			COMPO-NENTS IN LARGE QUANTITY	COMPO-NENTS IN SMALL QUANTITY	COMPO-NENTS IN LARGE QUANTITY	COMPO-NENTS IN SMALL QUANTITY						
	6	**STAGE**	ON CEILING		ON FLOOR							
			FITTING	WELDING	FITTING	WELDING						

Figure 4.3-2
P.W.B.S. Classification and Coding

The transition from traditional system oriented shipbuilding to the product work oriented methods promoted by this and other publications of the National Shipbuilding Research Program is a complex one. Aspects of this transition which involve classification and coding are discussed below.

1. Scope of Work Definition

The classification and coding system developed by this study has the capability to describe over 8,000 different types of interim products. The typical shipyard using a system oriented classification and coding system can describe the work content of its interim products to but a fraction of this level of definition. The management and organizational capability required to assimilate not only the change in work breakdown structure but the relative higher level of interim product definition is substantial.

For this reason, many shipyards make this transition in a multiple phase program assimilating the required changes over a period of time spanning several shipbuilding projects. These programs implement the new classification and coding system in phases which

a. Progressively increase the descriptive capability of the system *over* a period of time and/or,

b. Limit the implementation to a small portion of the shipyard in each phase.

2. System Oriented Cost Collection and Craft Labor Requirements

Some shipowners require construction cost to be reported in a system oriented format . Also, many shipyards employ union labor with a system oriented craft structure which restricts cross-craft work. These requirements can complicate both interim product identification and classi.fication. Although it devoted considerable research to the question, this project found no reasonable method to incorporate system oriented attributes in the classifiocation and coding SyStem.

45 *Interim Product Designation Schemes*

During the research phase of this project it became apparent that many users of group technology utilized two distinct and separate coding systems. One system a classification and coding system like the one provided in this manual described specific characteristics of a part or product which enabled it to be grouped with those sirnilar to it. The other system designated each part or product as an entity and in some way distinguished it from all other parts or products.

As the development of the classification and coding system moved into its final stages and the project team began to envision its use, it became apparent that a means of distinguishing between interim products with similar codes was needed For example there seemed to be little value in having a list of all similar interim products aboard a ship if the list contained several hundred entries. Clearly, a means of segregating interim products by location within the ship was required. Further study of this requirement established the following goals.

l Each interim product should be assigned an address that located it within a ship, and

l The address should be hierarchically cofigured to designate disposition of an interim product for later assembly of a larger interim product.

Unlike the classification and coding system the development of an interim product designation system was not a goal of this study. The various participants in the study, including the sponsor, felt that such a goal was unviable because

1. Many shipyards already had interim product designation systems in place and,

2. The development of an interim product designation system that met the varying requirements of-several shipyards may be undesirable if not impossible.

However, because an interim product designation system and its corresponding classification and coding system are interdependent this project had to envision, if only in a conceptual way, some form of interim product designation system. The details of this interim product designation system are discussed here only on a conceptual level and only to the degree that they interact with the classification and coding system. Its inclusion in this manual should not be construed as an endorsement of it, nor is it complete to the degree that would enable its use in a shipyard. It is included only for the purposes of example and illustration.

The interim product designation system envisioned by this project is made up of the five items shown in Figure 4.5-1. They are:

1. Hull No. Designation - Distinguishes one ship from another within the shipyard.

2. Block No. Designation - Distinguishes one block from others of a single ship.

3. Zone No. Designation - Distinguishes one zone, e.g., block semi-block outfit zone, or paint zone, from others within a ship or block

4. Sub-zone No. Designation - Distinguishes one sub-zone e.g. sub-block or unit from others within a single zone.

5. Work Package No. Designation - Designates work package assignrnent.

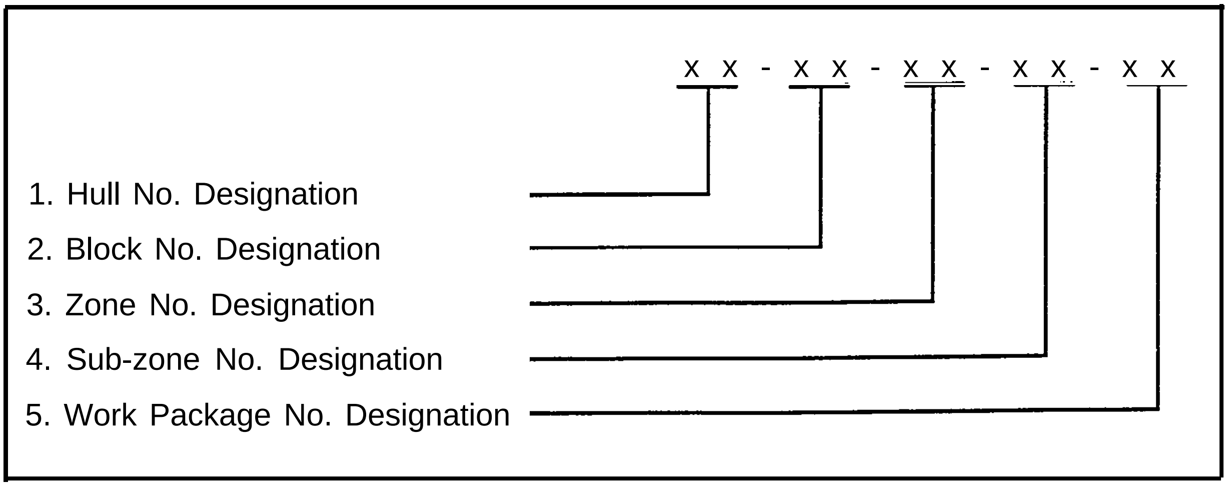


Figure 4.5-1

The interim product designation number defines the geographic location of an interim product in relation to the rest of the ship. Like the classification and coding system the interim product designation scheme is hierarchically configured with the designations becoming more specific from left to right. In this way, later disposition of an interim product is indicated. Because the classification and coding system defines a broad spectrum of work content, ranging from part fabrication to block erection and test, the interim product designation scheme must also be able to identify the location of a large range of interim products. In this way, the two are interdependent.

Research indicated that it would be valuable if the interim product designations utilized intelligent characters i.e., characters which symbolically represented specific information. Intelligent characters were used in the zone designation to symbolically represent a zone type. They were

CHARACTER	ZONE TYPE
l x	Shell Semi-Block
2x	Deck Semi-Block
3x	Transverse Structure Semi-Block
4x	Longitudinal Structure Semi-Block
5x	Miscellaneous Structure Semi-Block
6x	Prismatic Zone
7x	Prismatic Zone
8X	Prismatic Zone
9x	Miscellaneous Zone

Miscellaneous structure semi-blocks would encompass masts, stacks and rudders. Prismatic zones encompass any three dimensional space in which a worker could do work.

Intelligent characters were also used in the sub-zone designation to symbolically represent sub-zone types. They were

CHARACTER	SUB-ZONE TYPE
lx -4x	Structure Sub-zone
5X -8X	Outfit Sub-zone
9x	Paint Sub-zone

In developing an interim product designation system care should be taken to use intelligent characters only where they would represent information significant to interim product location and not duplicate information contained in the PWBS code.

The two examples above *use* numerals, however letters could be used if the sorting methods could accommodate them.

Further intelligence could also be incorporated into the system by numbering zones and sub-zones sequentially from the bow, aft, and from the baseline, up.

A final intelligent character is needed to indicate that a designation is not needed. For example, block assembly level work may not require a sub-zone designation. On board outfitting level work may not require a block designation, but still use a zone and sub-zone designation. In cases where a designation is insignificant, or nil, "99" is entered in place of the designation. "99" is also used to hold space for data to be entered at a later time.

The use of this interim product identification system is illustrated in the classification and coding example in Section. 3.6, Using the System - An Example.

4.6 *STANDARDIZATION*

In its research, this study found several companies that had used their classification and coding systems to promote standardization. By reviewing their part population, by group, they eliminated duplicate and inactive parts and those that differed in insignificant ways from other members of their group. When this had been done, the remaining population of parts were sufficiently unique and necessary to justify their continued production. Many companies designated frequently used parts which could be efficiently mass produced as standards within a group. These standards were usually designated by a suffix to the group code.

Standards could be used with the classification and coding system to designate comrnordy used

- Structural configurations for brackets, foundations, web frames, bulkheads, etc.,
- Outfitting unit configurations for various machinery, and
- Outfitting configurations for pipe, vent and wire runs.

For example, if a shipyard frequently used a particular type and size of structural bracket in the production of its ships, it might be advantageous to designate that bracket as a standard type and identify it with a suffix that captured this information and relayed it to the designer, steel fabrication shop and installer. Assuming that the bracket possesses the following attributes:

1. It was a discrete part i.e., not an assembly,
2. It was an internal part, cut from plate,
3. It did not require plate joining,
4. It did require cutting,
5. It did require that a flange be bent onto one side,

then:

1. Its group code during the cutting process would be H10021,
2. Its group code during the bending process would be H10022.

To identify this bracket as a standard bracket, a suffix is added to its group code when it is an interim product before cutting and before bending. For this example, an intelligent suffix, i.e. one which conveys information is used. In the suffix B6, the letter "B" symbolically identifies this part as a bracket and the numeral 6 is a serial number which identifies it as bracket type 6.

The complete group code for this bracket would be

1. H1oo21-B6 during the cutting stage, and
2. H10022-B6 during the bending stage.

The advantages of designating standard parts and assemblies in this way arc

1. Standard parts can be cataloged for repeated use by designers.
2. Numerical control data for standard parts can be stored and retrieved.
3. Fabrication and installation instructions and process plans can be stored arid retrieved.
4. Part geometry can be stored in CAD/CAM system parts libraries for use by designers and numerical control post processors.

4.7 *COMPUTER AIDED PROCESS PLANNING*

One goal of this study was to develop a classification and coding system that would serve as a foundation for a computer aided process planning system. To accomplish this goal, the study configured the classification and coding system to fulfill two requirement

1. Operate in a computer aided manner using software and hardware which had demonstrated the capability to perforrm computer aided process planning, and

2. Provide a sufficient level of descriptive capability to enable an interim product to be assigned to a generic production process work station, i.e., a work station common to several shipyards. This assignment capability was limited to a decision based solely upon work content criteria.

To determine and fulfill these requirements, this study had to make certain assumptions about how computer aided process planning would be implemented in a shipyard. These assumptions were based upon research which included visits to companies that utilized computer aided process planning, discussions with vendors of such systems and the review of pertinent literature. Where possible this study tried to avoid assumptions that would limit a shipyard's options concerning system architecture, software and hardware. A summary of these assumptions is provided below.

1. Approach

In its research this study found many companies approached computer aided process planning (CAPP) as a compilation of information and decisions. It assumed the shipbuilding industry would follow a similar approach. More specifically, this study assumed that information would be collected and decisions made in a highly structured classification, or decision tree process.

"Product Work Breakdown Structure", Section 1.3 briefly mentions three types of information that would be required for a shipbuilding CAPP system in its discussion of work package productivity value. It equates productivity value (PV) to a function of process time (T), resource quantity (N), and quality of work circumstance (Q). Before CAPP could be implementer decision trees containing the attributes and three structures for interim product T, N, and Q would have to be developed.

Figure 4.7-1 shows conceptually, how the classification and coding system could be linked to decision trees capturing Q and T information (trees can be linked in this manner in DCMSS using keys). In this illustration, the PWBS code enables selection of the proper "Q" tree and the Q coding enables selection of the proper "T" tree. All three codes are then read and the proper algorithm selected. The correct "N is entered into the algorithm along with varibles gathered in tree transversal to compute in-process time. This time could then be compared to values from previously accomplished similar work. If the time value was acceptable the interim prcduct could then be scheduled to a specific work station. If the value was unexceptable the process could be repeated selecting different “Q” attributes.

An example of a “Q” decision tree configured for welding processes is shown in Figure 4.7-2. An example of a “T” decision tree for hand held shielded metal arc welding is shown in Figure 4.7-3. Due to the complexity of the time computation algorithm no example is offered.

The computer aided process planning systems which this study witnessed enabled work station selection by presenting the user with a list of work stations which could accomplish the work indicated by the various codes. The work station list had been prioritized to show the optimum work station for the work in question followed by the first second and third alternates. After the planner selected a workstation the interim product was entered into the work schedule and start and complete dates were calculated. The planner then had the option of confirming the schedule, altering the start or complete date, or selecting a different work station.

This approach has been provided to depict, conceptually, the approach this study felt would lead to computer aided process planning in a shipyard. Its illustrations, particularly those concerning welding work are conceptual in nature and am not intended to be complete treatments of the subject

2. software

This study assumed that computer aided process planning would be accomplished using DCLASS software. This assumption was made for the reasons cited in Section 3.4, Computer Aided Classification and Coding and because it was the only product which demonstrated the capability to handle the complexities of computer aided process planning in a shipyard as this study perceived them. Appendix B, DCLASS Information contains information which discusses computer aided process planning with DCLass..

3. Hardware

By assuming that a computer aided process planning system would utilize DCLASS software, this study assumed by implication that computer hardware compatible with DCLASS would be used. Because DCLASS is compatible with a sufficient variety of computer hardware, this was felt to be a valid assumption. Appendix B., DCLASS Information, contains a list of DCLASS compatible hardware.

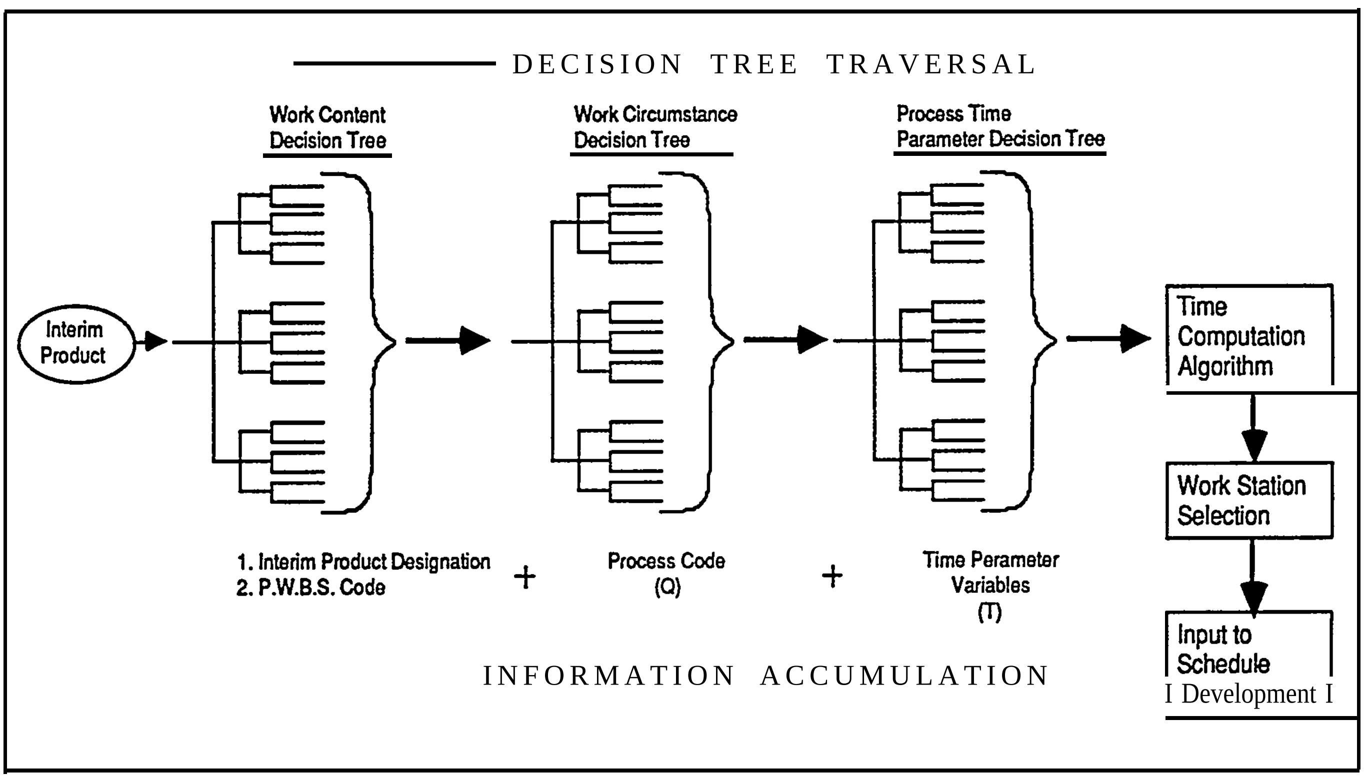


Figure 4.7-1
CAPP Decision Trees

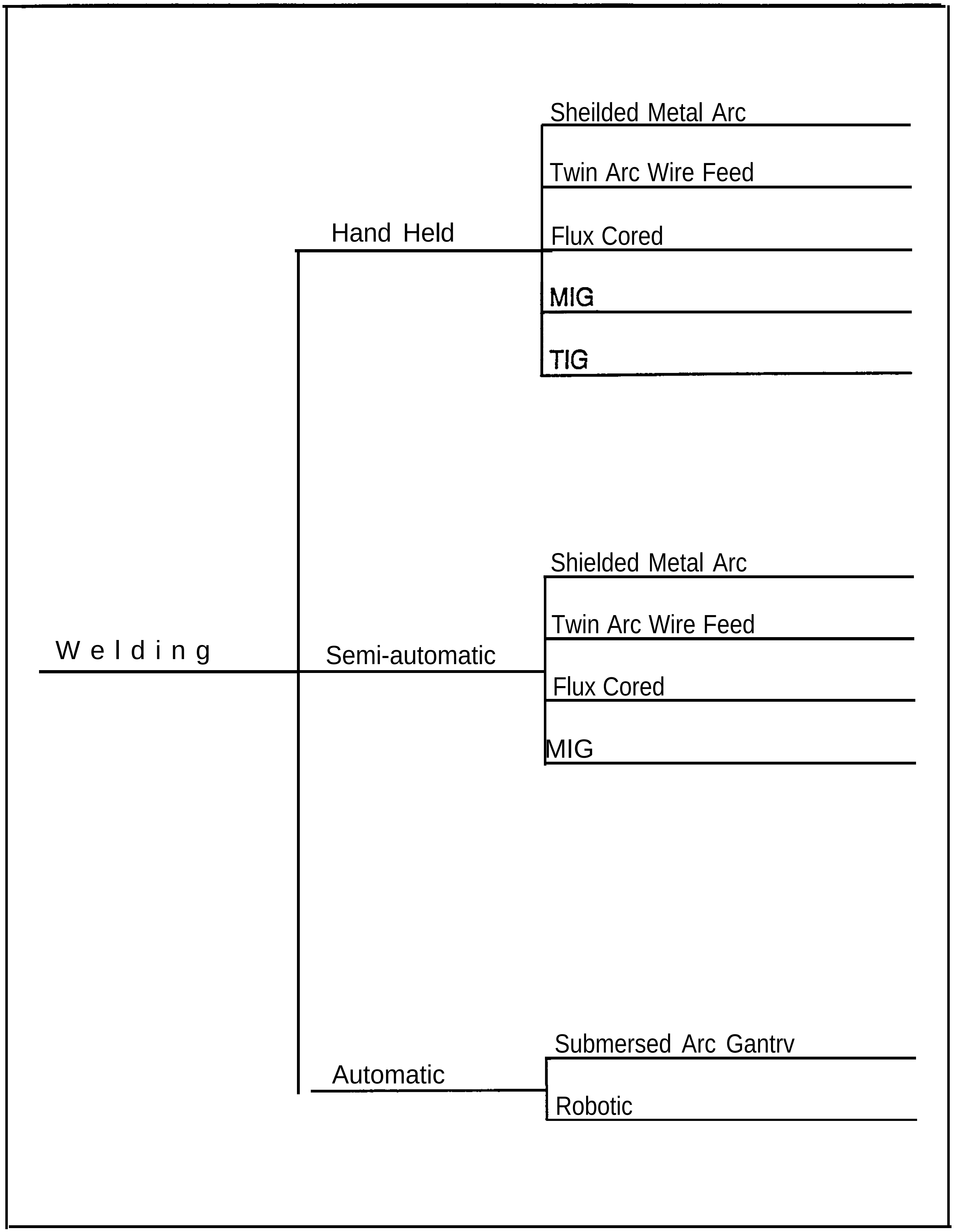


Figure 4.7-2 Process Selection Decision Tree for Welding Work Content

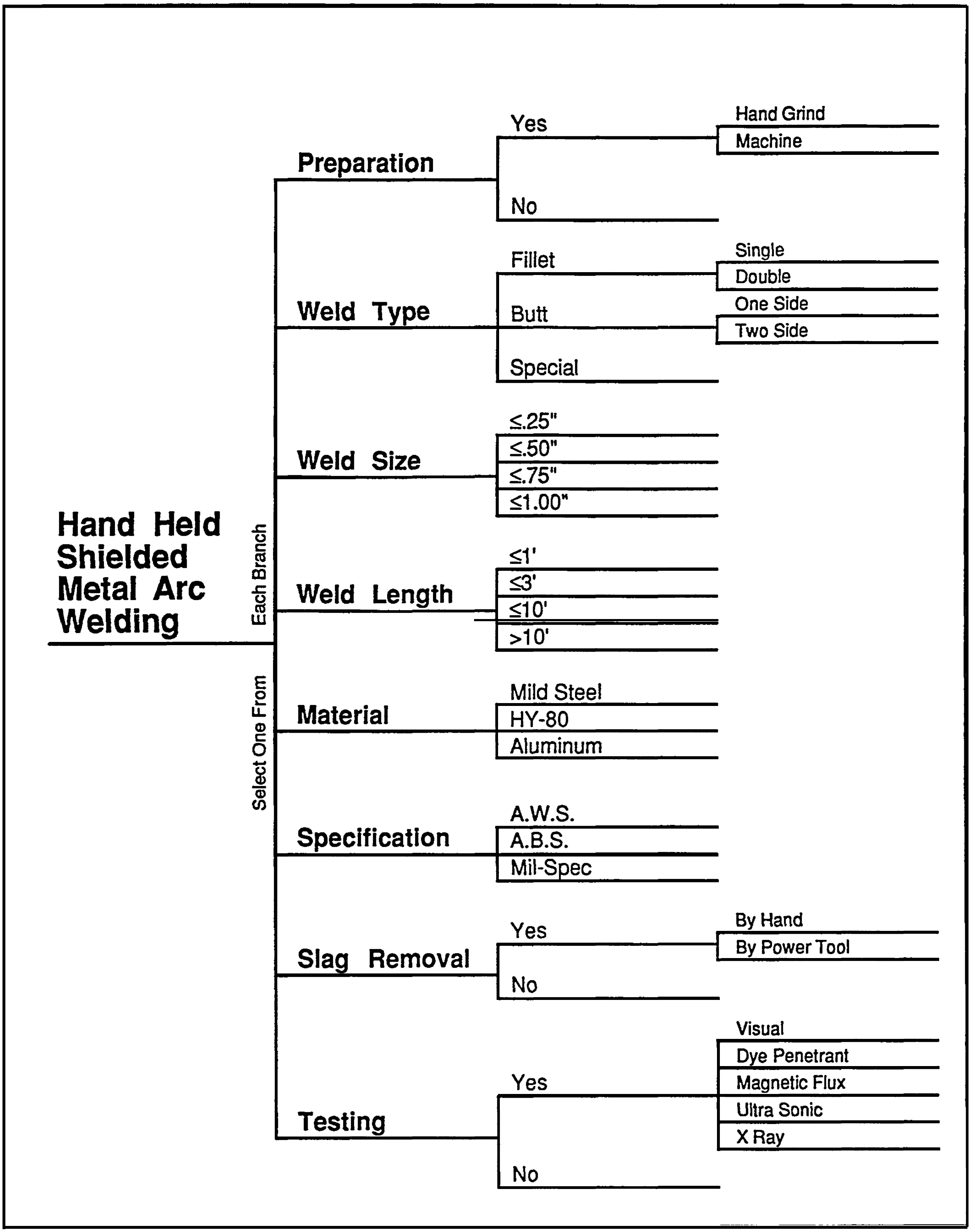


Figure 4.7-3 In Prccess Time Parameter Decision Tree for
Hand Held Shielded Metal Arc Welding

APPENDIX A

Resources

Appendix A provides the reader with resources to augment the application of classification and coding described in this manual.

G L O S S A R Y

Attribute - An inherent characteristic of a Part or PRODUCT, e.g. length, width, raw material, geometry.

CAPP - An acronym for Computer-Aided Process Planning.

Classify - To assign a part or product to a group.

Classification and Coding System - A structured arrangement of the attributes which a company uses to sort its parts and products into groups and an abbreviated means of identifying group assignment.

Classification Tree - A graphic illustration of the structure, attributes and codes of a classification and coding system.

Coding - A system of letters or numbers that represent group assignment.

DCLASS - A software product of the Brigham Young University CAM Software Research Computer Center. DCLASS is a generic decision tree processor frequently used in computer aided classification and coding. For further information see Appendix B - DCLASS Information.

Decision Tree - A graphic means of portraying a question and its possible answers.

Family Manufacturing - A synonym for Group Technology.

FMS - An acronym for Flexible Manufacturing System.

Group - A number of parts or products considered together because of similar attributes.

Group Technology - A means of attaining industrial or commercial objectives by scientifically considering individuals or things together because of certain similarities.

Hull Block Construction - A work type within Product Work Breakdown Structure concerned with the structure of a ship.

Interim Product - The end result of any one stage of production.

Manufacturing Level - A characteristic of an interim product which uses attributes for interim product control to differentiate between interim products at different points in the work sequence for a particular work type.

Part - A constituent member of a ship.

Problem Area - A characteristic of an interim product which uses attributes for interim product description to differentiate between interim products with dissimilar work requirements within a particular zone type.

Process - A work operation performed on a part or product.

Product - A manufactured item. See also Interim Product

Product Work Breakdown Structure - An application of Group Technology to ship assembly work oriented to similarities of product work.

PWBS - An acronym for Product Work Breakdown structure.

Stage - A characteristic of an interim product which uses attributes for interim product control to differentiate between interim products at different points in the work sequence for a particular problem area.

SWBS - An acronym for Ship Work Breakdown System.

Work Package - A grouping of interim products for production.

Work Type - A characteristic of an interim product which uses attributes for interim product description to differentiate between interim products possessing dissimilar work requirements.

Zone - A characteristic of an interim product which uses attributes for interim product description to differentiate between interim products with dissimilar production objectives within a particular manufacturing level.

Zone Outfitting - A work type within product work breakdown structure concerned with the procurement, installation and testing of equipment aboard a ship.

Zone Painting - A work type within Product Work Breakdown Structure concerned with the application of surface coatings aboard a ship.

LITERATURE

2.1 Periodicals

Listed below are periodicals which typically contain articles concerning group technology.

1. CAE, commner-Aided Engineerig (ISSN 0733-3536). A publication of:

   Penton/IPC, Inc.
   1111 Chester Avenue
   Cleveland, Ohio 44114

2. Journal of Ship Production (ISSN 8756-1417). A publication of:

   The Society of Naval Architects and Marine Engineers
   One World Trade Center
   Suite 1369
   New York New York 10048

3. manjfacturinEngineering (ISSN 0361-0853). A publication of the

   Society of Manufacturing Engineers
   P.O. Box 930
   Dearborn, Michigan 48121

4. Naval Engineers Journal (ISSN 0028-1425). A publication of:

   The American Society of Naval Engineers
   1452 Duke Street
   Alexandria, Virginia 22314

5. Production Engineering (ISSN 0146-1737). A publication OE

   Pemton/IFC, Inc.
   1111 Chester Avenue
   Clevelant Ohio 44114

2.2 *Papers*

All of the professional organizations listed in Appendix A-5 maintain libraries of technical papers produced by their members. Many of these papers concern group technology. Since these libraries are updated frequently, it is recommended that the reader contact these organizations to learn of their current offerings.

2.3 *Books*

Like many forms of advanced technology, group technology is developing and changing at a rapid rate. Unfortunately, this situation causes publishers to be very reluctant to produce all but the most rudimentary books on the subject. Listed below are those books which this study found to be helpful.

1. Ground Technology.. An Overview and Bibliography, by Marving F. DeVries, Susan M. Harvey and Viiav A. Tipnis. 'Publication No. MDC 76-601 SPonsored by Army Materials and Mechanics Research Center. Available from:

   Metcut Research Associates Inc.
   3980 Rosslyn Drive
   Cincinnati, Ohio 45209

2. Group Technology at Work, edited by Nancy Lea Hyer (ISBN 0-87263-154-0). Published by

   Society of Manufacturing Engineers
   Publications Development Department
   Marketing Services Division
   One SME Drive
   P.O. Box 930
   Dearborn, Michigan 48121

3. Introduction to Group Technology in Manufacturing and by R. C. Wilson and Robert A. Henry. Available front

   University of Michigan
   Industrial Development Division
   Institute of Science and Technology
   2200 Bonisteel Boulevard
   Ann Arbor, Michigan 48109

COMMERCIAL ENTERPRISES

The demand for group technology by industry has created a small number of firms or institutions which provide a variety of products ranging from consulting and analysis to turnkey computer integrated manufacturing systems. Listed below are those firms that this study became aware of in the course of its work Although no evaluation is offered concerning relative merit of these firms and their products, it is recommended that shipyards implementing group technology survey them to determine possible sources of assistance.

1. Brigham Young University
   CAM Software Research Center
   265 Tech
   Provo, Utah 84602
   (801) 378-3895

2. Brisch, Bim & Partners
   1656 S.E. loth Terrace
   Fort Launderdale, FIorida 33316
   (305) 525-3166

3. Computer Aided Manufacturing - International, Inc.
   (CAM-I)
   611 Ryan Plaza Drive
   Suite 1107
   Arlington, Texas 76011
   (817) 265-5328

4. The Charles Stark Draper Laboratory, Inc.
   555 Technology Square
   Carnbridge Massachusetts 02139
   (617) 258-2901

5. Organization of Industrial Reseach, Inc.
   240 Bear Hill Road
   Waltham,L Massachusetts 02154
   (617) 890-4030

PROFESSIONAL ORGANIZATIONS

Listed below are professional organizations known to encourage research, sponsor seminars and symposiums, publish and distribute information or in some way promote applications of group technology.

1. American Institute of Industrial Engineers
   25 Technology Park/Atlanta
   Norcross, Georgia 30092

2. American Society of Naval Engineers, Inc.
   1452 Duke Street
   Alexandria, Virginia 22314

3. The British Ship Reseach Association
   Wallsend Research Station
   Wallsen4 Tyne & Wear
   NE286UY
   United Kingdom

4. Scciety of Manufacturing Engineers
   Computer and Automated Systems Association
   One SME Drive
   P.O. Box 930
   Dearborn, Michigan 48121

5. The Society of Naval Architects and Marine Engineers
   One World Trade Center
   Suite 1369
   New York New York 10048

GOVERNMENT SPONSORED RESEARCH PROGRAMS

The Federal Government has funded research and development in group technology in an effort to improve production in defense related industries. Listed below are programs of this nature which this study became aware of and a brief description of each.

The Integrated Computer-Aided Manufacturing (ICAM) Program - The ICAM Progrm sponsored by the Air Force, generated a significant body of documentation and public domain software pertaining to group technology in the manufacture of aircraft. Of particular interest to shipbuilders is the work that concerned sheet metal parts. For more information contact

ICAM CM Library
AFWAI/MLTC
Wright Patterson AFB, Ohio 45433

2. The National Shipbuilding Research Program (NSRP) - The NSRP has produced several manuals such as this one, which present information concerning group technology in shipbuilding. The program is administered by the Ship Production Committee of the Society of Naval Architects and Marine Engineers whose address is in Appendix AA.

APPENDIX B

DCLASS INFORMATION

Appendix B contains information provided by the Brigham Young University CAM Software Research Center.

APPENDIX B - DCLASS INFORMATION | Page

DCLASS

InformationProcessing Systems

Brigham Young University

DCLASS USER

A. O. Smith Corporation
ACEC, Belgium
Allied Corporation
Allison Gas Turbine
AMP, Inc.
Amphenol Products
Arizona State University
Autotrol Technology Co.
AVCO Aerostructures
Beech Aircraft Corporation
Bell Helicopter Textron, Inc.
Boeing
Borg-Warner Corporation
Bruel & Kjaer, Belgium
Cable Belt Ltd., England
Camberley Enterprises
Cameron Iron Works, Inc.
Caterpillar Tractor
Cessna Aircraft Company
Chrysler Corporation
CIM Consulting, Denmark
Cincinnati Milacron
Clark Equipment
COMASE, Belgium
Dana Corporation
Daniel Industries
DCP Associates
Denmark Technological Univ.
Diamont Boart, Belgium
Digital Equipment Corporation
Dorm Corporation
Eastman Kodak
Eaton Corporation
EDS
Electro Scientific Industries
Emerson Electric
Evans & Sutherland Corporation
Faultless Caster Corporation
Fluid Regulators
Ford Aerospace
Ford Motor Company
Garrett Corporation
General Motors Corporation
Gleason Works
Goodyear Aerospace
Grumman Aerospace
G.T. Consultants B.V., Holland
HRB Singer, Inc.
Hewlett Packard
Illinois Central College
Imperial Clevite
Ingersoll-Rand, Inc.
J. 1. Case
John T. Hepburn, Ltd.
Kent Communications
Knoll International, Inc.
Kohler Company
Lehigh University
Libbey Owens Ford
Lord Corporation
Magnavox
Management Science, Inc.
Martin Marietta
McDonnell Douglas
Melroe Company
Miami University
Mixing Equipment
Molex, Inc.
Morton Thiokol
Northern Telecom, Ltd.
Northrop Corporation
Owatonna Tool
Pcrkin Elmer
Productivity Associates
Raytheon Company
Ridge Tool Company
Rockwell International
Rogers Corporation
Rolls-Royce Ltd., England
Saginaw Steering Gear
Selenia Autotrol, Italy
SME
Sperry Corporation
St. Lawrence Seaway
Storkdata, Holland
Swinburne Australia Institute
Tektronix
Teledyne CAE
Texas Instruments
Timken Company
Travenol Laboratories, Inc.
United Technologies
Valtek, Inc.
Varian Associates, Inc.
Vickers, Inc.
Warner Electric
Weber State College
Westinghouse Electric
Weston Controls
Xerox Corporation

DCLASS™ INFORMATION SYSTEM
AN INTRODUCTION

Background

since its creation In 1975, the Computer-Aided Manufacturing Laboratory at Brigham Young University has been l engaged in advancing research into the systems integration problems of the manufacturing enterprise. Directed by Dr. Dell K. Allen, the laboratory has emphasized the development of software that can link together the diverse facets of a manufacturing company, from design through production.

DCLASS is one result of this research. This syetem was developed starting in 1976 and now is licensed commercially by a wide variety of companies.

DCIASS Description

DCLASS is an acronym for Decision and Clasification Information System. It is a general purpose computer system for processing classification and decision-making logic. The system has two major features:

(1) DCLASS is a general purpose information tree processor that allows both standard and user defined logic.

(2) DCLASS is a flexible system that can be easily interfaced to the user-s own application program environment.

Tree Processor

DCLASS is a general purpoee tree processor. The tree structures may contain classification systems or user-defined logic. Figure 1 illustrates some examples of trees that could be used with DCLASS. The system allows the tree logic to be easily created and tailored by the technician or engineer user instead of requiring computer programming specialists.

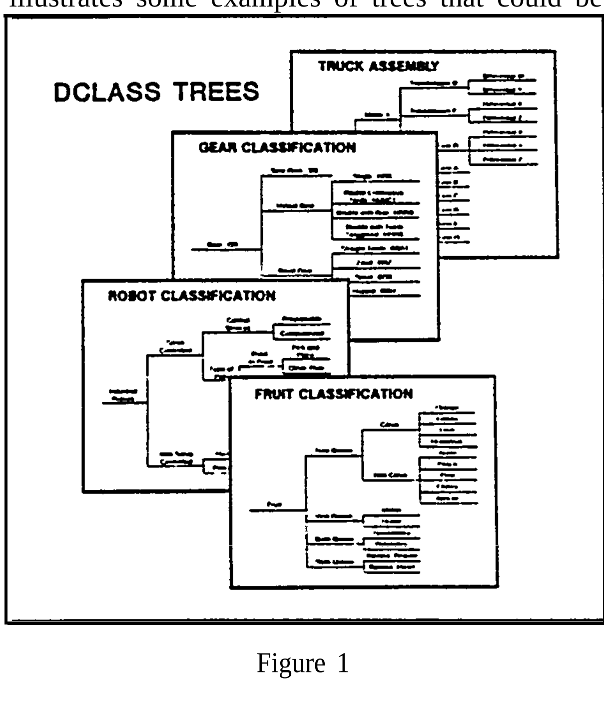


Figure 1

Classification Systems

The DCLASS system can accommodate any known classification system. The logic behind many commercially available classification systems has been converted to trees and used with the system. Once in a tree structure, the classification may be tailored to meet specific user needs.

User-Defined Decision Logic

The advanced tree processing features of DCLASS allow the user to not only classify items but to capture company specific decision-making logic. This logic can then be used to automatically make consistent and objective decisions in areas such as process planning, material selection, or circuit design.

The user-s trees provide an easily visualized graphic representation of a company-s technical knowledge. Trees are very useful to document and analyze existing methodology. Figure 2 shows an example of user defined tree logic.

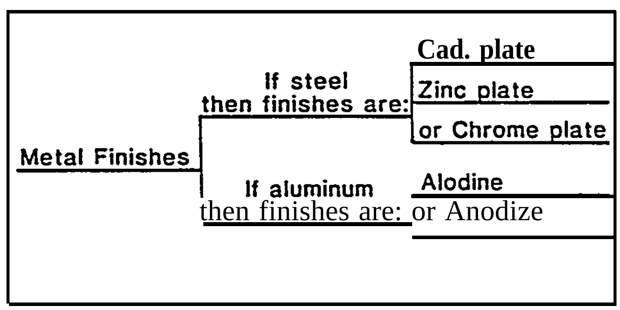


Figure 2

Flexible Subsystem

Even though it has many stand-alone capabilities, DCLASS is intended to be a subsystem of a larger user application. Because of the high level system interface, DCLASS can be quickLy tailored to a unique application environment by a very small team of programming personnel. An integrated DCLASS application will combine the DCLASS program and user trees with various user application programs and data. (See Figure 3)

Computer Systems

The DCLASS system is written In ANSI FORTRAN Iv. lt contains about 16,000 lines of FORTRAN and

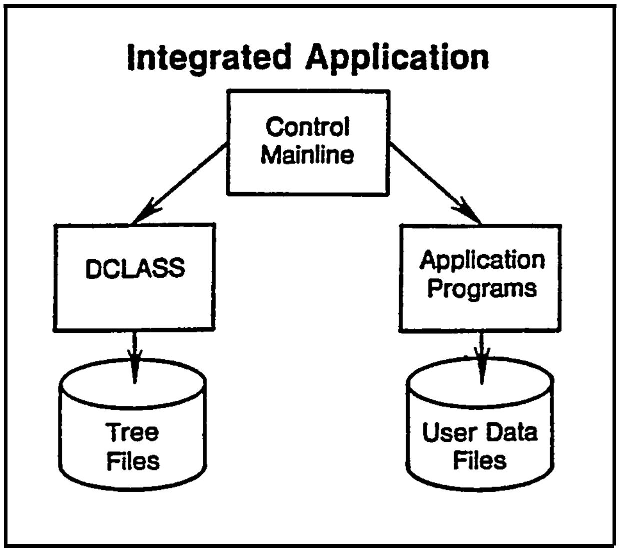


Figure 3

is currently supported on the following computer system:

Computer	Operating System
PDP-11	RSXIIM
VAX-11/780	VMS
NP 3000	MPE
IBM 370	CMS, TSO
UNIVAC 1100	0S1100
IBM PC-XT	DOS

Conclusion

As more companies investigate advanced computer systems in Computer-Integrated Manufacturing (CIH), many realize the need for systems that can be easily tailored to their specific user and system needs. DCLASS has been developed aS a very flexible and powerful tool to approach many problems and to allow the user to control and tailor computer-aided applications. Through continuing research in the CAM Laboratory, BTU has shown its commitment to be an innovative, partner with industry to develop effective computer-oriented solutions to many of the chellenges faced by manufacturing companies.

R. P. MILLET
8/18/83

DCLASS™ CAPABILITIES

The following is a brief summary of DCLASS capabilities l s used for classification, coding, information retrieval, decision making, system integration, and artificial intelligence applications. It is hoped that this information will prove useful in evaluating DCLASS as a highly useful programming system for your given applications.

Classification

The benefits of classification and group technology are well known. The CAM Software Laboratory is developing and testing a number of generic classification systems for all aspects of the CIM Data Base including those for mechanical and electronic components, gears, fasteners, raw materials, and material properties similar to those shown in Figure 1. These trees are available to DCLASS Users as part of the demonstration system. In addition, comprehensive classification systems are also provided for fabrication processes, equipment, and tooling.

The capability of classifying items by their types and by their attributes greatly simplifies the classification of complex items. A significant benefit of the DCLASS approach is that known classification or coding schemes may be readily formatted into DCLASS trees. Once in the tree structure these classification systems are very easy to update and maintain. Desired modification to the classification trees may be quickly made by DCLASS Users without the need of relying on computer specialists or consultants.

Coding

Codes often provide a useful shorthand notation to aid in communication. With DCLASS, the code length is extremely flexible. It can be 3, 12, 16, or any number of digits depending upon your need. As shown in the example In Figure 2, various parts as the code may be used independently to provide pointers into specific parts of the database or they can be appended to make a comprehensive code of any desired length. Some

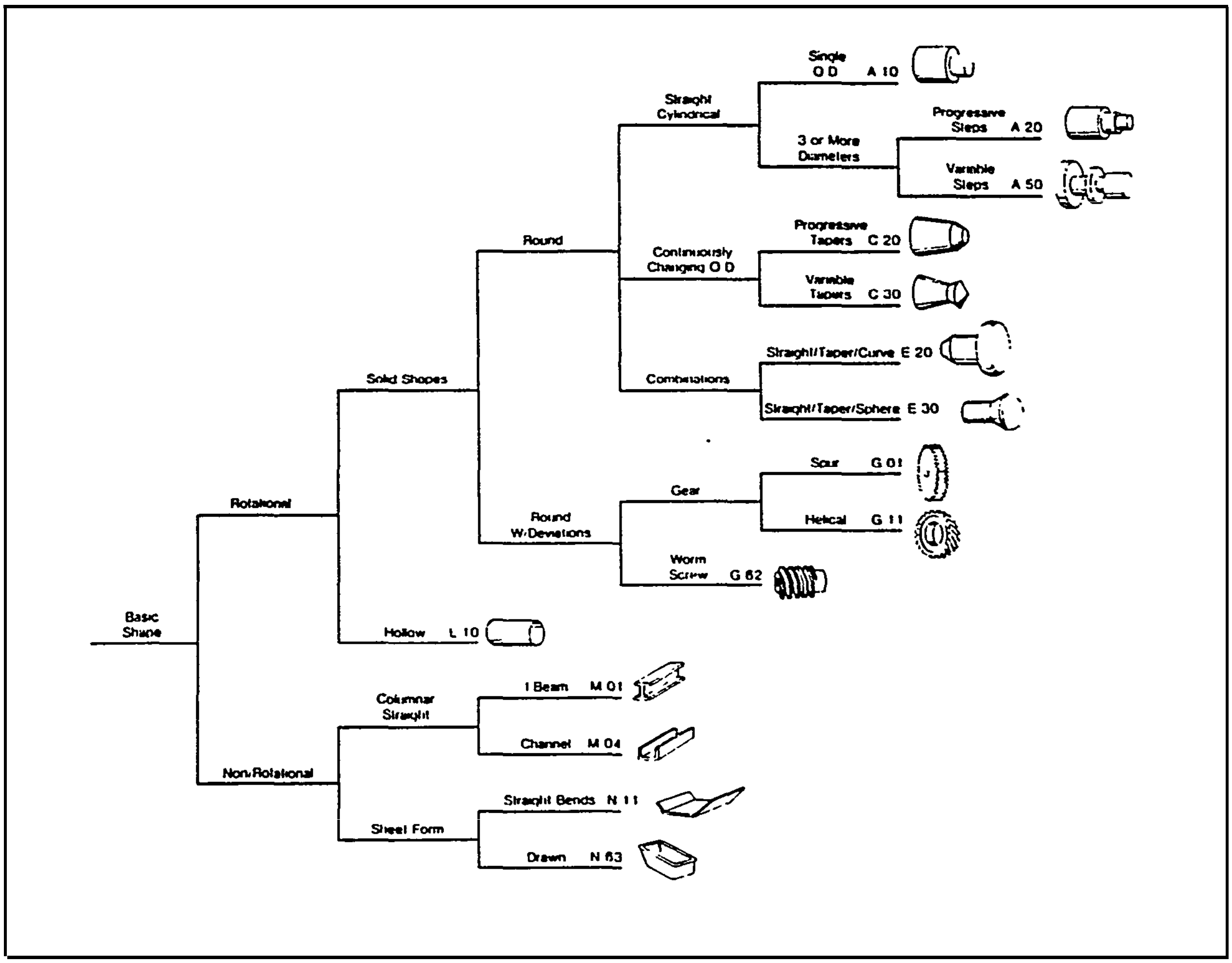


Figure 1

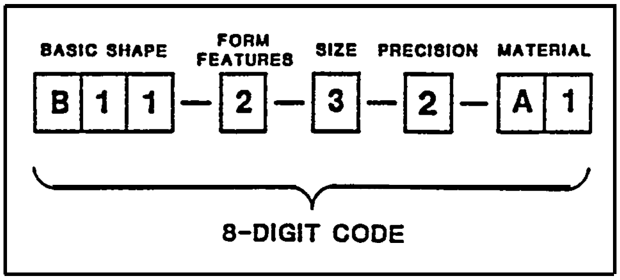


FIGURE 2

users have found that a short human-readable code coupled with a computer-readable DCLASS bit-string provides excellent resolution of even minute item details. These codes can be fixed length monocodes or polycodes or more flexible variable length codes.

Information Retrieval

Information retrieval with DCLASS technology is much faster than with other approaches. The degree of match between the defined target item and what is currently in the database may be easily varied from a perfect match to any user specified degree of similarity. DCLASS retrieval is not limited to searching and sorting on a fixed length code. AS with other systems, code length can be variable. AS shown in Figure 3, internal pointers dramatically reduce data baSe access time and for the first time provide a viable approach to rapid information retrieval.

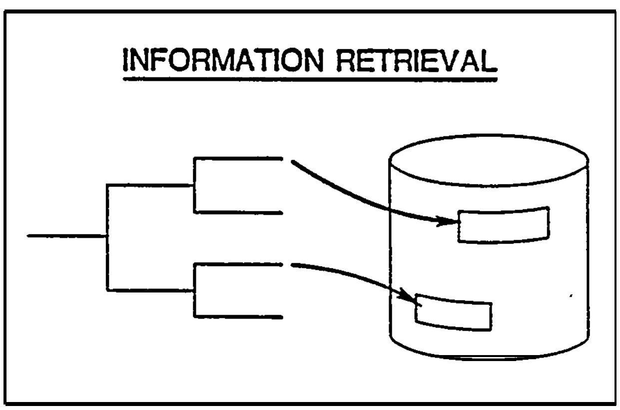


Figure 3

DCLASS can be used in conjunction with existing database systems for storage of codes and variables and for subsequent retrieval using traditional database management systems. This provides a very easy linkage between various CAD/CAH Databases and application programs.

Decision-Making

DCLASS provides a very simple and straightforward way of helping a company capture its decision-making logic before its technical specialists retire. The speed and low cost of programming with DCLASS allows even non-computer programmers to quickly capture decision logic to dramatically increase their productivity. DCLASS trees contain the logic, sequences, calculations, keys, data elements, and codes used for such diverse activities as Generative Process Planning, Automated Time Standards, N/C and Robotic Programming, Automatic Materials Selection, and even Parametric Product Design. Decision trees permit the user to relate conditions and actions. For l example, in the figure below, a simple decision tree is shown for cutting various materials.

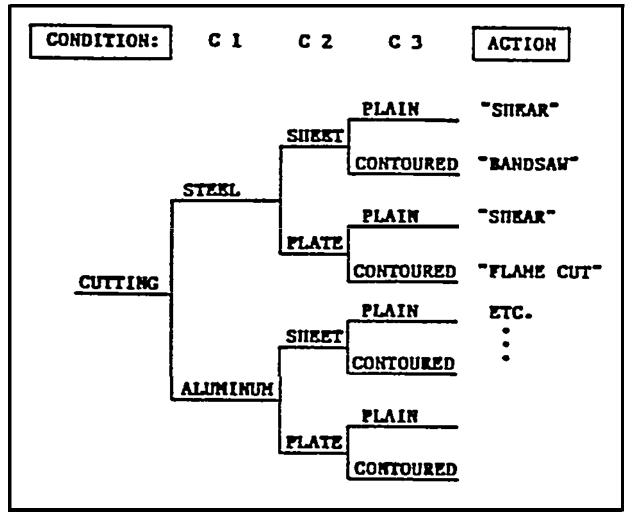


Figure 4

The conditions include material type, material form and thickness, and whether the cut is plain or contoured. The possible actions for each set of conditions includes shearing, bandsawing, flamecutting, etc. No other system comes close to the power, simplicity, and speed of DCLASS for complex decision-making. This power and speed may be achieved in either a q main-frame, minicomputer, or microcomputer distributed environment.

A relatively small in-house team can start making quite sophisticated decision trees following the standard 2-day DCLASS training course. DCLASS comes with a small mainline program l and trees for classification and coding, design retrieval and generative process planning. There is no waiting for technical users or management to get the feel of using DCLASS when using the demonstration system provided.

System integration

Most companies already have a variety of software and wonder how it can be used as part of their integrated system. One of the very useful benefits of DCLASS technology is its ability to lntegrace quite diverse CAD)/CAM applications programs. Any node of the DCLASS tree can be used to issue a subroutine call and pass data between various applications programs.

As shown in Figure 5, DCLASS can process various trees for classification, coding, or decision-making and then pass resulting codes and values co the mainline control module for use with other application programs. To date, DCLASS seems to be one of the best answers around for creating integraced engineering, design, and manufacturing systems.

DCLASS System Architecture

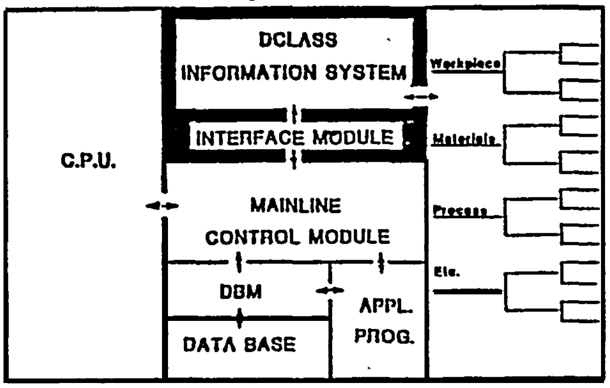


Figure 5

Artificial Intelligence

DCLASS possesses the same capabilities as the so-called "expert" artificial intelligence systems. To date, this capability has only begun to be explored for applications such as diagnotics, strategic planning, and many others which involve complex decision making based upon known, quantifiable conditions.

DCLASS has many valuable features, capabilities and l enhancements possessed by no other system; it is flexible and can be used for many, many applications.

The license fees for DCLASS are good news, too. There is no corporate fee, and little or no outside consulting is normally required. Initial and monthly license rates are reasonable, non-computer experts can program it, and DCLASS trees provide l excellent documentation. Furthermore, trees are easy to create, visualize, and maintain. Efficient and consistent classification, speedy design retrieval, rapid generative planning, and minimal data base storage requirements all add up to outstanding performance.

Some of the bonus features include its artificial intelligence capabilities, portability, and compatibility with distributed processing activities which make DCLASS a truly outstanding tool for improved productivity and quality.

D. K. Allen
3-23-83

D C I A S S™ A D V A N T A G E S

Introduction

As you investigate cost l and quality benefits of Computer-Integrated Manufacturing and Group Technology for your business, you will soon realize the need for advanced computer software tools. The DCLASS Information System, licensed by Brigham Young University, can provide a simple solution co complex problems. The DCLASS Information processor and tree definition language cam be easily tailored to meet your specific needs.

This paper will discuss the advantages of the DCLASS approach over other systems which use Group Technology concepts. Advanced DCLASS capabilities which go far beyond other existing systems will also be discussed.

Group Technology

Group Technology is a method of manufacturing piece parts by classifying these parts into groups and subsequently applying similar technological operations to each group. This obtains economics which l are normally associated with large scale production in the small scale situatiom

Other Systems and DCLASS

To achieve the ultimate l economic benefits of group technology, several different approaches have been tried. Four of these approaches will be briefly described.

Level 1. Manual Classification Systems. This method has been in existence for some time co classify parts and commodities into groups or families according to similar attributes and attach a code to each individual family. The manual approach is non-computerized and is often Used to group families of drawings and codes for design retrieval purposes. The tabular classification in Figure 1 is a good example of how this particular method might be set up using printed charts.

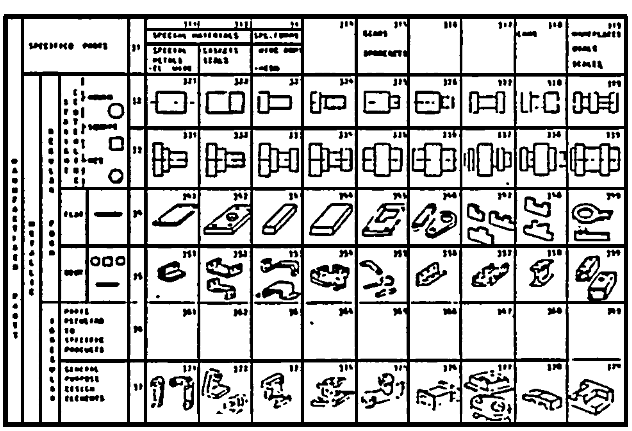


Figure 1

Level 2. Rard-Coded Computerized Classification Systems. The next step up from a manual classification system is to computerize the logic sequence necessary to derive a specific code. The interactive series of questions to derive the code is programmed in a computer language like FORTRAN. The derived code can then be stored in a computer file for later access or searching. However, becauae the program creates a very specific classification and coding eystem, it can only classify the given types of items. To extend the classification for other families is a major task. The program must be re-written and debugged. Because of the relative complexity of programming with a language like FORTRAN, the computer program may consist of many thousand lines of instructions. The program is difficult to change or tailor and requires a computer specialist to do so.

Level 3. Standard Coding Software Systems. Because of the difficulty in tailoring and adding a new classification to a hard-coded system, software has been developed to handle standard monocode and polycode systems (see Figure 2.)

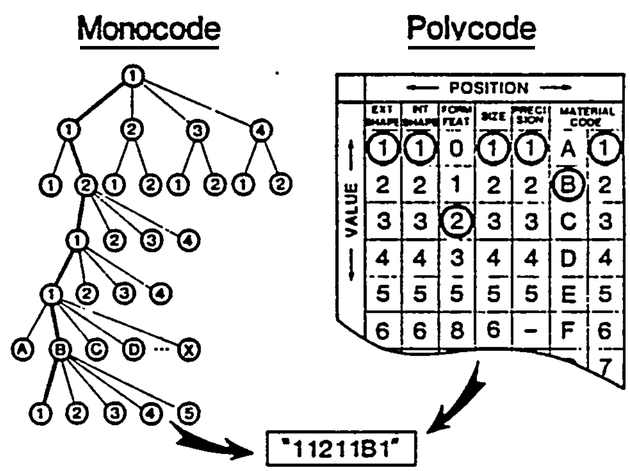


Figure 2

With this approach, the definitions of coding questions are usually contained in a computer data file. The software operates on the data file and asks the questions to derive the given code. Since the system is closely tied to generating a fixed length alphanumeric code, it is limited in the amount of information that can be processed. This limiting factor inhibits many potential applications of a computerized method of classification.

Level 4. General Purpose. Tree Processor System. As the name indicates, this computerized system processes tree structures such as those found in Figure 3. The tree structure provides a new approach to computer programming. Each) of the previous three coding systems can be simulated in a tree structure. This approach provides for multiple path branching, multiple level branching, and automatic processing. Thus , a general purpose tree processor, such as DCLASS, can be used along with its very high level tree definition language. Because of the flexibility of the many types of

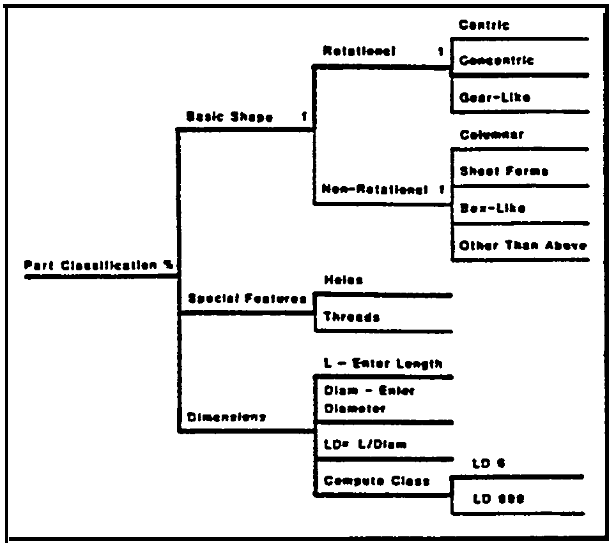


Figure 3

tree structures supported by DCLASS, it is now relatively simple to automate many difficult decision-making tasks.

Summary of Capabilities. Figure 4 is an illustration of the four types of systems which have been reviewed. Each 18 an expansion of the capabilities of the one before. By computerizing a manual classification system, its use can be somewhat expanded. By adding standard coding software, specific classification systems can be changed With less difficulty and new classifications can be added. In more advanced systems involving general purpose tree processors, any known coding system can be incorporated quickly and simply. In addition, it has the capabilities for manual or automatic decision making. It can also be used for performing the functions attributed to the expert artificial intelligence systems which are being considered for use in CAD/CAH systems of the future.

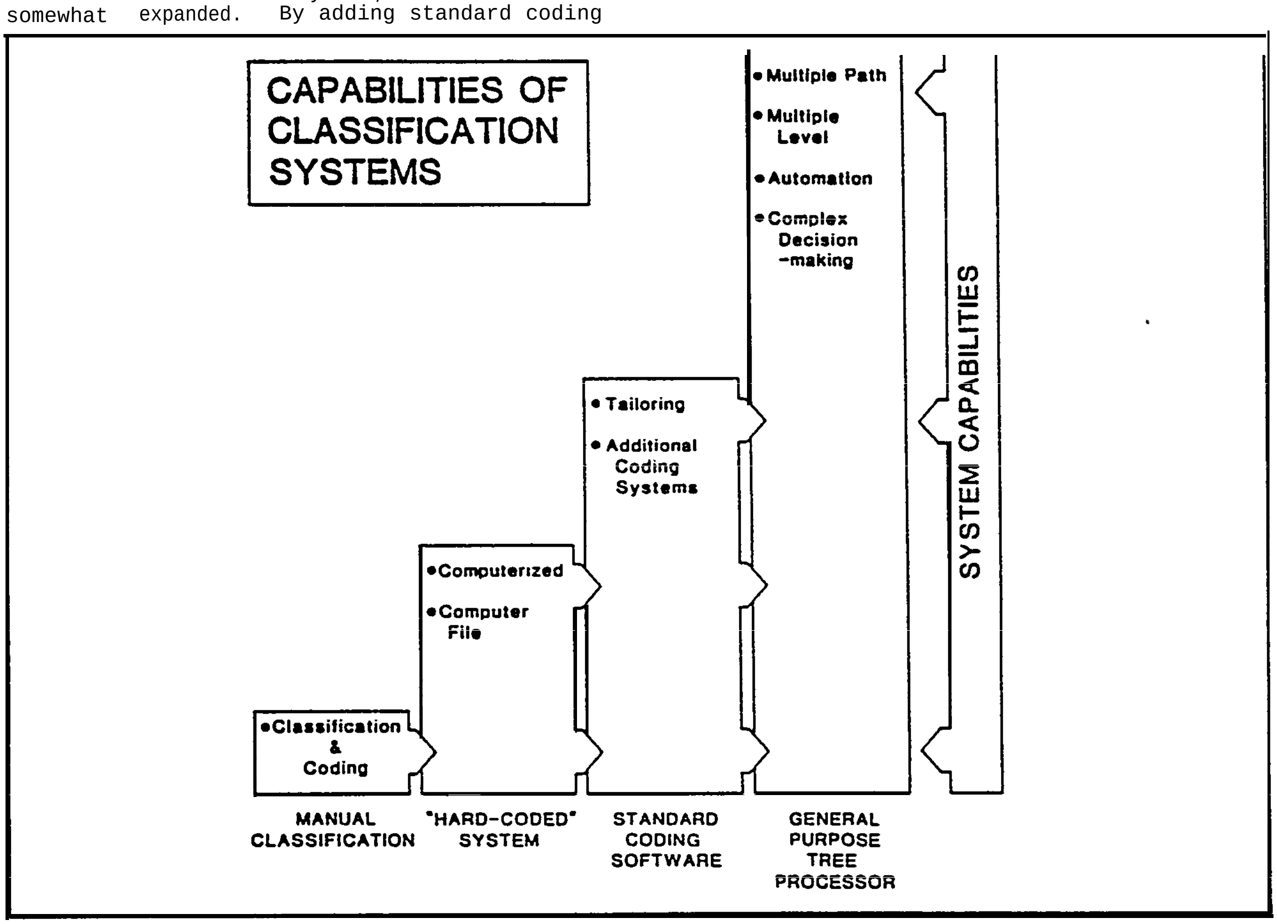
DCLASS Advantages

The remainder of this paper will focus on the advanced DCLASS capabilities that allow it to do much more than any of the previously described l approaches. The following three topics will be discussed:

(1) DCLASS trees can capture detailed information not possible by a standard coding software system.

(2) DCLASS has high-level tree definition language that can capture decision-making logic used by your expert planners, designers, and estimators.

(3) DCLASS is easily integrated with other user applications and data bases.



Detailed Information in DCLASS Trees

A standard monocode or polycode clarification is limited in the amount of detailed information it can contain. This is because of the limitation of squeezing the information into a code that is fixed length and understandable to a human.

Figure 5 illustrate a tree simulation of a standard polycode with two numeric digits. There are many uses for the information that it contains. However, because the information is limited to only the two digit code, the depth of information stops at two levels. Even a thirty digit polycode is still quite limited in the amount of information it can contain. Consequently, it is limited in its usefulness in process planning and estimating.

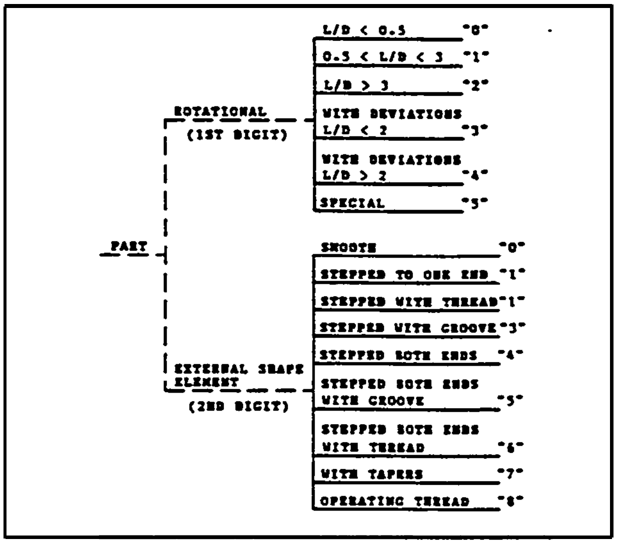


Figure 5

Figure 6 illustrates a DCLASS tree that could provide the same information shown in Figure 5, but also add information on threads, grooves, and holes that the polycode could not contain. DCLASS can generate the polycode with its many uses, but can also add additional information using its unique

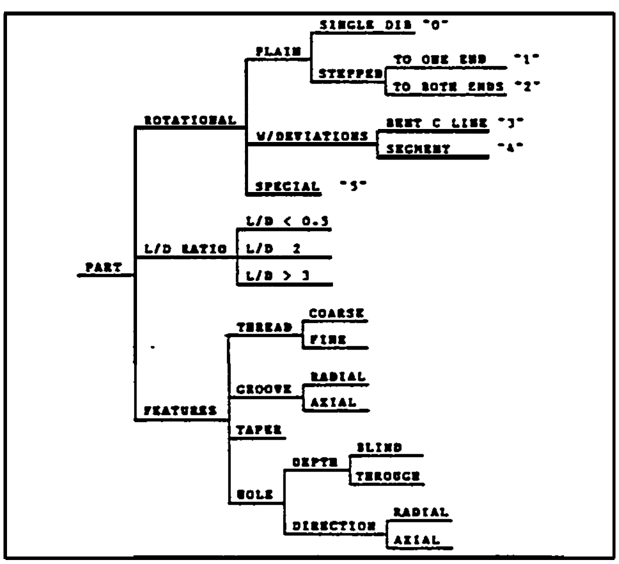


Figure 6

multiple path branching capabilities for as many levels as the user wanes. This flexibility of the DCLASS trees is important to capture the necessary information for functions such l s generative process planning.

Multiple-Path and Multiple-Level Branching

DCLASS Trees are very flexible in that they combine the powerful features of both multiple path and multiple level branching. This is made possible by a powerful new variable length binary code generated by DCLASS for a given session through a tree. This code is called a Machine Readable Code (MRC) as opposed to human readable monocodes and polycodes.

In a aonocode classification, selections are limited to a single path, although it may go several levels deep. In a polycode classification, selections are limited to two levels deep. Even a monocode/polycode combination retains these limitations for the monocode portion and the polycode portion of the code.

Figure 7 shows a Venn Diagram depicting the information contained in a DCLASS Machine Readable Code as compared to a monocode or polycode.

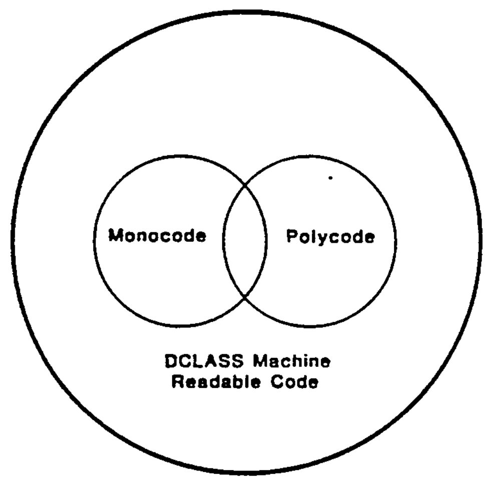


Figure 7

DCLASS can derive standard monocodes and polycodes, but additional information is also available. Because of the DCLASS Machine Readable Code, every piece of information is available for future use. For example, if a DCLASS decision-making tree requires information such *as is* the part rotational or does it have blind radial holes, the MRC can automatically provide it. Each requested piece of information is scored as a bit in the Machine Readable Code and is available as needed for automatic decision making. DCLASS codes are expandable and detailed, but require very little computer storage space.

Variables: Range or Actual Value

Another feature of DCLASS that is used in classification and coding is the ability to store variables such as "length" or "diameter." With the actual values, it can then evaluate simple arithmetic expressions such as automatically calculating L/D ratios. It is usually not suffcient for every need to fit a variable (e.g. DIAMETER) into a range of values and store it in a polycode digit. The design department may want one grouping of variable range a and the manufacturing department another. DCLASS helps to solve this problem by having a variable list along with the Machine Readable Code. A range code or the actual value of a variable is available to any user in the format he desires.

DCLASS - A Very High Level Programming Language

Since highly automatic tree processing capabilities are available In addition to multiple-path and multiple-level branching capabilities, DCLASS may be beat defined as a tree processing system with *a* very high-level tree definition language. This is why DCLASS not only can be used to derive codes, but it can tackle complex decision-making and "expert" artificial intelligence problems that were not easily approach before.

Decision-making know-how is a key element of a company-s business. You might be interested in counting how many of your experienced experts are now retiring and taking this valuable know-how with them. DCLASS allows you to analyze and co capture their decision-making logic and technical _know-how" so that it may be easily and consistently used by others in your company. Some companies that have DCLASS use the printed tree output as an official company document to define the company-s "decision-making logic". Since DCLASS has a very high level tree definition language, engineers with no computer experience can structure DCLASS trees themselves. This avoids dependence on computer specialists for needed programming tasks. Engineers and other non-programmers can easily modify and update tree logic so reflect changes in process capability. This makes it easy to automatically process new or old parts through the updated decision-making tree logic to reflect the latest technology and economics. Figure 8 contains a list of current industrial applications of DCLASS that

ADVANCED APPLICATIONS OF DCLASS™ BY INDUSTRIAL USERS

- Process Planning
  - A) Generative
  - B) Variant
- Time Standards
- Cost Estimating
- Part List Selection
- Circuit Design
- Personnel Selection
- (ECAM) Electronic Process Planning
- Tool Selection
- Equipment Selection
- APT Front-end Processing
- Material Selection

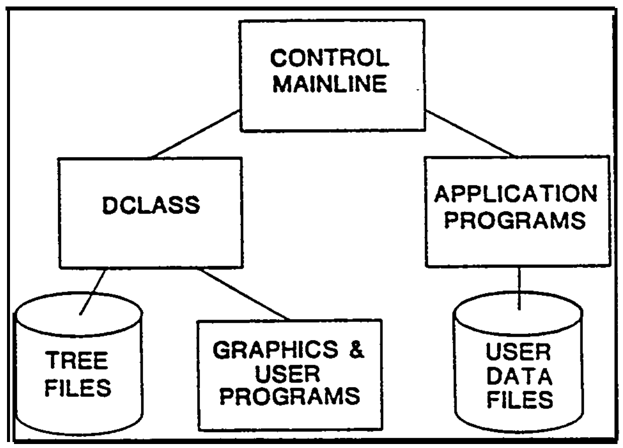
Figure 8

are dependent on these advanced tree programming capabilities.

Integrating DCLASS With Ocher Application Programs

The basic philosophy of DCLASS 19 two-fold. First, it is capable of accepting and processing any standard or user defined tree. Second, it is able to act as a subsystem to a user defined application.

DCLASS is a high-level programming system which, like a FORTRAN subroutine, can be integrated into many, many user application. BYU provides a simplified data base and Mainline program for tree development, testing and certain limited production aPPlication such as clasification and coding of parts and design retrieval. Written and delivered in FORTRAN source code, this Mainline can be tailored by the user, or DCLASS can be called by the users own mainline or explication system. DCLASS also contains interfaces for controlling the DCLASS tree processing. For example. user applications or graphics may be added in the middle of a tree traversal to pass data or codes needed to generate graphics on various CAD/CAM systems. Figure 9 illustrates the system environment of DCLASS integrated with a user application.



Conclusion

In this paper several important features of the DCLASS Information System have been briefly discussed, including how they compare to other commercial clasification systems.

DCLASS combines the very best features and capabilities of manual classification systems, 'hard-coded' clasification systems, and standard coding software systems. In addition, it has the unique advantage of being a general purpose tree processor, which greatly reduces your cost and trouble of having many expensive software systems which do not communicate with each other.

The advanced tree processing features of DCLASS allow it to process standard user defined trees containing information or decision-making logic. This logic can be easily tailored by the technician or engineer inastead of requiring computer programming specialist, DCLASS iS designed to provide many features as a stand-alone system and is also eastly tailorable to become a utility subsystem in a larger user application program, or as a powerful tool for system integration and standardization.

DCLASS has been developed as a very flexible and easy-to-use tool for solving many of today's complex problems. Its power and flexibility are important reasons for many companies choosing the DCLASS approach for their business.

R. P. Nillett
5-1-83

DCLASS™/APT INTERACTIVE PROGRAMMING SYSTEM

Purpose

The purpose of my thesis was to answer the question, "can an interactive programming system utilizing DCLASS technology be used to improve part programming productivity?"

Problem Statement

Present computer-assisted part programming languages for numerically controlled machine tools require extensive training of the programmer, the programming time is generally lengthy, and preparation and debugging of N/C tapes 1s often troublesome. These factors reduce N/C part programming productivity.

Approach

A series of tree structures was developed to provide an interactive menu-driven system to ease communication between the operator and the computer. The prototype system provides choices for each selection and each choice is logically controlled by the DCLASS processor. If the operator inputs incorrect data, an error message will be immediately displayed. A major advantage is that this programmer does not have to start the processing all over again. The system will automatically recover through the last corrected entry.

Furthermore, the system providea internally stored and easily. retrievable documentation which can provide tutorial information about various choices should the programmer desire it.

The prototype system was designed for use with rotational parts having one, two, or three outside diameters, bores, chamfers, grooves, and axial holes. During the setup mode, a series of interactive menus are presented to the programmer to describe part dimensions (length and diameter), form features, and workpiece material. This decision-making logic then automatically develops a sequence of required tool paths, calculates cutting speed and feed, provides horsepower requirements for the rough and finishing cut, and selects the appropriate tooling.

Once the information requested during the setup mode has been entered, the system automatically generates an "output record file." This file la then transferred to a preprocessor for decoding by meana of a FORTRAN compiler program to convert DCLASS records into APT statements for specific operations. During the preprocessor mode, the programmer is requested by the system to enter miscellaneous information such as programmer-s name, part name, part number, machine number, date, and coordinates for the home position. The generative source statements are stored in a temporary file for later post processing to provide instructions for a specific machine tool.

During the preprocessor mode, two reports are generated: (1) the manufacturing process sheet, and (2) the tool data sheet. The manufacturing process sheet contains the sequence of operations, feed rate, cutting speed, tool number and tool name for each operation. This tool data sheet contains the tool sequence, tool number, gage length, tool dimensions, and insert type for each operation.

Test Results

The automatic decision trees used for machinability calculations and tool selection produced reliable consistent results. This feature eliminates the need for N/C program verification. The machinability tree logic saves programmer time in finding the correct cutting speed for a given vorkpiece material. The system also allows the programmer to manually enter cutting depth or feed rate.

Tests were conducted using three subjects to program and evaluate system performance. The Intent of these tests was to determine if this system was efficient for use by those who were not specifically trained part programmers. Evaluation criteria included effort and time consumed in part programming tasks. The first selected subject was given a short 20-30 minute explanation of the system after which he was permitted to familiarize himself with the operation of the system. The subject was then given a part drawing for shape AOO and asked to program the part using the menu-driven system. Output tapes of programmed parts were then taken to the lathe for conducting actual test costs.

The second subject used to evaluate the system was a part programmer from a local manufacturing firm. His went through a brief indoctrination period similar to the first subject, after which he was asked to program part families A10 and A20 using the same system as before. The subject quickly adapted himself to use of the system as had the previous subject. Even though the second and third parts were move complex than the first one, the total producing time was considerably less than with the first subject.

Comments concerning operation of the system and suggested improvements were solicited from each subject immediately following the test.

The tabulated times for programming of the three test parts by both the "conventional" and the "interactive' methods are summarized in the table **below:**

PART FAMILY	CONVENTIONAL PROGRAMMING TIME	INTERACTIVE PROGRAMMING TIME
A00	105 min.	4.34 min.
A10	75.5 min.	4.50 min.
A20	99.5 min.	4.93 min.

This preliminary test, although not extensive, shows a reduction of 95% in programming time using the interactive method based on DCLASS technology. A further significant point is that relatively non-skilled programmers can provide rapid, consistent, and accurate results. The promising results of this study indicate that this method of programming should be expanded and promoted as a method for greatly improving programming- quality and productivity.

Sman Hamsrisuk
Graduate Student
nay 1983

WIRE AND CABLE COST ESTIMATING

Introduction

The purpose of this paper is to describe a current industrial application of the DCLASS Information System at Eaton Corporation. This application involves generating coat estimates for complex wire and cable extrusions at the Aurora, Ohio plant.

The application Is a dramatic example of a problem ideally suited to the high level programming features of DCLASS. Because of the power and ease of use of the DCLASS tree processor, the complex logic of this application was quickly programmed and a production system in place in a matter of a few weeks.

Problem Statement

The Aurora, Ohio Eaton plant manufactures complex wire and cable extrusions. There are literally hundreds of possible options to choose from including length, number and types of wire, and types of extrusions. An illustration of a sample product is contained in Figure 1. A team of three and one-half full-time engineers was required to determine cost estimate information for the more than 600 bids that were processed each month. Because of the complexity of the product, an average of one and one-half hours are needed to compute one cost estimate.

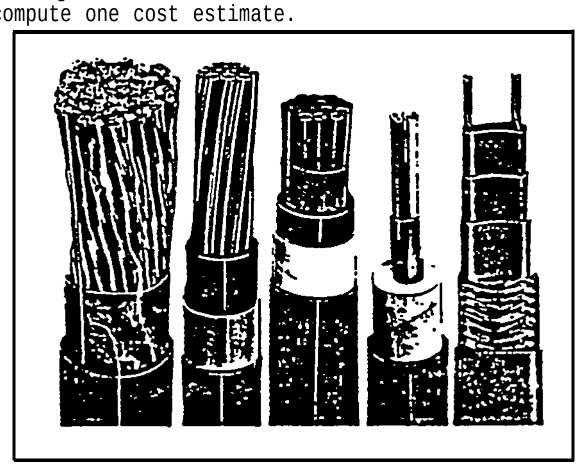


Figure 1

Logical DCLASS Application

DCLASS has been licensed to Eaton Corporation since early 1982 at the Corporate Manufacturing Services Division in Willoughby Hills, Ohio. The engineers in this division act as consultants to other Eaton divisions in solving manufacturing and other problems. Upon visiting the Aurora plant, Manufacturing Services engineers, headed by Willard Burge and Al Soles, proposed that DCLASS be used to approach a computerized solution to their cost estimating problem. The problem was very complex, had many possible options and variables, and the choice of one option would determine the possibilities for options further down the line. DCLASS was designed to solve just this type of complex problem.

DCLASS Tree Development

Once it was decided to implement the cost estimating procedure using DCLASS, the logic of the process was captured in DCLASS trees. The trees included the menus for the numerous options and the entry and computation of up to 175 different variables. About 600 man-hours were expended to design and enter these trees. An example of a small portion of one of these logical trees in shown in Figure 2.

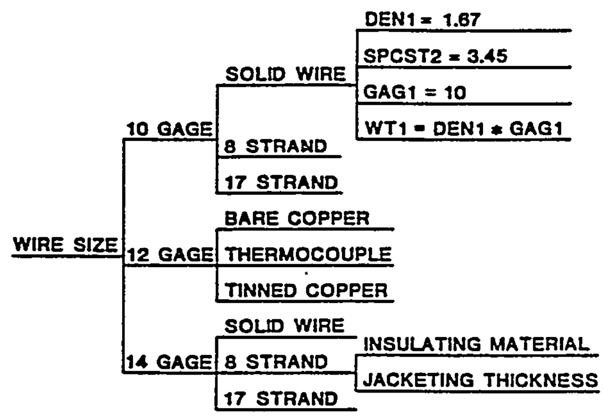


Figure 2

Production System

Because of the high level programming possible with DCLASS trees, the system was quickly tested and put into production three months after beginning the project. Minor system programming changes to the DCLASS mainline program were made by the Manufacturing Services staff to tailor the system to this application. This system tailoring in FORTRAN took only 1 week with one programmer.

The immediate results of the system were surprising even to the Manufacturing Services engineers. Instead of one and one-half hours for an estimate, the DCLASS-based system only took from five to six minutes. About 500 man hours are now being saved each month.

The built-in DCLASS capabilities of database statistics and design retrieval could now allow analysis of similar wire and cable extrusions and how many are being produced in various categories. A great potential is foreseen in using this data in marketing.

Additionally, Further future benefits are foreseen in using the computed variables for tooling selection and other programs down the line once an extrusion is ordered. A comparison of the time per part is shown in Figure 3 for the manual vs. the DCLASS-based system. Other important benefits are detailed in Figure 4.

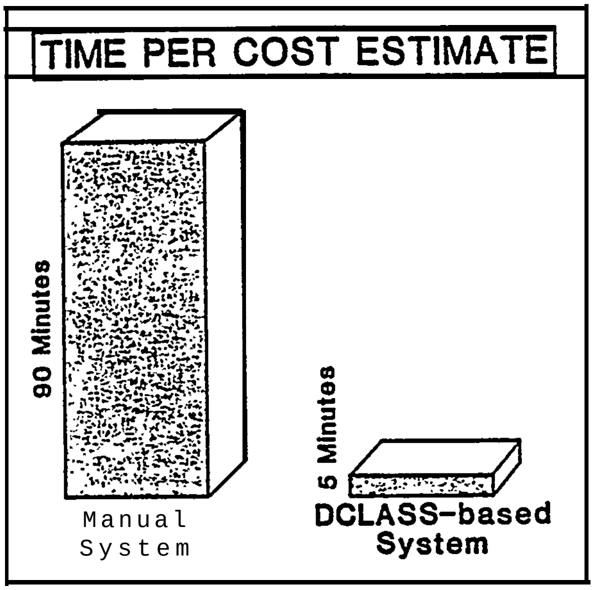


Figure 3

DCLASS BENEFITS

COST ESTIMATING AT EATON CORPORATION

- **Trees easy to develop**
- **Logic easy to visualize and debug**
- **More consistency in estimate**
- **Analysis of estimates possible**
- **Entered and computed data usable futher "downstream" (e.g. tooling selection)**

Figure 4

Conclusion

This paper has shown an example of a DCLASS application at Eaton Corporation that was quickly Implemented with very rapid return on investment. This example points out that DCLASS can be used for much *more* than classification and coding or process planning. It is a high level programming language **that is easy to use to solve complex decision-making problems. DCLASS is designed to be used by engineers and technicians rather than computer** specialists, and therefore can become a tool in the hands of the people who really know the problems.

In this application, Eaton engineers found that using DCLA8S was the logical decision.

Willard Burge
September 1983

Introduction

BYUPLAN is a Prototype generative process planning system developed at the BYU CAM Software Laboratory to show how the DCLASS Information System may be used in a process planning environment. BYUPLAN consists of a mainline control program that calls in sequence three decision trees, performs a look-up of operation text from data files, and formats the finished process plan.

Approach

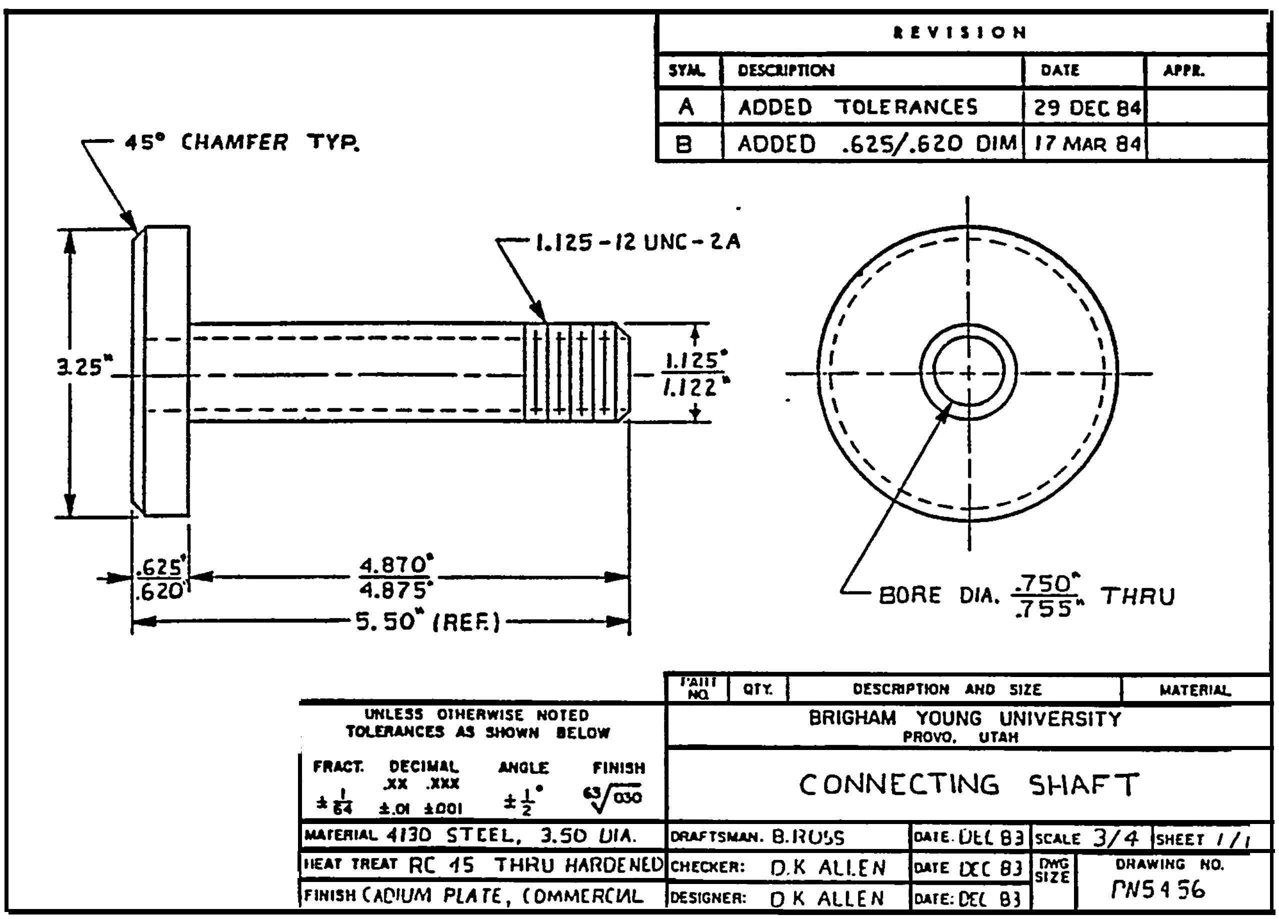
BYUPLAN was designed to Plan six families of rotational parts, and two families of sheet metal parts. Also included were seven different types of features, seven materlals, eight treatments and finishes. and three lot sizes.

Three DCLASS trees were then built to classify and code the part- select material and finishes, and select and sequence operations. The classification tree asksm questions concerning the shape of the part, and detailed questions about the form features it Contains. The material tree allows. the user to Select what type of raw material will be used, its size, and any finish requirements such as heat treatments and coatings. The third tree is a decision tree that is automatically traversed using Information previously gathered from the first two trees, and its output is a series of operation codes in proper sequence.

A report generator was then built to format a complete routing sheet or process plan from information gathered during the DCLASS tree traversal. The operation codes and variables from the DCLASS tree processing would be passed to the report generator where a table look-up to a data file would be performed to retrieve the complete text of the operation required. Any variables listed in the operation text would be inserted, and the final text for each operation would be added to the process plan. The completed plan would then be output to a line printer.

BTUPLAN Sample Run

Below is a part print for part number PN5456. After the print is an example run of process planning this part using BTUPLAN.



B`BYUPLAN3

```
CHOOSE OPTION : TERMINAL TYPE
   1 - VTI00
   2 - APPLE MONITOR
   3 - HARD COPY
   4 - SOROC (BILLINGS B-IOO).
   s - OTHER TERMINAL
   =9> 1

        * * B Y U P L & N * *

      DCLASS
        DEMONSTRATION
          PROCESS
            PLANNING
              SYSTEM

      BRIGHAM YOUNG UNIVERSITY

   CHOOSE OPTION :
   1 - DEFAULT DOCUMENTATION LEVEL
   2 - DOCUMENTATION LEVEL 10
   ==> 1

   ENTER DATE >07/27/84

   CHOOSE OPTION :
   1 - 40 CHARACTER LINE
   2 - 80 CHARACTER LINE
   =x>2

   . ENTER PLANNER NAME >> P R SMITH

        * * B Y U F L R N * *

     CHOOSE OPTION :
      1 - VARIANT PROCESS PLANNING
      2 - GEWNERATIVE PROCESS PLANNING
      3 - FART FILE MAINTENANCE
      4 - EDIT PLAN
      5 - PRINT PLAN
     99 - STOP
     ==>2

   ENTER FART NUMBER
   >>PN54S6

   ENTER PART NAME >>CONNECTING SHAFT

   ENTER REVISION NUMBER >>B

   ENTER DISTRIBUTION REQUEST >>.

     BASIC SHAPE
   *  1  - Rotational
      2 - NON-ROTATIONAL

   **>

 ROTATIONAL
*  1 -CENTRIC
   2 - CONCENTRIC
   3 - GEAR-LIKE

**> BU

   BASIC SHAPE
*  1 - ROTATIONAL
   2 - NON-ROTATIONAL

**>

 ROTATIONAL
*  1 -CENTRIC
   2 - CC)NCENTRIC
   3 -GEAR-LIKE

**> xx

 *************************%*%
   ROTATIONAL PARTS HAY BE:
   CENTRIC--NO CENTER HOLE
   CONCENTRIC--WITH CENTER HOLE
   GEAR-LIKE--WITH GEAR TEETH
   *****************************

TO CONTINUE - CARRIAGE RETURN >

  Rotational
*  1 - CENTRIC
   2 - CONCENTRIC
   3 - GEAR-LIKE

**> 2

  CONCENTRIC WITH A SINGLE DIAMET BORE
   1 - SINGLE O.D.
   2 - TWO 0.D.'S
   3 - THREE O.D.'S (STEPPED TO ONE END)

**> 2

  BORE DIAMETERS
   1 - ONE
   2 - TWO
   3 - THREE (STEPPED TO ONE END)

**> 1

        ENTER LENGTH 1     (ALL
        DIMENSIONS IN INCHES)
>.>.625

        ENTER LENGTH 2
>>4.875

        ENTER BORE LENGTH 1
>>5.50

        ENTER DIAMETER 1
>>3.25
```

ENTER DIAMETER 2
>>1.125

ENTER BORE DIAMETER
>>.750

ENTER STOCK SIZE
>>3.50

DIAMETER MINIMUM TOLERANCE
1 - TOLERANCE .0005-002
2 - TOLERANCE .002-.010

**> 1

ROTATIONAL FORM FEATURES
1 - HOLES
2 - THREADS
3 - CHAMFERS
4 - NO FEATURES

**> 293

THREADS
1 - INTERNAL THREADS
2 - EXTERN AL THREADS 2

**> 2

EXTERNAL THREAD TYPE
- UNIFIED NATIONAL COARSE (UNC)
2 - UNIFIED NATIONAL FINE (UNF)

**> 1

SELECT EXTERNAL THREAD
1 - CLASS 1A
2 - CLASS 2A
3 - CLASS 3A

**> 2

ENTER EXT, THREAD DIAM AND
THREADS / INCH (E.G. 2.0-8)
>>1.125-12

CHAMFER ANGLE
1 - 30 DEGREES
2 - 45 DEGREES
3 - 60 DEGREES
4 - OTHER CHAMFER ANGLE

**> 2

ENTER NUMBER OF CHAMFERS
>>2

CHOOSE PROCESSING OPTION:
1 - REVIEW CHOICES
2 - CONTINUE

==>2

MATERIAL
* 1 - MATAL.
2 - NON-METAL

**>

METAL
1 - ALUMINUM
2 - STEEL

**> 2

STEEL
1 - LOW CARBON
2 - ALLOY STEEL

**> 2

ALLOY STEEL
1 - 4130
2 - 4340

****> 1**

IS HEAT TREATMENT REQUIRED
1 - YES
2 - N o

**> 1

STEEL HEAT TREATMENT
1 - THRU HARDEN
2 - SURFACE HARDEN
3 - ANNEAL

**> 1

IS METAL FINISH COATING REQUIRED
1 - YES
2 - N o

**> 1

PLATING
- ZINC PLATING
2 - CODMIUM PLATING
3 - CHROMIUM PLATING

**> 2

CADMIUM PLATING
1 - TO MILITARY SPECIFICATIONS
2 - T O COMMERCIAL SPECIFICATIONS

**> 2

IS PAINTING REQUIRED
1 - YES
2 - N O

**> 2

```
CHOOSE PROCESSING OPTION:
 1 - REVIEW CHOICES
 2 - CONTINUE

 ==>2
       ENTER QUANTITY REQUIRED
>>10

       MACHINING TIME
             VALUE = 3.525597
>>

        PART HANDLING/IDLE TIME
             VALUE = 6.169795
>>

       TOTAL WORKPIECE TIME
             VALUE = 9.695392
>>

       COST PER WORKPIECE
             VALUE = 8.070000
>>
```

```
               -ENTER RC HARDNESS REQUIRED
       >>45


               ** B Y U P L A N **

       CHOOSE OPTION :
        1 - VARIANT PROCESS PLANNING
        2 - GENERATIVE PROCESS PLANNING
        3 - PART FILE MAINTENANCE
        4 - EDIT PLAN
        5 - PRINT PLAN
       99 - STOP
       ==>5

     ENTER PART NUMBER
     >>PN5456

     CHOOSE OPTION :  PRINT TO
     1 - SCREEN
     2 - PRINTER
     ==>1
```

```
--------------------------------------------------------------------------
--------------------------------------------------------------------------
                      ** B Y U P L A N **
                      GENERATED PROCESS PLAN
PART NO :PN5456                PART NAME : CONNECTING SHAFT
SHAPE : 811   MATL : A3-4130  REVISION NO : B
DATE :  3/23/1984              PLANNER : P R SMITH
--------------------------------------------------------------------------

OPNO DEPT DESCRIPTION               EQUIP  TOOLING  STD TIME RMRKS
--------------------------------------------------------------------------
  10 10  TURN FIRST DIAMETER TO    101-D  101-1-020
          ( 3.25      ) INCHES            101-7-020

  20 10  TURN SECOND DIAMETER TO
          ( 1.125     ) INCHES

  30 10  CENTER DRILL FOR BORE     101-D  111-1-040
                                          110-7-220

  40 10  DRILL CENTERHOLE FOR      101-D  111-1-020
          BORE                            111-7-020

  50 10  BORE I.D.  ( .750      )  101-D  102-1-040
          INCHES THRU                     102-7-020

  60 10  TURN ( 2         )        101-D  101-7-220
          CHAMFERS AT ( 45        )
          DEGREES

  70 10  TURN CLEARANCE GROOVE     101-D  104-1-080
          FOR EXTERNAL THREAD             104-7-040

  80 10  TURN ( 1.125-12 ) DIAM.   101-D  105-1-020
          UNC-( 2A       ) EXT.           105-7-020
          THREAD

  90 10  CUTOFF PART ( 5.500000 )

 100 95  HEAT TREAT TO             500-A
          ( 50        ) RC

 110 95  TEMPER TO ( 45       )RC  500-D

 120 55  GRIND O.D.'S TO SPEC.     121-E  121-1-020

 130 35  GAGE GROUND DIAMETERS

 140 55  VAPOR DEGREASE            623-A

 150 55  PICKLE PART CLEAN         609-A

 160 20  CADMIUM PLATE PER SPEC.   671-B

 170 90  FINAL INSPECTION, VISUAL

--------------------------------------------------------------------------
APPROVAL.................. DATE..............
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--------------------------------------------------------------------------
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COMPUTER-AIDED PROCESS PLANNING

BY: Dell K. Allen

Paul R. Smith

October 15, 1980

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CONTENTS

GENERATIVE PROCESS PLANNING

- ABSTRACT -

The problems and needs of process planning are presented along with two basic approaches for computer assisted process planning. Characteristics of the variant and generative approaches for process plannning are discussed. The use of decision tables and trees is explored as applied to generative process planning. Implementation of logical decision trees by means of a unique tree handling system is explained and typical generated process plans are shown.

- KEYWORDS -

Generative, process-planning, decision, tables, trees, computer-aided, DCLASS, variant, selection, and sequencing.

1.0 INTRODUCTION

1.1 Importance

The importance of process planning is succinctly stated in the statement: "Without the plan there is no process:" and its corrolary 'Without the process there is no product".

Creation of the process plan is an activity which is very important to orderly and efficient operation of the manufacturing enterprise. Once the product has been designed, work of the process planner probably has more impact on the cost, quality, and rates of production than any other activity of the enterprise.

Creation of a process plan in which process capabilities are mismatched with product requirements can result in excessive scrap and re-work, low output, excessive in-process inventory and high production costs. Alternatively, well formulated process plans can provide products of the required quality in the desired "quantity on the planned schedule and at a minimal cost.

1.2 Problem

There are a number of prob"lems with current manual planning methods.[1] These problems largely arise from the fact that manual process planning is a subjective function. It is based on previous experience of the planner, personal preference, extent of shop knowledge, interpretation of design requirements, and many, many judgement factors. The result is:

Inaccurate plans
1. Inconsistent plans
3. High production costs

Manual process planning requires continual re-education of planners regarding introduction of new processes and retiring of obsolete equipment. The shortage of experienced and skilled planners is a serious problem. Furthermore, many experienced planners are approaching retirement age and will take their processing knowledge with them when they retire. Inability to capture this knowledge base will be a serious loss to industry.

1.3 Needs

As has been pointed out, it is important to have good, consistent, and accurate process plans to regulate the production functions of the manufacturing enterprise. In order to create such plans it is necessary to have a logical, systematic process of developing and maintaining these plans. Furthermore, it is important to have agreed-upon conventions and rules for capturing the decision-making logic of process planning.

Following are some design objectives which have been suggested for systems which are to automatically generate process plans.[{c’]

1. Use only data available on the drawing
2. Eliminate all subjective, judgemental choices
3. Consistently produce the same plan for the same part
4. Must be simple to use; require minimal typing skills
5. Allow manual intervention for complex parts
6. Easy to incorporate new production techniques in system logic
7. System to operate on a small/medium size computer

In order to meet the above mentioned system design objectives it is necessary to develop (1) a standard data base and (2) a method of processing the data. Two computerized approaches to automated process planning have been developed; the first approach is called the variant approach and the second is called the generative approach. These approaches along with the traditional and workbook approaches will be briefly reviewed.

2.0 APPROACHES TO PROCESS PLANNING

2.1 Traditional Approach

The traditional approach to process planning is to examine a part print, identify similar parts (from memory or from a code book) and manually retrieve process plans for these similar parts. A new process plan is then created by modifying and adapting the old one to meet special requirements of the new part print. It is also customary practice for the process planner to consult with the foreman in the production shop to find out how the part is really being processed. The traditional approach to process planning has some advantages and several disadvantages. Two advantages are its low investment cost, and its flexibility. Disadvantages are the lack of consistency in identifying and in planning even similar parts, difficulty of specifying common tooling, and the difficulty of updating a manual file to reflect new processes and tooling.

Process planning has been largely an art--intuitive, subjective, and learned after considerable experience. The challenge today is that many of the natured process engineers are reaching retirement age and there is not a supply of process engineers waiting in the wings to replace them.

2.2 Workbook Approach

An innovative and quite efficient approach to process planning is to construct a workbook containing a menu of prestored sequences of operations for given types of workplaces. These stored process groups may be quickly selected and sequenced by the process planner. The menu selections are then typed on the regular process sheet and reproduced as required. An advantage of the system,is that a few well trained planners can produce large numbers of process plans for simple parts using this method. The main disadvantage of the method is that only a small number of variables may be accommodated without making the system unduly bulky. For example, only a few selected materials with a specified geometry, size, and quality may be readily planned. As a variety increases, the number of possible permutations and pages in the workbook increases exponentially.

2.3 Variant Approach

The variant approach to process planning is similar to the traditional approach except that a computer assisted planning program (CAPP) is required. Also a workpiece classification and coding system is needed. In use, standard process plans for each given family of parts are stored on magnetic disc. Editing and high speed printing capabilities of the computer are used to good advantage in printing modified standard plans. Major functions performed by the CAPP system are editing and retrieval; however, no logic is available to aid in creating or maintaining standard plans.

The variant system has been described by Barnes[3] as follows:

> A variant system is one based upon the retrieval and extension of a standard manufacturing plan, with the identification of such plan resulting from an established decision rule. A standard plan in this case being a permanently established ordered sequence of fabrication steps for a specific category of mono-detail parts.
>
> CAPP system logic is derived from Group Technology methods of classifying and coding machined parts for the purpose of segregating these into family groups. Each part family will be comprised of "like" parts having attributes sufficiently common to prescribe a common manufacturing method to all of the parts in that family group.
>
> The "sameness" of a group of parts will be determined by analysis of the classification codes of the encoded part spectrum. Sorting on discrete values, or sets or ranges of values, for individual attributes embedded in the part codes, will reduce the encoded part spectrum to increasingly numerous, homogeneous groups. The final reduction will result in part families, each with a membership of parts naturally susceptible of fabrication by a basically common method. Refine-

ment and/or sub-division of these groups will probably then be necessary to accommodate the constraints, capabilities and general characteristics of the object production facility.

In CAPP system terminology, the common manufacturing method established for a specific part family is the Standard Plan for that part family.

Some major disadvantages of the variant approach are: (1) the difficulty of constructing good standard plans, (2) the difficulty of maintaining consistency in editing practices, (3) inability to adequately accommodate various combinations of geometry, size, precision, material, quality, and shop loading, (4) the rather extensive keyboard activity required to enter and modify plans, (5) lack of transportability of the system, and (6) rather significant on-line data base requirements to accomodate stored plans and all their modifications. In an effort to overcome some of the difficulties of creating standard plans in a consistent manner, a glossary of opcodes and work elements was created.[4] This glossary provides a list of opcodes for machined parts as well as algorithms to aid in creating opcodes, work elements, and work element parameters for non-machining processes. It has also been found that extensive keyboard activity by the CRT operator can be minimized by storing many options with each standard plan and then deleting them, since the delete function is faster than keyboard entry.

The conditions under which the variant approach to process planning seems most viable is when:

1. The product design is fairly stable
2. Lot size is medium-high
3. Parts within a family are of similar size
4. Material type is the same for all members of the family
5. Few engineering changes are normally made

In spite of the promised benefits, the variant approach to computer aided process planning is not widely used because of the previously noted difficulties and the generally limited conditions under which it may be appropriately applied.

2.4 Generative Approach

The Generative approach to process planning may be described as a system for rapid creation of consistent, repetitive process plans based upon a series of pre-defined algorithms. The pre-defined algorithms may include decision-tree logic, classification theory, keywords, mathematical models, formatting routines, and the like. The major advantages of Generative process planning are the rapidity and consistency with which plans may be generated and ease of incorporating into the plans new processes, equipment, methods, and tooling.

Generative process planning was described by Barnes[5] in 1976 as follows:

> A generative system does not depend upon preordained sequences of operations. Instead, it is able to construct an optimum fabrication sequence of its own accord through a series of more refined and sophisticated decision algorithms which operate with much greater detail than those of a variant system.
>
> A generative approach is naturally desirable because of the high degree of automation achieved. However, we must walk before we can run. It is generally agreed that a generative process planning system must interrogate a 3-dimensional CAM part model as well as a comprehensive manufacturing technology data base for the system capability envisioned to become a reality. Progress is being made in both of these areas on many fronts. General solutions for the two requirements are, however, not yet available.

The requirements for generative process planning noted by Barnes are:

Logical decision algorithms
1. CAD part model
3. Manufacturing technology data base

While these requirements have not been totally met today, significant break-throughs have made it possible to do generative process planning for many types of parts and assemblies.

3.0 DECISION TABLES AND TREES

Logical decision-making algorithms are critical to generate process planning. Development of decision trees logic in the late 1950's paved the way for capturing the complex logic required for process planning by means of decision-tables and decision-trees.

3.1 Decision Tables

The cost of computer programming, debugging, and maintenance is now a substantial cost of a computer system. Programming productivity and efficiency are becomming very important factors in controlling software costs and providing rapid response to required system changes. In addressing these issues Humby (1973) says:

> One of the features of a well- designed program is the ease with which it can be modified. Ease of development corresponds closely to the systematic way the program was planned. The use of decision tables is often a hallmark of the systematic approach. (p.1)

One of the sure things in a manufacturing related computer program is change. Change is required because of changes in the product design, productive capability, consumer demands, improved understanding of interrelated variables and many other factors. In order to accommodate required changes in an efficient manner, Humby offers this important advice:

> One strategy.. . in designing a program that is to be easily updated is to consider those aspects that are most liable to change and *to* arrange (them in the form) of tables that can easily be renewed.

Decision tables are composed of conditions, data, and actions which are the principal elements of all computer programs. (Fig.1)

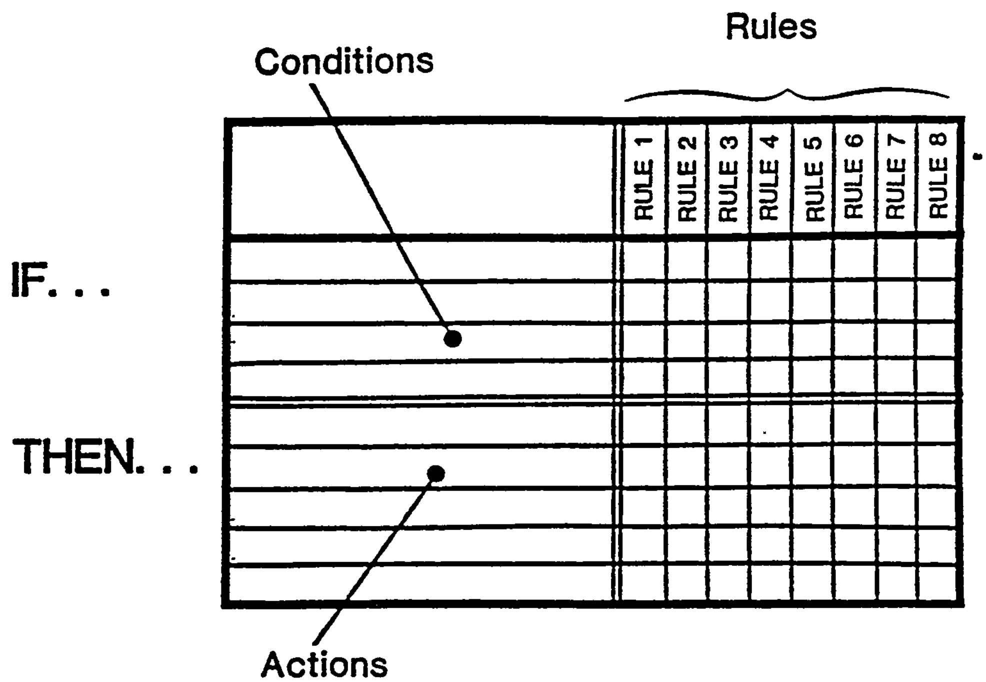


FIGURE 1. Decision Table-Basic Elements

Decision tables may be used, not only as a device which readily accomodates data changes but, one which may also contain a large part of the logic of any program.[7]

Decision tables were introduced in 1957 as aids for programming tasks requiring many logical processing actions but few arithmetic operations.[8] Decision tables are also very useful for systems analysis work in which logical alternatives are to be assessed. Furthermore, decision tables are a useful aid in reducing problems to their simplest form and present the results in a form that is easy to visualize and grasp.

A decisi on table may be defined as a tabular arrangement in which are defined all prerequisite conditions for all possible logical actions of a system separated from these possible actions. Given combinations of conditions are related to appropriate actions by means of columns of entries which constitute decision rules. The “If-Then" relationship of the decision rules is a significant feature of decision table logic.

3.1.1 Workpiece Classification Application

Decision tables are intended to direct complex processing of information in a compact and efficient manner, such as with workpiece classification or process planning. For example, shown in Figure 2 is a typical workpiecece which is to be classified as a prerequisite to process planning In Figure 3 and 4 are shown decision tables to aid in this workpiece classification and workpiece families. The double horizontal and vertical lines separate the conditions from the actions. Conditions are shown above the double lines and actions below them. Each vertical combination of conditions and actions is called a decision rule. The table is read by examining a single rule at a time in conjunction with the conditions at the left. Decision Rule 8, for example, portrays the following logic: IF the cylindrical workpiece to be classified has multiple diameters (three in number) stepped to one end with increasing steps, and with a thru going bore THEN the part family code to be assigned is B21. This same logic can be extended as far as necessary to aid in classifying various parts.

Some decision tables are self-contained or “closed” as shown in the previous examples. However, it is often desireable to call one table from another table to perform a specific function as with a subroutine.

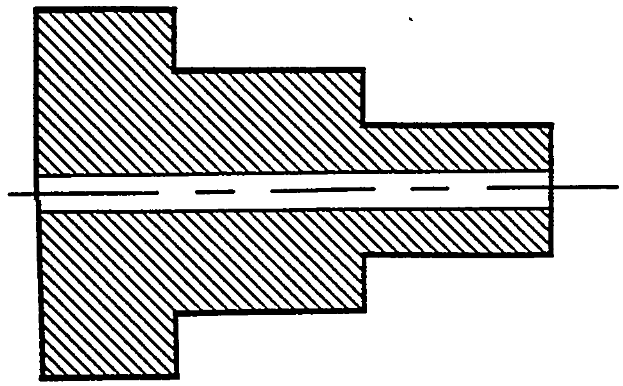


FIGURE 2 - Typical Workpiece

Cylindrical Parts	1	2	3	4	5	6	7	8	9	10
Multiple Diameter?	N	Y	Y	Y	Y	N	Y	Y	Y	Y
Three Diameter?	N	N	Y	Y	Y	N	N	Y	Y	Y
Stepped To One End?	N	Y	Y	N	N	N	Y	Y	N	N
Increasing Steps?	N	Y	Y	Y	N	N	Y	Y	Y	N
With Through Bore?	N	N	N	N	N	Y	Y	Y	Y	Y
Part Code A00	X									
Part Code A10		X								
Part Code A20			X							
Part Code A30				X						
Part Code A40					X					
Part Code B01						X				
Part Code B11							X			
Part Code B21								X		
Part Code B31									X	
Part Code B41										X

FIGURE 3 - Cylindrical Parts Decision Table

and then return to the original table. In Figure 5 are shown several decision tables and their sequence of execution. The calling table are "open" tables and are often executed by a "Go-To" statement. The closed table performs the function of a subroutine and may be accessed by using the "Do" command.

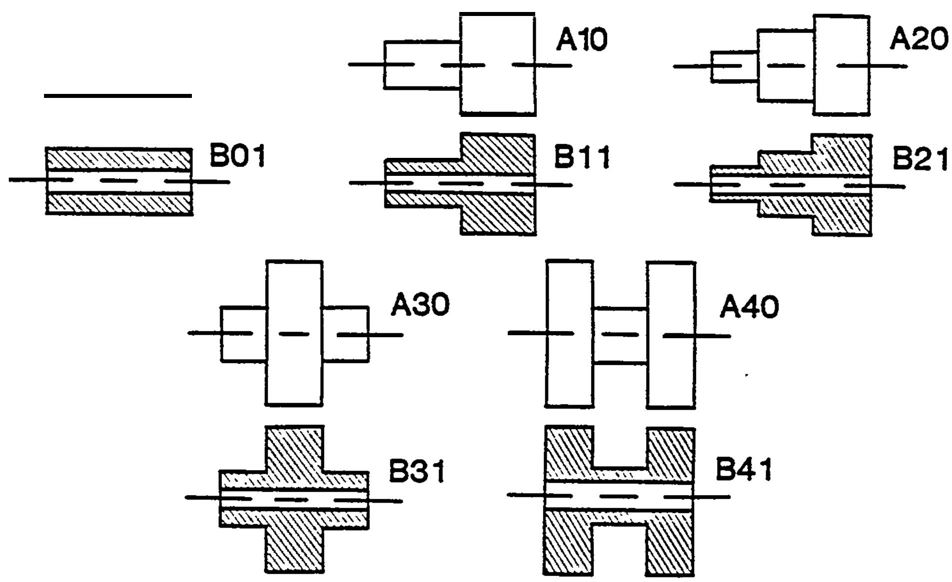


FIGURE 4 - Workpiece Families For Decision Table Shown in Figure 3

3.1.2 Process Planning Application

Another possible application for decision tables is in automated process planning. In Figure 6 is shown a process decision table for a plain cylindrical workpiece which has been classified as belonging to family "AOV'. Decision Rule 1 shows that the workpiece can be produced by material removal processes and gives an instruction to go to table 100. Table 100 (Figure 7) in turn shows that the part is to be made by mechanical material removal processes and Table 110 shows that the part should be turned and ground. It is quite easy to see how this logic could be expanded to include alternate materials, part sizes, and production quantities.

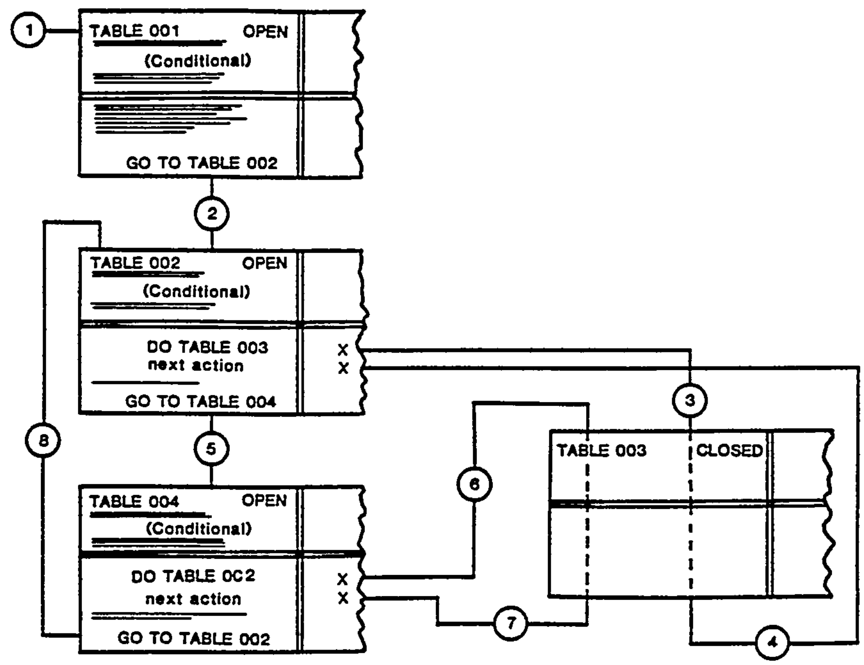
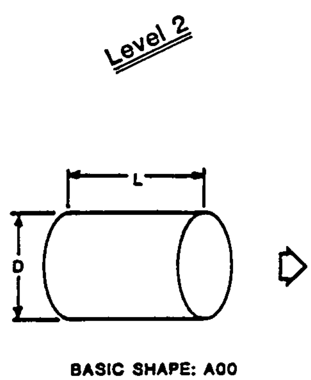


FIGURE 5 - Decision Table Sequencing



Process Decision Table

Table: A00 (Basic Shape)	1	2	3	4	5	6	7
Material Removal Process	Y						
Forming / Forging		Y					
Casting / Molding			Y				
Thermal Treating				N			
Cleaning / Finishing					N		
Joining						N	
Inspect							N
GO TO Table 100	X						
GO TO Table 200		X					
GO TO Table 300			X				
GO TO Table 400							
GO TO Table 500							
GO TO Table 600							
GO TO Table 700							
RE-ENTER TABLE	X	X	X	X	X	X	X

FIGURE 6 - Process Decision Table

While decision tables are potentially good tools, they are not widely understood nor used. They are quite difficult to maintain in practice and present some difficulty in expansion and updating. Finally, few decision table handlers are available. With these problems in mind, the next section deals with a new approach to decision logic.

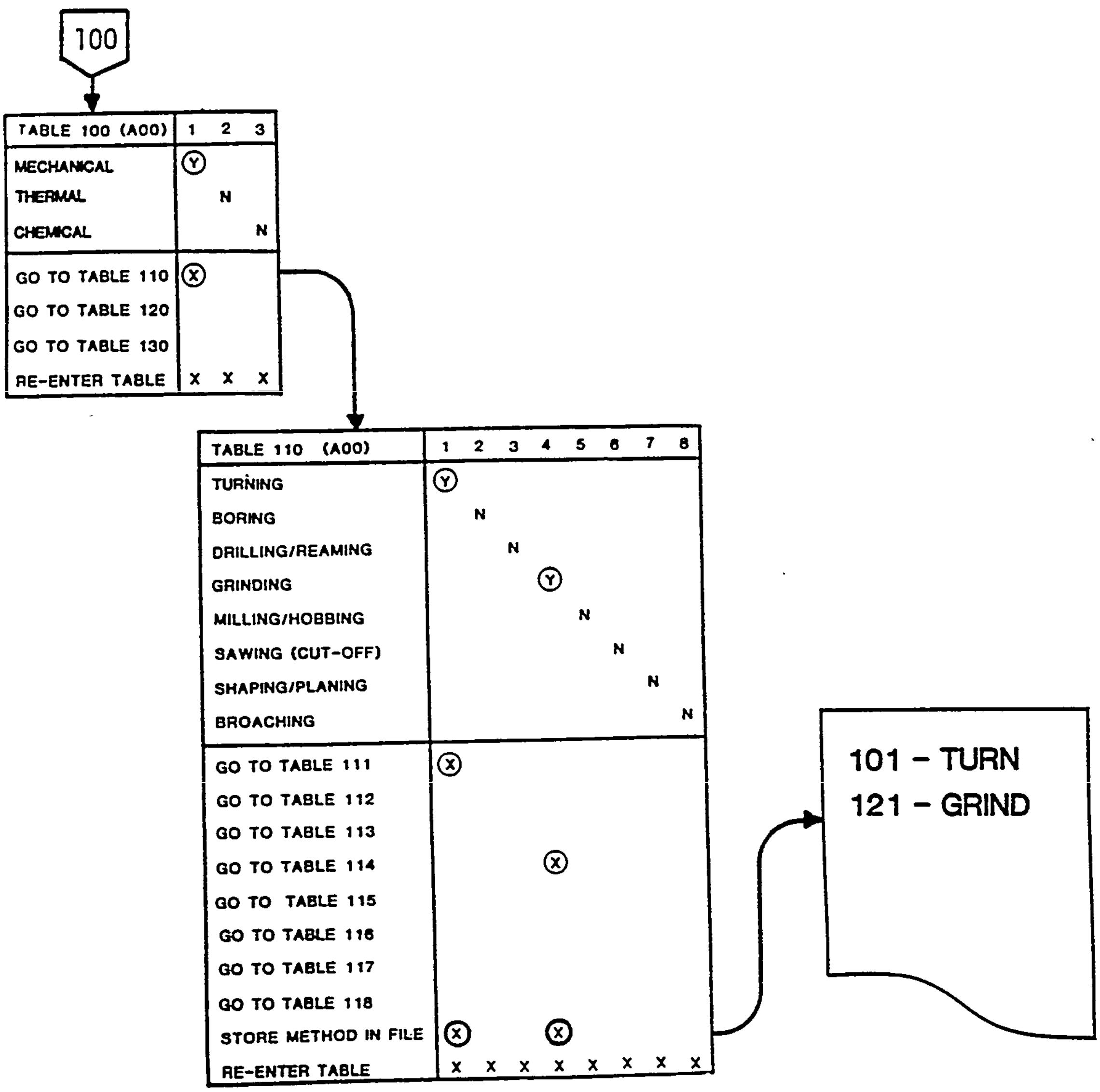


FIGURE 7 - Decision Table for Process Planning

3.2 Decision Trees

Decision tables may be converted into decision trees as shown in Figure 8.[6]

Decision Table - Decision Tree

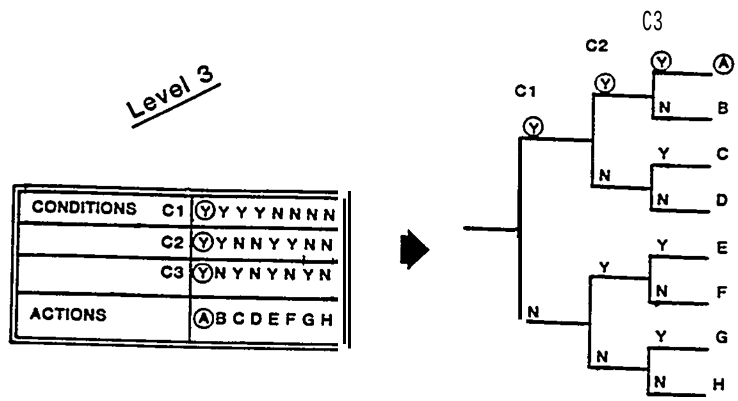


FIGURE 8. Decision Table Conversion To A Decision Tree

Decision trees have certain definite benefits over decision tables: First, trees are easier to update and maintain than decision tables. Second, selected branches of the decision tree may be extended to a considerable depth if necessary, while other branches may be quite short, which is more difficult to do with decision tables. Third, some branches of the decision tree may be used to define TYPE and others, ATTRIBUTES, which results in relatively small trees, and Fourth, trees are easy to customize, visualize, develop, and de-bus. There are several types of trees which may be developed to aid in classification, characterization, selection, and complex decision-making. These types of trees will now be briefly discussed.

3.2.1 E-Trees

The E-tree shown in Figure 9 is basically a hierarchal tree consisting of mutually exclusive paths. There may be binary or multiple branches at each node. Experience has shown that an excessive number of branches at a given node increases the likelihood of incorrect path selection. The E-tree is useful in dividing large populations of things by type and sub-type into small, manageable families.

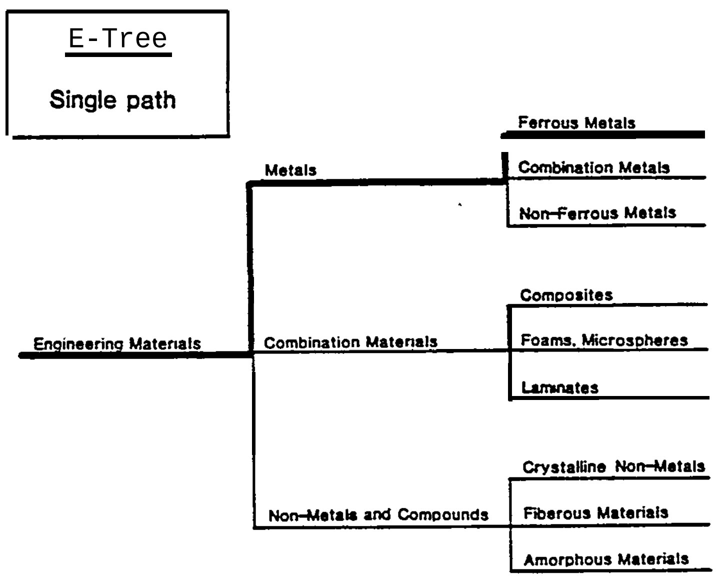


FIGURE 9. E-Tree

In use,a keyword is entered and ONE path is selected at each node until a terminal node is reached. The E-tree is particularly useful for classification and design retrieval. Family codes may be associated with terminal nodes if desireable. In Figure 10 is shown a portion of an E-tree for workpiece classification.

During tree traversal with computerized systems bit-strings may be generated which provides a very rapid method of comparison for retrieving of similar parts.

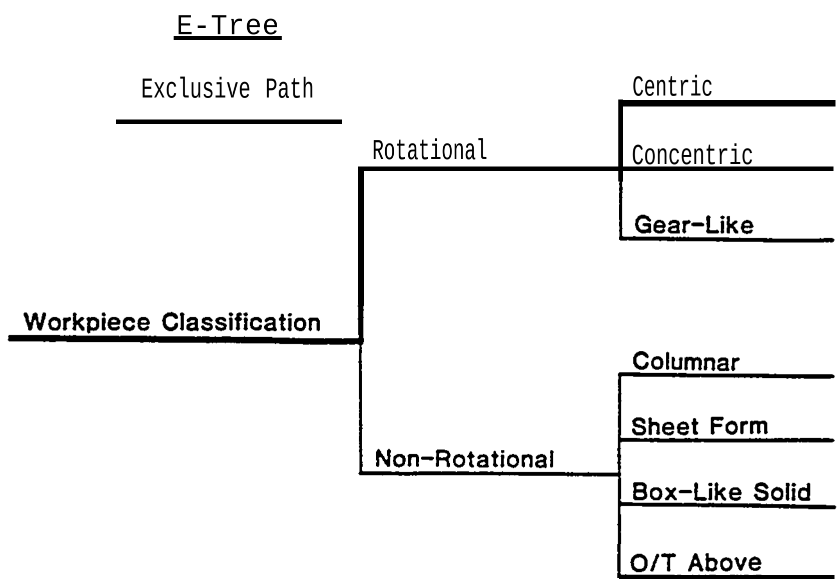


FIGURE 10. Workpiece Classification Tree

3.2.2 N-Tree

Another very useful type of tree is the N-tree which stands for NON mutually exclusive path selection. This tree, shown in Figure 11 allows the user to characterize a given entity (workpiece) to almost any degree desired. In use, any number of nodes may be selected concurrently. The attributes selected may include form features (holes, slots, threads, etc.), treatments (anneal, normalize, surface harden, etc.) or finishes (anodize, chromeplate, burnish, etc.). In addition, position, orientation, and any pattern of features may be described with an N-tree. Attributes of particular interest are those required for process planning and estimating.

3.2.3 Combination Trees

An extremely powerful tree results with the E-tree/N-tree combination. Things may be readily classified into families by type and subtype using the E-tree and then completely characterized by means of the N-tree attributes. Relatively small trees can, with this scheme, be used to uniquely classify literally billions of things.

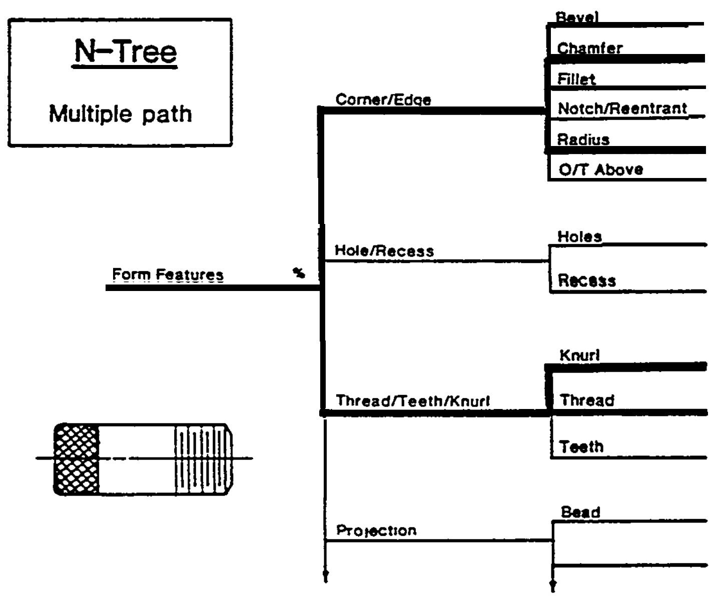


FIGURE 11. N-Tree

3.2.4 D-Tree

The D-tree or decision tree is useful for complex decision-making. Output codes or keys collected from E-trees and N-trees may be used as input keys to decision trees. With this approach and decision tree handling systems such as DCLASS, automatic decision making results. For example complex process plans may be generated, equipment and processing parameters selected, and costs estimated--automatically. In Figure 12 is shown part of a decision-tree for generative process plans for sheetmetal parts.

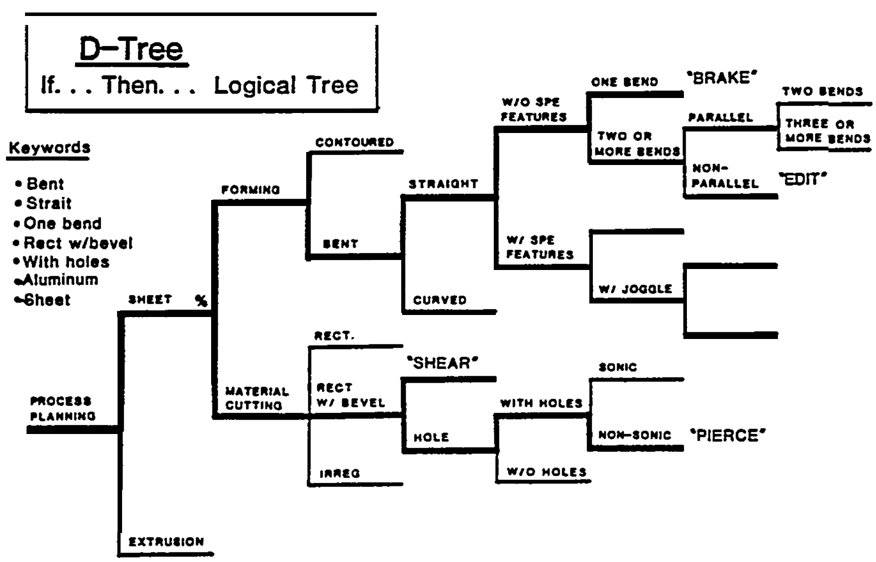


FIGURE 12. D-Tree

The D-tree forms the basis for one common method of generative process planning.

Use of the D-tree approach enables an organization to capture company-specific logic and standardize of production methods for given families of products. This same type of logic may also be applied to many other aspects of the manufacturing enterprise.

4.0 GENERATIVE PROCESS PLANNING

Generative process planning using tree structures poses several possibilities. First, is the use of decision trees with keys and second, the use of hierarchal information trees with keyyords.

In the decision tree approach, the information required for process planning is first acquired from the classification of the part. This information (keys) are then used to determine the path selection on a process decision tree. The path selected contains the processes, equipment, and tooling required to manufacture a given part.

The hierarchal information tree approach is based on the classification of items rather than if. ..then ...decisionsion tree logic. Keywords are loaded against general type information trees and the logical combinations of the keywords will output the necessary processes, equipment, and tooling required.

4.1 Decision Logic Trees

Process planning using decision logic trees consists of two major functions, part information acquisition and decision tree traversal. The part information can be acquired by traversal of general classification and coding tree. Some of the major items that need to be included in this classification are basic shape, features, treatments, size, quantity, tolerance, critical dimensions Figure 13 and material Figure 14. As these items are encountered during the coding of the part, keys are collected and stored for later use on the decision tree. Some minor calculations such as length/diameter ratios may also be done during the

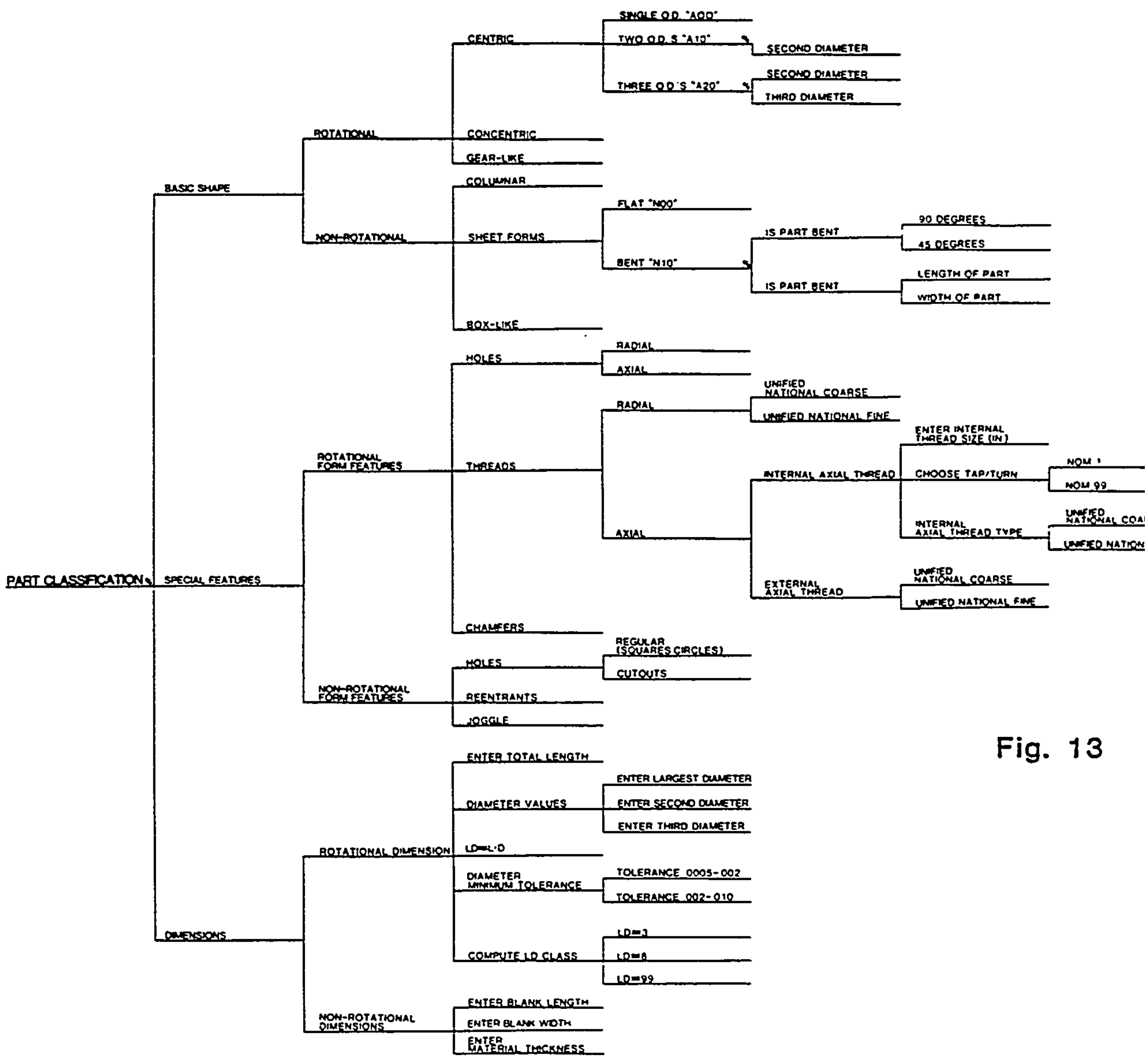

PART CLASSIFICATION
BASIC SHAPE
ROTATIONAL
CENTRIC
SINGLE O.D. "A00"
TWO O.D.S "A10"
SECOND DIAMETER
THREE O.D.'S "A20"
SECOND DIAMETER
THIRD DIAMETER
CONCENTRIC
GEAR-LIKE
NON-ROTATIONAL
COLUMNAR
SHEET FORMS
FLAT "N00"
BENT "N10"
IS PART BENT
90 DEGREES
45 DEGREES
IS PART BENT
LENGTH OF PART
WIDTH OF PART
BOX-LIKE
SPECIAL FEATURES
ROTATIONAL FORM FEATURES
HOLES
RADIAL
AXIAL
THREADS
RADIAL
UNIFIED NATIONAL COARSE
UNIFIED NATIONAL FINE
AXIAL
INTERNAL AXIAL THREAD
ENTER INTERNAL THREAD SIZE (IN)
CHOOSE TAP/TURN
NOM 1
NOM 99
INTERNAL AXIAL THREAD TYPE
EXTERNAL AXIAL THREAD
UNIFIED NATIONAL COARSE
UNIFIED NATIONAL FINE
CHAMFERS
NON-ROTATIONAL FORM FEATURES
HOLES
REGULAR (SQUARES CIRCLES)
CUTOUTS
REENTRANTS
JOGGLE
DIMENSIONS
ROTATIONAL DIMENSION
ENTER TOTAL LENGTH
DIAMETER VALUES
ENTER LARGEST DIAMETER
ENTER SECOND DIAMETER
ENTER THIRD DIAMETER
LD=L/D
DIAMETER MINIMUM TOLERANCE
TOLERANCE .0005-.002
TOLERANCE .002-.010
COMPUTE LD CLASS
LD=3
LD=8
LD=99
NON-ROTATIONAL DIMENSIONS
ENTER BLANK LENGTH
ENTER BLANK WIDTH
ENTER MATERIAL THICKNESS

Fig. 13

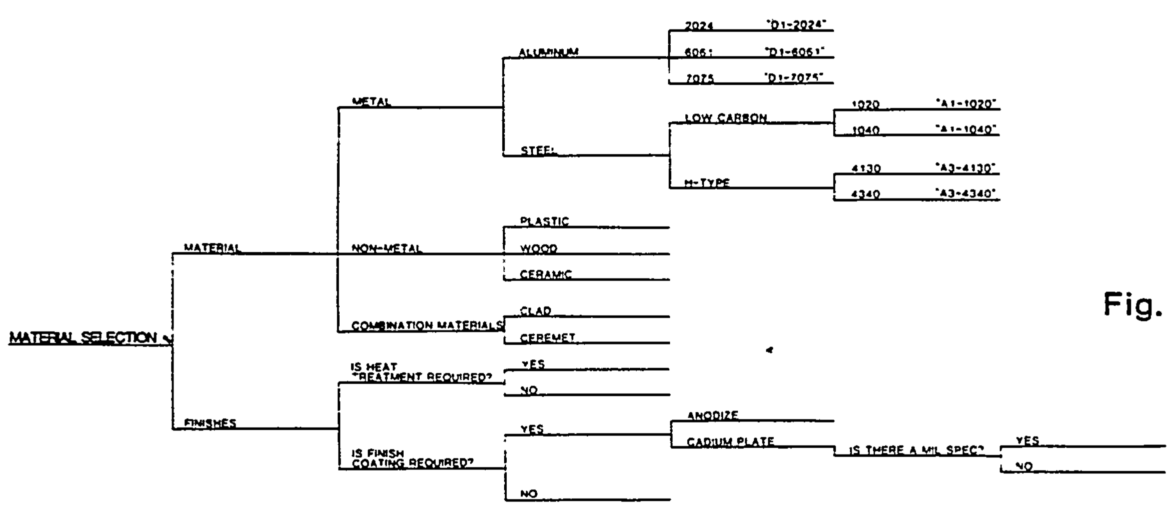

MATERIAL SELECTION
MATERIAL
METAL
ALUMINUM
2024 "D1-2024"
6061 "D1-6061"
7075 "D1-7075"
STEEL
LOW CARBON
1020 "A1-1020"
1040 "A1-1040"
H-TYPE
4130 "A3-4130"
4340 "A3-4340"
NON-METAL
PLASTIC
WOOD
CERAMIC
COMBINATION MATERIALS
CLAD
CEREMET
FINISHES
IS HEAT TREATMENT REQUIRED?
YES
NO
IS FINISH COATING REQUIRED?
YES
ANODIZE
CADIUM PLATE
IS THERE A MIL SPEC?
YES
NO
NO

Fig. 14

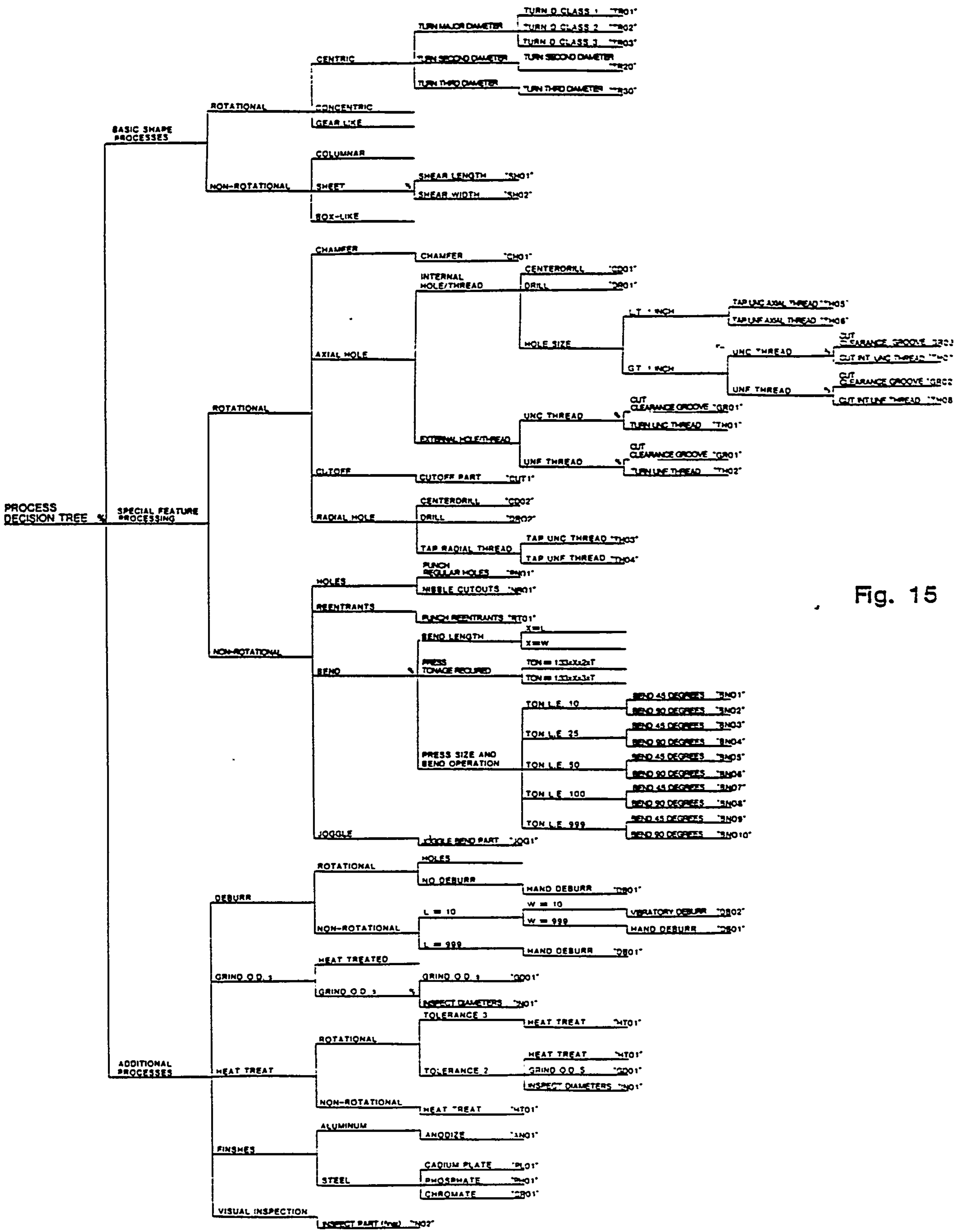

PROCESS DECISION TREE
BASIC SHAPE PROCESSES
ROTATIONAL
CENTRIC
TURN MAJOR DIAMETER
TURN D CLASS 1 "TR01"
TURN D CLASS 2 "TR02"
TURN D CLASS 3 "TR03"
TURN SECOND DIAMETER
TURN SECOND DIAMETER "TR20"
TURN THIRD DIAMETER
TURN THIRD DIAMETER "TR30"
CONCENTRIC
GEAR LIKE
NON-ROTATIONAL
COLUMNAR
SHEET
SHEAR LENGTH "SH01"
SHEAR WIDTH "SH02"
BOX-LIKE
SPECIAL FEATURE PROCESSING
ROTATIONAL
CHAMFER
CHAMFER "CH01"
AXIAL HOLE
INTERNAL HOLE/THREAD
CENTERDRILL "CD01"
DRILL "DR01"
HOLE SIZE
L.T. 1 INCH
TAP UNC AXIAL THREAD "TH05"
TAP UNF AXIAL THREAD "TH06"
G.T. 1 INCH
UNC THREAD
UNF THREAD
EXTERNAL HOLE/THREAD
UNC THREAD
CUT CLEARANCE GROOVE "GR01"
TURN UNC THREAD "TH01"
UNF THREAD
CUT CLEARANCE GROOVE "GR01"
TURN UNF THREAD "TH02"
CUTOFF
CUTOFF PART "CUT1"
RADIAL HOLE
CENTERDRILL "CD02"
DRILL "DR02"
TAP RADIAL THREAD
TAP UNC THREAD "TH03"
TAP UNF THREAD "TH04"
NON-ROTATIONAL
HOLES
PUNCH REGULAR HOLES "PN01"
NIBBLE CUTOUTS "NB01"
REENTRANTS
PUNCH REENTRANTS "RT01"
BEND
BEND LENGTH
X=L
X=W
PRESS TONAGE REQUIRED
TON = 1.33xXx2xT
TON = 1.33xXx3xT
PRESS SIZE AND BEND OPERATION
TON L.E. 10
BEND 45 DEGREES "BN01"
BEND 90 DEGREES "BN02"
TON L.E. 25
BEND 45 DEGREES "BN03"
BEND 90 DEGREES "BN04"
TON L.E. 50
BEND 45 DEGREES "BN05"
BEND 90 DEGREES "BN06"
TON L.E. 100
BEND 45 DEGREES "BN07"
BEND 90 DEGREES "BN08"
TON L.E. 999
BEND 45 DEGREES "BN09"
BEND 90 DEGREES "BN010"
JOGGLE
JOGGLE BEND PART "JOG1"
ADDITIONAL PROCESSES
DEBURR
ROTATIONAL
HOLES
NO DEBURR
HAND DEBURR "DB01"
NON-ROTATIONAL
L = 10
W = 10
W = 999
VIBRATORY DEBURR "DB02"
HAND DEBURR "DB01"
L = 999
HAND DEBURR "DB01"
GRIND O.D. 1
HEAT TREATED
GRIND O.D. 1
GRIND O.D. 1 "GD01"
INSPECT DIAMETERS "IN01"
HEAT TREAT
ROTATIONAL
TOLERANCE 3
HEAT TREAT "HT01"
TOLERANCE 2
HEAT TREAT "HT01"
GRIND O.D. S "GD01"
INSPECT DIAMETERS "IN01"
NON-ROTATIONAL
HEAT TREAT "HT01"
FINSHES
ALUMINUM
ANODIZE "AN01"
STEEL
CADIUM PLATE "PL01"
PHOSPHATE "PH01"
CHROMATE "CR01"
VISUAL INSPECTION
INSPECT PART (final) "IN02"

Fig. 15

classification of the part. The information collected (keys, variables, codes) is then transferred to a process decision tree.

The decision tree has several features not found in other tree structures. These features include the option of structuring the tree to properly sequence output, the ability to be easily modified to accommodate new capabilities or capacities, the ability to detect, at specific decision points, keys from previous trees, and to use these keys to choose a particular path.

The process decision tree is structured to duplicate an existing manufacturing facility as to its process capabilities, equipment, and planning strategies. These items are structured into if.. .then... logical situations with the appropriate decision points set to detect particular keys.

Process planning is then accomplished by classifying a particular part to obtain the keys, codes, and variables required to traverse the decision on tree Figure 15. This information is passed to the decision tree which is then traversed automatically, stopping only to ask any unanswered questi ons. The path through the tree is determined by the keys and variables obtained from previous trees. The result of the tree traversal and its subsequent path is a series of codes in a given sequence. These codes can then be passed to a text editor or report generator for processing into the appropriate text and format for a process routing sheet. Attachments A, B and C are sample outputs generated by this method using several small demonstration trees. Output may be varied to include as much or as little detail as required depending upon the complexity of the decision tree structure and the text editor. Time standards may also be calculated using appropriate decision trees.

4.2 Hierarchal Information Trees

The second approach to generate process planning is to use hierarchal information trees (E-trees and keywords) instead of decision trees, While this method has not been fully tested at present, it has several potential advantages over decision trees for some applications. The most notable advantage. is that any manufacturing facility can use the general taxonomies without having to redevelop company specific decision trees, thus providing transportability.

In order to perform generative process planning hierarchal information trees the following prerequisites are needed:

1) Workpiece Classification System
2) Process Taxonomy
3) Materials Taxonomy
4) Equipment Taxonomy
5) Tooling Taxonomy
6) Keywords and Codes

Items 1 through 5 are general classification trees that are transportable to any manufacturing facility. The keywords and codes are user defined to make the trees reflect a particular manufacturing situation.

After the trees have been established, the keywords must be loaded onto them. Keywords need to be developed for such things as basic shapes, form features, treatments, quantity, material, tolerance, etc. These keywords are derived from the workpiece classification. The keywords are then individually loaded on the taxonomies by traversing the tree and selecting all paths that pertain to that keyword.

This approach requires the use of two process trees. The first tree is used to determine the major process to create the basic shape of the part while the second tree contains all the possible operations needed for the details of the process routing sheet.

Process planning may be accomplished by classifying the part, which supplies a list of keywords and codes. These keywords may then be logically “anded” on the taxonomies with suitable processes, equipment, and tooling codes provided as output codes. Since the taxonomy cannot be structured to sequence its output, sequencing is needed to list the codes in proper order for the routing sheet. Three possible sequencing methods include 1) manual sequencing, 2) use of a sequencing algorithm such as a truth table, or 3) the creation of a decision tree for sequencing. As with the decision tree, the output codes may then be transferred to a text editor or report generator to be properly formatted into a routing sheet.

5.0 SUMMARY

In Generative Process Planning using Decision Trees, the planning algorithm is contained in the tree structure and keys. The keys picked up from previous information trees, with their associated linkages, are used to traverse a process tree automatically, stopping only to ask unanswered questions. Because of the nature of a decision tree, it can be structured to sequence its output (codes) depending on the path through the tree. This is particularly useful for the sequencing of detail operations as part characteristics are changed.

The decision tree is built to reflect a given manufacturing shop along with the manufacturing theory of the facility. If capabilities or capacities are acquired or lost, the decision tree is easily modified to reflect those changes. As plans can be generated each time, instead of retrieved from old files, they are constantly in harmony with the capabilities and capacities of the existing manufacturing facility.

In the hierarchal approach, general information trees or taxonomies may be used with the planning algorithm contained in the keywords and their associated combination of paths through the trees. While new trees do not have to be redeveloped for each facility, the keyword paths must be established by each user. An external sequencer is also required.

Generative process planning is almost totally automatic. It requires minimal input from the operator, and then only when logic has not been completely satisfied, or when human decision making is best. It is believed that perhaps as much as 80 percent of the process plans may be generated, and the balance, which will be the more difficult ones, left to experienced process planners. Thus, the goal is to let machines do those things for which they are best suited, namely the routine, logical, and high speed searching and comparison, and let humans perform the more complex, non-routine, and creative tasks.

* * * *

REFERENCES

1. Wamba, Phil. "Boeing Generative Process Planning System" Boeing Computer Services, Inc. Seattle, WA. Coverhead slide presentation.

2. Ibid.

3. Barnes. Robert D. "Group Technology Concepts Relative to the CAM-I Automated Process Planning (CAPP) System' presented to the Executive Seminar on Coding, Classification and Group Technology for automated planning, 21 Jan. 1976, St. Louis, MO, p. 136.

4. Allen, Dell K. "Computer Aided Process Planning OPCODES and Work Elements for Machined Parts" Final Report for CAM-I, Inc. Arlington, TX, Dec. 2, 1978.

5. Barnes, Robert, D. Op. Cit. p. 136.

6. Humby, E., Programs from Decision Tables, American Elsevier, N.Y. 1973.

7. ________________________ Decision Tables, IBM.

8. Chapin, Neo, "An Introduction to Decision Tables", Computer Digest, August 1967, p. 5 ff.

TURNED PART

PART NO.NEW PART NAME : LOCK BOLT
SHAPE : A1O MAIL : A3-4340 REVISION NO: 2
DATE : 15-SEF-8O PLANNER : PAUL R. SMITH

OpF'NO	DEPT	DESCRIpTION	EQUIF	TOOLING	STD TIME	REMARKS
10	10	TURN FIRST (2.OO) DIAMETER	101-D	101-1-020 101-7-020		
20	10	TURN SECOND (.750) DIAMETER				
30	10	TURN CHAMFERS	101-D	101-1-020 101-7-020		
40	10	TURN CLEARANCE GROOVE FOR AXIAL THREAD	101-D	104-1-080 104-7-040		
50	10	TURN (3/4-16) SIZE UNF THREAD	101-D	105-1-025 105-7-020		
60	10	CUT TO (3.00) LENGTH	101-D	104-1-020 104-7-020		
70	25	CENTER DRILL FOR RADIAL HOLE	111-G	111-1-040 111-8-020 110-7-080		
80	25	DRILL (.500) RADIAL HOLE THRU	111-G	111-1-020 111-8-020 110-7-080		
90	15	HANU DEBURR		613-1-020		
100	95	HEAT TREAT (56) TO RC HARDNESS	500-A			
110	90	FINAL INSPECTION, VISUAL				

APPROVAL.................... . D A T E
DISTRIBUTION : INDUSTRIAL ENGINEERING

SHEET METAL PART

PART NO,NEW
SHAPE : N1O /lATL : D1-2024
DATE : 15-SEP-80

PART NAME : BRACKET
REVISION NO : 5
PLANNER : PAUL R. SMITH

OF NO.	DEPT	DESCRIPTION	EQUIP	TOOLING	STD TIME	RMRKS
10	30	SHEAR STOCK (48.0) TO BLANK LENGTH	131-A	131-1-020		
20	30	SHEAR STOCK (8.0) TO BLANK WIDTH				
30	65	STAMP REGULAR HOLES	140-T			
40	70	BEND 45 DEGREES 50 TON PRESS BRAKE	350-4	351-1-020		
50	70	JOGGLE BEND	360-A	353-1-020		
60	15	HAND DEBURR		613-1-020		
70	20	ANODIZE	673-A			
80	90	FINAL INSPECTION VISUAL				

APPROVAL.................. DATE...............
DISTRIBUTION : PRODUCTION CONTROL

PRINTED WIRING BOARD ASSEMBLY

PART NO. NEW] PART NAME : MEMORY BOARD
SHAPE : RML1 MATL : T2-EF'OX REVISION NO : 6
DATE : 16-SEF-80 PLANNER : PAUL R. SMITH

OPNO	DEF'T	DESCRIPTION	EQUIP	TOOLING	STD	TIME	RMRNS
10	10	ETCH ALL LAYERS	197-A	197-2-MUL			
20	30	LAilINATE (6) BOARD LAYERS	282-A				
30	45	DRILL MOUNTING HOLES	111-D	111-1-020			
40	45	ROUT BOARD EDGES					
50	65	SELECT HARDWARE (MANUAL)					
60	65	SELECT COMPONENTS (MANUAL)					
70	75	INSTALL HARDWARE					
80	75	PREFORM COMPONENTS					
90	80	INSERT COMPONENTS FIVE OPERATORS					
100	25	TRIM COMPONENT LEADS					
110	60	BAKE BOARD DRY					
120	35	HAND SOLDER					
130	45	RUN FUNCTIONAL TEST					
140	45	RUN HOT & COLD TEST					
150	55	RUN BURN-IN TEST					

APPROVAL . . . . DATE . . . .
DISTRIBUTION : PRODUCTION CONTROL

DCLASS LICENSE AND FEE STRUCTURE

DEFINITIONS

I. The following operating systems are designated as "Type A" Installations:

Type AI	Type AII
1. VAX 11/780 VMS	1. IBM/TSO
2. HP3000 MPE	2. UNIVAC 1100 0S1 100
3. IBM 370 VM/CMS	3. Data General MV4000 AOS/VS

H. The following operating systems are designated as "Type B" Installations:

1. Apollo Domain/Aegis Operating System
2. Micro VAX 11/VMS

III. The following operating systems are designated as 'Type C" Installations:

1. IBM PC-XT DOS or compatible

PAYMENTS

I. Fees (per Installation) for "Type A" Installations

A. First Installation:

1. Lump sum payments: Twenty-Five Thousand Dollars ($25,000.00) upon delivery of the documentation; and Twenty Thousand Dollars ($20,000.00) upon successful completion of the Installation; and

2. Yearly payments: Six Thousand Dollars ($6,000.00) per year for Type AI systems; Nine Thousand Dollars ($9,000.00) per year for Type AII systems.

B. Additional Installations:

Discounts for additional "Type A" Installations will be separately negotiated.

(over)

11. Fees (per Installation) for "Type B" Installations

A. First Installation:

1. Lump sum payments: Five Thousand Dollars ($5,000.00) per Installation upon delivery of the documentation; and Five Thousand Dollars ($5,000.00) per Installation upon successful completion of the Installation; and

2. Yearly payments: One Thousand Eight Hundred Dollars ($1,800.00) per year per Installation.

B. Additional Installations:

Discounts for additional "Type B" Installations will be separately negotiated.

III. Fees (per Installation) for "Type C" Installations

A. For licensees not having a "TYpe A" Installation. or for licensees where the first Installation will be a "Type C" Installation, payment for the first "Type C" Installation shall be:

1. Lump sum payment: Five Thousand Dollars ($5,000.00) upon delivery of the documentation; and

2. Yearly payments One Thousand Eight Hundred Dollars ($1,800.00) per year.

B. For licensees having one or more 'Type A" Installations, payments for the first "Type C" Installation shall be:

1. Lump sum payment: Two Thousand Dollars ($2,000.00) upon delivery of the documentation; and

2. Yearly payments: Six Hundred Dollars ($600.00) per year.

C. Additional Installation:

Discounts for additional "Type C" Installations will be separately negotiated.

pc#l/dclass/fees

APPENDIX C

EXAMPLE DATA

Appendix C presents information and data concerning the exampIe discussed in Section 3.6 that were either too bulky or not appropriate to include in the text of the manual. All of the information and data concern computer aided classification and coding using DCLASS.

VIEWING THE EXAMPLE

The computer aided portion of the example was performed on a computer Iocatcd at the CA\l Software Research Center of Brigham Young University. At the conclusion of the example, the Administrators of the CAM Center agreed to leave the classification and coding system and the example data on file in the computer for review via modem access by interested shipbuilders. To review the system and the example, please contact:

Paul Smith
CAM Software Research Center
265 Tech
Provo, Utah 84602
(801) 378-3895

SOURCE FILE

The source is the file which describes the tree structure, attributes and codes in DCLASS.

```
;;SUBTREE IA INTERIM PRODUCT DESIGNATION
;;TREE
IPD.1.2 4 HULL.2.1 BLCK.3.1 ZOND.4.1 SUZN.5.1
;;TEXT
1 INTERIM PRODUCT DESIGNATION
2 HUL - ENTER HULL NO.
3 BLK - ENTER BLOCK NO.
4 ZON - ENTER ZONE NO.
5 SZN - ENTER SUB - ZONE NO.
;;END
;;SUBTREE TA MAIN USE THIS ONE
;;TREE
WORK.1.2 3 WP.56.1   VARS.55.14    PWCC.2
PWCC.2   3 BLOCK.4.11 OUTFIT.5.12 PAINT.6.13
;;// RESOUR.3 3 MATER.7.14 MAN.8.15 EXPENS.9.16
;;TEXT
1  PRODUCT WORK CLASSIFICATION & CODING
2  PRODUCT ASPECTS BY WORK TYPE
3 PRODUCT RESOURCES
4 HULL BLOCK CONSTRUCTION
5 ZONE OUTFITTING
6 ZONE PAINTING
7 MATERIAL
8 MANPOWER
9 FACILITIES AND EXPENSES
55 INTERIM PRODUCT DESIGNATION
56 WP - ENTER WORK PACKAGE NUMBER
;;CALLED SUBTREES
11 TB HULL BLOCK CONSTRUCTION
12 TC ZONE OUTFITTING
13 TD ZONE PAINTING
14 IA
;;CODES
BLOCK H
OUTFIT Z
PAINT P
;;END
;;SUBTREE TB TEST JULI
;;TREE
* HULL.1.1 7 PART1.5 PART2.6 SUB1.7
SEMI1.9 BLOCK1.13 BLOCK2.14 HULL1.18
PART1.5.2  3 ZONE1.21 AREA1.8 STAGE1.27
* AREA1.8.1 5 PARLEL.10 NONPAR.11 INTERN.12
ROLLED.46 OTHER.23
STAGE1.27.1 3 PJOIN.15 MARK.16 BEND.17
PART2.6.2 3 ZONE2.22 AREA2.8  STAGE2.27
ZONE2.22.1 2  PART3.2 SUB2.3
AREA2.8.1 2 SUBP1.20 BUPART.19
STAGE2.27.1 2 ASSEM1.25 BEND1.17
SUB1.7.2 3 ZONE3.22 AREA3.8 STAGE3.27
ZONE3.22.1 2 SBLK1.3 NIL1.24
AREA3.8.1 2 SIML1.28 SIMS1.29
STAGE3.27.1 2 ASSEM2.25 BASMB1.26
SEMI1.9.2  3 ZONE4.22 AREA4.8  STAGE4.27
ZONE4.22.1 2 BLOCK3.4 NIL2.24
AREA4.8.1 2 SIML2.28 SIMS2.29
STAGE4.27.1 3 PLATE2.15 ASSEM3.25 BASMB2.26
BLOCK1.13.2 3 ZONE5.22 AREA5.8 STAGE5.27
ZONE5.22.1 2 BLOCK4.4 NIL3.24
* AREA5.8.1 5 FLAT1.32 SFLAT1.33 CURVE1.34
SCURV1.35 SUPER1.36
STAGE5.27.1  4 PLATE3.15 FRAME1.38 ASSEM4.25 BASMB3.26
BLOCK2.14.2 3 ZONE6.22 AREA6.8 STAGE6.27
ZONE6.22.1 3 BLOCK5.4 SHIP1.30 NIL4.24
AREA6.8.1 3 FLAT2.40 CURVE2.41 SUPER3.36
STAGE6.27.1 3 JOIN1.43 PERE1.44 BPERE1.45
HULL1.18.2 3 ZONE7.31 AREA7.8 STAGE7.27
* AREA7.8.1  5 FORE1.47 CARGO1.39 ENGIN1.49
AFT1.50 SUPSTR.36
STAGE7.27.1 2 EREC1.52 TEST1.53
;;TEXT
1 HULL BLOCK CONSTRUCTION
2 PART
3 SUB-BLOCK
4 BLOCK
5 PART FABRICATION LEVEL
6 PART ASSEMBLY LEVEL
7 SUB-BLOCK ASSEMBLY LEVEL
8 AREA
9 SEMI-BLOCK ASSEMBLY LEVEL
10 PARALLEL PART FROM PLATE
11 NON-PARALLEL PART FROM PLATE
12 INTERNAL PART FROM PLATE
13 BLOCK ASSEMBLY LEVEL
14 GRAND-BLOCK JOINING LEVEL
15 PLATE JOINING
16 MARKING & CUTTING
17 BENDING
18 HULL ERECTION LEVEL
19 BUILT UP PART
20 SUB-BLOCK PART
21 ZONE  = PART
22 ZONE
23 OTHER
24 NIL
25 ASSEMBLY
26 BACK - ASSEMBLY
27 STAGE
28 SIMILAR WORK LARGE QUANTITY
29 SIMILAR WORK SMALL QUANTITLY
30 SHIP
31 ZONE = SHIP
32 FLAT
33 SPECIAL FLAT
34 CURVED
35 SPECIAL CURVED
36 SUPERSTRUCTURE
37 BLOCK
38 FRAMING
39 CARGO HOLD
40 FLAT PANEL
41 CURVED PANEL
42
43 JOINING
44 PRE-ERECTION
45 BACK PRE-ERECTION
46 PART FROM ROLLED SHAPE
47 FORE-HULL
48
49 ENGINE ROOM
50 AFT HULL
51
52 ERECTION
53 TEST
;;CODES
HULL H
PART1 1
AREA1 0
ZONE1 0
PARLEL 0
NONPAR 1
INTERN 2
ROLLED 3
OTHER 4
PJOIN 0
MARK 1
BEND 2
PART2 2
AREA2 0
PART3 0
SUB2 1
SUBP1 0
BUPART 1
ASSEM1 0
BEND1 1
SUB1 3
AREA3 0
SBLK1 0
NIL1 1
SIML1 0
```

```
SIMS1 1
ASSEM2 0
BASMB1 1
SEMI1 4
AREA4 0
BLOCK3 0
NIL2 1
SIML2 0
SIMS2 1
PLATE2 0
ASSEM3 1
BASMB2 2
BLOCK1 5
AREA5 0
BLOCK4 0
NIL3 1
FLAT1 0
SFLAT1 1
CURVE1 2
SCURV1 3
SUPER1 4
PLATE3 0
FRAME1 1
ASSEM4 2
BASMB3 3
BLOCK2 6
AREA6 0
BLOCK5 0
SHIP1 1
NIL4 2
FLAT2 0
CURVE2 1
SUPER3 2
JOIN1 0
PERE1 1
EPERE1 2
HULL1 7
AREA7 0
ZONE7 0
FORE1 0
CARGO1 1
ENGIN1 2
AFT1 3
SUPSTR 4
EREC1 0
TEST1 1
;;END
;;SUBTREE TC
;;TREE
* ZONE.1.1  6  COMPPL.2  UNITAL.3  GRUNJL.4
ONBLOC.5  ONBORD.6  OPTLVL.7
COMPPL.2.2  3 ZOCOMP.8  AREA1.9  STAGE1.10
AREA1.9.1   3 IHMFG.11  OSMFG.12  PURCHG.13
STAGE1.10.1 3 DMPREP.14  MANUFG.15  PALLET.16
UNITAL.3.2  3 ZONE1.17  AREA2.9  STAGE2.10
ZONE1.17.1  2 COMPON.18 UNIT1.19
AREA2.9.1   2 LARSU1.20 SMLSIU.21
STAGE2.10.1 2 ASSY.22 WELDG1.23
GRUNJL.4.2  3 ZONE2.17 AREA3.9 STAGE3.10
ZONE2.17.1  2 UNIT2.19 NIL1.24
AREA3.9.1   2 LARSU2.20 NIL2.24
STAGE3.10.1 2 JOING.25 WELDG2.23
* ONBLOC.5.2  4 ZONE3.17 SPCLT1.27 AREA4.9
STAGE4.10
ZONE3.17.1 2 BLOCK.26 NIL3.24
* SPCLT1.27.1 5 DECK1.28 ACCOM1.29 MACHY1.30
ELECT1.31 WEAPN1.32
AREA4.9.1   2 COLGQT.33 COSMQT.34
* STAGE4.10.1 4 ONCFTG.35 ONCWEL.36 ONFFTG.37
ONFWEL.38
* ONBORD.6.2  4 ZONE4.17 SPCLT2.27 AREA5.9
STAGE5.10
* ZONE4.17.1  6 FORHUL.41 MDBODY.42 ENGRM.43
AFTHUL.44 SUPERS.45 NIL4.24
* SPCLT2.27.1 5 DECK2.28  ACCOM2.29 MACHY2.30
ELECT2.31 WEAPN2.32
AREA5.9.1   3 SMVOL.46 SIMWLV.47 SIMWHS.48
* STAGE5.10.1 4 OSPFTG.49 OSPWEL.50 CLSPFG.51
CLSPWE.52
OPTLVL.7.2  3 ZONE5.17 SPLTAR.39 STOPTS.40
* SPLTAR.39.1 5 DECK3.28 ACCOM3.29 MACHY3.30
ELECT3.31 WEAPN3.32
;;TEXT
1  ZONE OUTFITTING
2  COMPONENT PROCUREMENT LEVEL
3  UNIT ASSEMBLY LEVEL
4  GRAND UNIT JOINING LEVEL
5  ON-BLOCK OUTFITTING LEVEL
6  ON BOARD OUTFITTING LEVEL
7  OPERATION AND TEST LEVEL
8  ZONE = COMPONENT
9  AREA
10 STAGE
11 IN HOUSE MANUFACTURING
12 OUTSIDE MANUFACTURING
13 PURCHASING
14 DESIGN AND MATERIAL PREPARATION
15 MANUFACTURING
16 PALLETIZING
17 ZONE = SHIP
18 COMPONENT
19 UNIT
20 LARGE SIZE UNIT
21 SMALL SIZE UNIT
22 ASSEMBLY
23 WELDING
24 NIL
25 JOINING
26 BLOCK
27 SPECIALTY
28 DECK
29 ACCOMDATION
30 MACHINERY
31 ELECTRICAL
32 WEAPON
33 COMPONENTS IN A LARGE QUANTITY
34 COMPONENTS IN A SMALL QUANTITY
35 ON CEILING FITTING
36 ON CEILING WELDING
37 ON FLOOR FITTING
38 ON FLOOR WELDING
39 SPECIALTY / AREA
40 STAGE = OPERATION AND TEST
41 FORE-HULL
42 MID-BODY
43 ENGINE ROOM
44 AFT HULL
45 SUPERSTRUCTURE
46 SIMILAR WORK IN SMALL VOLUME
47 SIMILAR WORK IN LARGE VOLUME
48 SIMILAR WORK BY HIGH SKILL
49 OPEN SPACE FITTING
50 OPEN SPACE WELDING
51 CLOSED SPACE FITTING
52 CLOSED SPACE WELDING
;;CODES
ZONE 1
COMPPL 1
ZOCOMP 0
AREA1 0
IHMFG 0
OSMFG 1
PURCHG 2
DMPREP 0
MANUFG 1
UNITAL 2
PALLET 2
COMPON 0
UNIT1 1
AREA2 0
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LARSU1 0
SMLSIU 1
ASSY 0
WELDG1 1
GRUNJL 3
UNIT2 0
NIL1 1
AREA3 0
LARSU2 0
NIL2 1
JOING 0
WELDG2 1
ONBLOC 4
BLOCK 0
NIL3 1
DECK1 0
ACCOM1 1
MACHY1 2
ELECT1 3
WEAPN1 4
COLCOT 0
COSMOT 1
ONCFTG 0
ONCWEL 1
ONFFTG 2
ONFWEL 3
ONBORD 5
FORHUL 0
MDBODY 1
ENGRM 2
AFTHUL 3
SUPERS 4
NIL4 5
DECK2 0
ACCOM2 1
MACHY2 2
ELECT2 3
WEAPN2 4
SMVOL 0
SIMWLV 1
SIMWHS 2
OSPFTG 0
OSPWEL 1
CLSPFG 2
CLSPWE 3
OPTLVL 6
ZONE5 0
DECK3 0
ACCOM3 1
MACHY3 2
ELECT3 3
WEAPN3 4
STOPTS 0 0
;;END
;;SUBTREE TD
;;TREE
* PAINT.1.1  4  SHPRIM.2  PRIMER.12 FUNDPL.38
FINPL.46
SHPRIM.2.2   3  ZONE.3 AREA.6 STAGE.9
ZONE.3.1     2  MAT.4  NIL.5
AREA.6.1     2  PLATE.7  SHPOTH.8
STAGE.9.1    2  BLAST.10  PAINTG.11
* PRIMER.12.2 4  ZONE1.3  AREAPM.20  AREANC.25
STAGE1.9
* ZONE1.3.1    7  COMPON.13 BLOCK.14 ONBDFH.15
ONBDCH.16 ONBDER.17 ONBDAH.18 ONBDSS.19
* AREAPM.20.1  4 CONVEN.21  EPOXY.22 INZSIL.23
OTHER.24
* AREANC.25.1 8 OCNA.26 OCPD.27 OCPP.28 OCMA.29
TCNA.30 TCPD.31 TCPP.32 TCMA.47
* STAGE1.9.1  6 SURFP.33 CLEAN.34 PAINT1.11
SPRAT.35 CLNAT.36 PNTAT.37
* FUNDPL.38.2 4 ZONE2.3  ARPTMT.20 ARENC1.25
STAGE2.9
* ZONE2.3.1 9 COMPN1.13 TBFOBO.39 CFOBO.40 OBFH1.15
OBCH1.16 OBER1.17 OBAH1.18 OBSS1.19 NIL1.5
* ARPTMT.20.1 8 CONVN1.48 EPOXN1.49 INZSN1.50 OTHEN1
CONVS1.52 EPOXS1.53 INZSS1.54 OTHES1.55
* ARENC1.25.1 8 OCNA1.26 OCPD1.27 OCPP1.28 OCMA1.29
TCNA1.30 TCPD1.31 TCPP1.32 TCMA1.47
* STAGE2.9.1 8 SURFP1.33 CLEAN2.34 TOUCHP.44 PAINT2.
SPRAT1.35 CLNAT1.36 TCHAT.45 PNTAT1.31
* FINPL.46.2  4 ZONE3.3  APMAT1.20 ARENC2.25
STAGE3.9
* ZONE3.3.1 8 COMPN2.13 TBFOB1.39 CFOBO1.40 OBFH2.15
OBCH2.16 OBER2.17 OBAH2.18 OBSS2.19
* APMAT1.20.1 8 CONVN2.48 EPOXN2.49 INZSN2.50 OTHEN2
CONVS2.52 EPOXS2.53 INZSS2.54 OTHES2.55
* ARENC2.25.1 8 OCNA2.26 OCPD2.27 OCPP2.28 OCMA2.29
TCNA2.30 TCPD2.31 TCPP2.32 TCMA2.47
* STAGE3.9.1 4 SURFP2.33 CLEAN4.34 TOUCH1.44
PAINT3.11
;;TEXT
1 ZONE PAINTING
2 SHOP PRIMER LEVEL
3 ZONE
4 MATERIAL
5 NIL
6 AREA
7 PLATE
8 SHAPES & OTHER
9 STAGE
10 BLASTING
11 PAINTING
12 PRIMER LEVEL
13 COMPONENT
14 BLOCK
15 ON BOARD / FORE HULL
16 ON BOARD / CARGO HOLD
17 ON BOARD / ENGINE ROOM
18 ON BOARD / AFT HULL
19 ON BOARD / SUPERSTRUCTURE
20 AREA / PAINT MATERIAL
21 CONVENTIONAL
22 EPOXY
23 INORGANIC ZINC SILICATE
24 OTHER
25 AREA / NO.OF COATS
26 ONE COAT / NOMINAL AREA
27 ONE COAT / POSITIONAL DIFFICULTIES
28 ONE COAT / POST PAINT BURN OR WELD DAMAGE
29 ONE COAT / NEED TO MAINTAIN APPEARANCE
30 MULTIPLE COATS / NOMINAL AREA
31 MULTIPLE COATS / POSITIONAL DIFFICULTIES
32 MULTIPLE COATS / POST PAINT BURN OR WELD DAMAGE
33 SURFACE PREP
34 CLEANING
35 SURFACE PREP AFTER TURNING
36 CLEANING AFTER TURNING
37 PAINTING AFTER TURNING
38 FINISH UNDERCOAT PAINT LEVEL
39 UNIT TO BE FITTED AT ON BOARD OUTFITTING
40 COMPONENT FITTED ON-BLOCK AT ON-BLOCK OUTFITTING
41 AREA / SCAFFOLD
42
43
44 TOUCH UP
45 TOUCH UP AFTER TURNING
46 FINISH PAINT LEVEL
47 MULTUIPLE COATS / NEED TO MAINTAIN APPEARANCE
48 NO SCAFFOLD REQD / CONVENTIONAL PAINT
49 NO SCAFFOLD REQD / EPOXY
50 NO SCAFFOLD REQD / INORGANIC ZINC SILICATE
51 NO SCAFFOLD REQD / OTHER
52 SCAFFOLD REQD / CONVENTIONAL PAINT
53 SCAFFOLD REQD / EPOXY
54 SCAFFOLD REQD / INORGANIC ZINC SILICATE
55 SCAFFOLD REQD / OTHER
;;CODES
PAINT 3
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SHPRIM 1
MAT 0
NIL 1
AREA 0
PLATE 0
SHPOTH 1
BLAST 0
PAINTG 1
PRIMER 2
COMPON 0
BLOCK 1
ONBDFH 2
ONBDCH 3
ONBDER 4
ONBDAH 5
ONBDSS 6
CONVEN 0
EPOXY 1
INZSIL 2
OTHER 3
OCNA 0
OCPD 1
OCPP 2
OCMA 3
TCNA 4
TCPD 5
TCPP 6
TCMA 7
SURFP 0
CLEAN 1
PAINT1 2
SPRAT 3
CLNAT 4
PNTAT 5
FUNDPL 3
COMPN1 0
TBFOBO 1
CFOBO 2
OBFH1 3
OBCH1 4
OBER1 5
OBAH1 6
OBSS1 7
NIL1 8
OCNA1 0
OCPD1 1
OCPP1 2
OCMA1 3
TCNA1 4
TCPD1 5
TCPP1 6
TCMA1 7
CONVN1 0
EPOXN1 1
INZSN1 2
OTHEN1 3
CONVS1 4
EPOXS1 5
INZSS1 6
OTHES1 7
SURFP1 0
CLEAN2 1
TOUCHP 2
PAINT2 3
SPRAT1 4
CLNAT1 5
TCHAT 6
PNTAT1 7
FINPL 4
COMPN2 0
TBFOB1 1
CFOBO1 2
OBFH2 3
OBCH2 4
OBER2 5
/
OBAH2 6
OBSS2 7
OCNA2 0
OCPD2 1
OCPP2 2
OCMA2 3
TCNA2 4
TCPD2 5
TCPP2 6
TCMA2 7
CONVN2 0
EPOXN2 1
INZSN2 2
OTHEN2 3
CONVS2 4
EPOXS2 5
OTHES2 7
SURFP2 0
CLEAN4 1
TOUCH1 2
PAINT3 3
;;END
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LISTING OF INTERIM PRODUCTS

Below are listed 1074 of the more than 4200 interim products developed as part of the example discussed in section 3.6.

001	31 SHELL A&B PLT CUT	TA	H 1 0 0 0 1
002	31 SHELL A&B PLT ROLL	TA	H 1 0 0 0 2
003	31 SHELL A&B PLT ASSY	TA	H 5 0 0 3 0
004	31 SHELL LONG'L CUT	TA	H 1 0 0 3 1
006	31 SHELL A&B LONG'L ASSY	TA	H 5 0 0 3 1
007	31 CVK VERT PLT CUT	TA	H 1 0 0 2 1
008	31 CVK FACE PLT CUT	TA	H 1 0 0 0 1
009	31 CVK BRKT VERT PLT CUT	TA	H 1 0 0 2 1
010	31 CVKX BRKT FACE PLT CUT	TA	H 1 0 0 0 1
011	31 CVK FACE PLT ASSY	TA	H 2 0 0 1 0
012	31 CVK BRKT FACE PLT ASSY	TA	H 2 0 0 1 0
013	31 CVK ASSY	TA	H 3 0 0 0 0
014	31 SHELL GIRDER VERT PLT CUT	TA	H 1 0 0 2 1
015	31 SHELL GIRDER FACE PLT CUT	TA	H 1 0 0 0 1
016	31 SHELL GIRDER FACE PLT CUT	TA	H 2 0 0 1 0
017	31 SHEL;L GIRDER BKT VERT PLT CUT	TA	H 1 0 0 2 1
018	31 SHELL GIRDER BRKT FACE PLT CUT	TA	H 1 0 0 0 1
019	31 SHELL GIRDER BRKT FACE PLT ASSY	TA	H 2 0 0 1 0
020	31 SHELL GIRDER ASSY	TA	H 2 0 0 1 0
005	31 SHELL LONG'L BEND	TA	H 1 0 0 3 2
021	31 CVK SHELL ASSY	TA	H 5 0 0 3 1
022	31 SHELL GIRDER SHELL ASSY	TA	H 5 0 0 3 1
024	31 DOCK BRKT PLATE CUT	TA	H 1 0 0 2 1
025	31 A&B SHELL WEBFACE PLT CUT	TA	H 1 0 0 3 1
026	31 DOCK BRKT FACE PLT CUT	TA	H 1 0 0 3 1
027	31 A&B SHELL WEB SELF ASSY	TA	H 2 0 0 1 0
028	31 DOCK BRKT SELF ASSY	TA	H 2 0 0 1 0
029	31 A&B SHELL WEB SHELL ASSY	TA	H 5 0 0 3 1
030	31 DOCK BRKT SHELL ASSY	TA	H 5 0 0 3 1
031	31 A&B SHELL WEB BRKT CUT	TA	H 1 0 0 2 1
032	31 A&B SHELL WEB COLLAR CUT	TA	H 1 0 0 2 1
033	31 A&B SHELL TANK PLATE CUT	TA	H 1 0 0 1 1
034	31 SEA CHEST PLATE CUT	TA	H 1 0 0 2 1
035	31 A&B SHELL TANK STIFFENER CUT	TA	H 1 0 0 3 1
036	31 A&B SHELL TANK STIFFENER ASSY	TA	H 3 0 0 0 1
037	31 A&B SHELL TANK ASSY	TA	H 3 0 0 1 0
038	31-SEA CHEST STIFFENER CUT	TA	H 1 0 0 3 1
039	31 SEA CHEST STIFFENER ASSY	TA	H 3 0 0 0 0
040	31 SEA CHEST ASSY	TA	H 3 0 0 1 0
041	31 A&B SHELL TANK SHELL ASSY	TA	H 5 0 0 3 1
042	31 SEA CHEST SHELL ASSY	TA	H 5 0 0 3 1
043	31SEA CHEST BAFFLE CUT	TA	H 1 0 0 3 1
044	31 SEA CHEST BAFFLE BEND	TA	H 1 0 0 3 2
045	31 SEA CHEST BAFFLE ASSY	TA	H 3 0 0 1 0
046	31 SEA CHEST BAFFLE INST	TA	Z 4 0 2 1 0
047	31 BHD 212 PLATE CUT	TA	H 1 0 0 1 1
048	31 BHD 212 PLATE ASSY	TA	H 2 0 1 0 0
049	31 BHD 250 PLATE CUT	TA	H 1 0 0 1 1

050	31 BHD 250 PLATEN ASSY	TA	H 2 0 1 0 0
051	31 BHD 212 STIFFENER CUT	TA	H 1 0 0 3 1
052	31 BHHD 250 STIFFENER CUT	TA	H 1 0 0 3 1
053	31 BHD 212 BRKT CUT	TA	H 1 0 0 2 1
054	31 BHD 250 BRKT CUT	TA	H 1 0 0 2 1
055	31 BHD 212 BRKT ASSY	TA	H 2 0 1 0 0
056	31 BHD 250 BRKT ASSY	TA	H 2 0 1 0 0
057	31 BHD 212 STIFFENER ASY	TA	H 4 0 0 0 2
058	31 BHD 250 STIFFEN R ASSY	TA	H 4 0 0 0 2
059	31 BHD 21 HEADER CUT	TA	H 1 0 0 3 1
060	31 BHD 250 HEADER CUT	TA	H 1 0 0 3 1
061	31 BHD 212 HEADER ASSY	TA	H 4 0 0 0 2
062	31 BHD 2150 HEADER ASSY	TA	H 4 0 0 0 2
063	31 BHD 250 FDN SELF CUT	TA	H 1 0 0 3 1
064	31 BHD 250 FDN SELF CUT	TA	H 3 0 0 0 0
065	31 BHD 250 FDN BHD ASSY	TA	H 4 0 0 0 2
066	31 BHD 212 TRUNK PLATE CUT	TA	H 1 0 0 2 0
067	31 BHD 212 TRUNK STIFFENERS CUT	TA	H 1 0 0 3 1
068	31 BHD 212 TRUNK FDNX SELF CUT	TA	H 1 0 0 3 1
069	31 BHD 212 TRUNK FDN HEADER CUT	TA	H 1 0 0 3 1
070	31 BHD 212 TRUNK FDN SELF ASSY	TA	H 3 0 0 0 0
071	31 BHD 212 TRUNK FDN HEADER ASSY	TA	H 4 0 0 1 2
072	31 BHD 212 TRUNK FDN TRUNKX ASSY	TA	H 4 0 0 0 1
073	31 BHD 212 TRUNK SELF ASSY	TA	H 3 0 0 0 0
074	31 BHD 212 TRUNK BHD ASSY	TA	H 4 0 0 1 1
075	31 BHD 212 SHELL ASSY	TA	H 5 0 0 3 2
076	31 BHD 250 SHELL ASSY	TA	H 5 0 0 3 2
077	31 BHD 212 SHELL COLLAR CUT	TA	H 1 0 0 2 1
078	31 BHD 212 SHELL COLLAR ASSY	TA	H 5 0 0 3 2
079	31E BHD 250 SHELL COLLAR ASSY	TA	H 1 0 0 2 1
080	311 BHD 250 SHELL COLLAR ASSY	TA	H 5 0 0 3 2
081	31 SHELL C&D PLT CUT	TA	H 1 0 0 0 1
082	31 SHELL C&D PLATE ROLL	TA	H 1 0 0 0 2
083	31 SHELL C&D PLATE ASSY	TA	H 4 0 0 1 0
084	31 SHELL C D LONG'L ASSY	TA	H 4 0 0 0 1
055	31 A&B SHELL WEB FACE PLT ROLL	TA	H 1 0 0 3 2
096	31 DOCK BRKT FACE PLT ROLL	TA	H 1 0 0 3 2
087	31 C&D SHELL WEB PLATE CUT	TA	H 1 0 0 2 1
069	31 C&D SHELL WEB SELF ASSY	TA	H 3 0 0 0 0
090	31 C&D SHELL WEB SHELL ASSY	TA	H 4 0 0 0 1
091	31 C&D SHELL WEB COLLAR CUT	TA	H 1 0 0 2 1
092	31 C&DSHELL WEB COLLAR ASSY	TA	H 4 0 0 0 1
093	31 C&D SHELL WEB BRKT CUT	TA	H 1 0 0 2 1
094	31 A&B SHELL WEB COLLAR ASY	TA	H 5 0 0 3 1
096	31 C&D SHELL TANK PLATE CUT	TA	H 1 0 0 1 1
097	31 C&D SHELL TANK STIFFENER CUT	TA	H 1 0 0 3 1
098	31 C&D SHELL TANK STIFFENER ASSY	TA	H 3 0 0 0 1
099	31 C&D SHELL TANK ASSY	TA	H 3 0 0 1 0

100	31 C&D SHELL TANK SHELL ASSY	TA	H 4 0 0 1 1
101	31 C&D SHELL TANK COLLAR ASSY	TA	H 1 0 0 2 1
102	31 SHELL C&D STRAKE ASSY	TA	H 5 0 0 3 2
103	31 250 TANK A/2 PLT CUT	TA	H 1 0 0 0 1
104	31 250 TANK A/1 PLT CUT	TA	H 1 0 0 1 1
105	31 250 TANK CL BHD CUT	TA	H 1 0 0 0 1
106	31 250 TANK XVERSECUT	TA	H 1 0 0 2 1
107	31 250 TANK GIRDER CUT	TA	H 1 0 0 2 1
108	31 250 TANK STIFFENER CUT	TA	H 1 0 0 3 1
109	31 250 TANK COMP. SLV. CUT	TA	H 1 0 0 3 1
110	31 250 TANK COMP.SLV BEND	TA	H 1 0 0 3 2
111	31 250 TANK A/1 7 A/2 PLT ASSY	TA	H 4 0 0 0 0
112	31 250 TANK TANK FRAMING	TA	H 4 0 0 0 1
116	31 250 TANK STANCHION CUT	TA	H 1 0 0 3 1
117	31 250 TANK STANCHION ASSY	TA	H 2 0 1 0 0
118	31 250 TANK STANCHION ASSY	TA	H 5 0 0 3 2
119	31 250 TANK INSTALLATION	TA	H 5 0 0 3 2
120	31 250 TANK HEADER CUT	TA	H 1 0 0 2 1
121	31 250 TANK GUSSETS CUT	TA	H 1 0 0 2 1
122	31 250 TANK BRKTS CUT	TA	H 1 0 0 2 1
123	31 250 TANK COLLAR CUT	TA	H 1 0 0 2 1
124	31 250 TANK HEADER ASSY	TA	H 4 0 0 0 2
125	31 250 TANK GUSSET ASSY	TA	H 4 0 0 0 2
126	31X 250 TANK BRKT ASSY	TA	H 4 0 0 0 2
127	31 250 TANK COLLAR INST.	TA	H 5 0 0 3 2
128	31 ER TRUNKS BHD PLATE CUT	TA	H 1 0 0 1 1
129	31 ER TRUNKS BHD FLAT BEND	TA	H 1 0 0 1 2
130	31 ER TRUNKS STIFFENER CUT	TA	H 1 0 0 3 1
131	31 ER TRUNKS FDN CUT	TA	H 1 0 0 3 1
132	31 ER TRUNKS FDN ASSY	TA	H 3 0 0 0 0
133	31 ER TRUNKS FDN BRKT CUT	TA	H 1 0 0 2 1
134	31 ER TRUNKS BRKT CUT	TA	H 1 0 0 2 1
135	31 ER TRUNKS PLATE JOINING	TA	H 4 0 0 1 0
136	31 ER TRUNKS STIFFENER INST	TA	H 4 0 0 1 2
137	31 ER TRUNKS BRKT INST	TA	H 4 0 0 1 2
138	31 ER TRUNKS FDN INST	TA	H 4 0 0 1 1
139	31 ER TRUNKS INSTALL	TA	H 7 0 0 2 0
140	31 A&B SHELL TANK PLATE CUT	TA	H 1 0 0 1 1
141	31 SEA CHEST PLATE CUT	TA	H 1 0 0 2 1
142	31 A&B SHELL TANK STIFFENER CUT	TA	H 1 0 0 3 1
143	31 A&B SHELL TANK STIFFENING ASSY	TA	H 3 0 0 0 1
144	31 A&B SHELL TANK ASSY	TA	H 3 0 0 1 0
145	31 SEA CHEST STIFFENER CUT	TA	H 1 0 0 3 1
146	31 SEA CHEST STIFFENER ASSY	TA	H 3 0 0 0 0
147	31 SEA CHEST ASSY	TA	H 3 0 0 1 0
148	31 A&B SHELL TANK SHELL ASSY	TA	H 5 0 0 3 1
149	31 SEA CHEST SHELL ASSY	TA	H 5 0 0 3 1
150	31 SEA CHEST BAFFLE CUT	TA	H 1 0 0 3 1
151	31 SEA CHEST BAFFLE BEND	TA	H 1 0 0 3 2
152	31 SEA CHEST BAFFLE ASSY	TA	H 3 0 0 1 0
153	31 SEA CHEST BAFFLE INST	TA	Z 4 0 2 1 0
154	31 SEA CHEST PLATE CUT	TA	H 1 0 0 2 1
155	31 SEA CHEST STIFFENER CUT	TA	H 1 0 0 3 1
156	31 SEA CHEST STIFFENER ASSY	TA	H 3 0 0 0 0
157	31 SEA CHEST ASSY	TA	H 3 0 0 1 0
158	31 SEA CCHEST SHELL ASSY	TA	H 5 0 0 3 1
159	31 SEA CHEST BAFFLE CUT	TA	H 1 0 0 3 1
160	31 SEA CHEST BAFFLE BEND	TA	H 1 0 0 3 2
161	31 SEA CHEST BAFFLE ASSY	TA	H 3 0 0 1 0
162	31SEA CHEST BAFFLE INST	TA	Z 4 0 2 1 0
163	31 SEA CHEST PLATE CUT	TA	H 1 0 0 2 1
164	31 SEA CHEST STIFFENER CUT	TA	H 1 0 0 3 1
165	31 SEA CHEST STIFFENER ASSY	TA	H 3 0 0 0 0
166	31 SEA CHEST ASSY	TA	H 3 0 0 1 0
167	31 SEA CHEST SHELL ASSY	TA	H 5 0 0 3 1
168	31SEA CHEST BAFFLE CUT	TA	H 1 0 0 3 1
169	31 SEA CHEST BAFFLE BEND	TA	H 1 0 0 3 2
170	31 SEA CHEST BAFFLE ASSY	TA	H 3 0 0 1 0
171	31 SEA CHEST BAFFLE INST	TA	Z 4 0 2 1 0
172	31 C&D SHELL WEB PLATE CUT	TA	H 1 0 0 2 1
173	31 C&D SHELL WEB FACE PLT CUT	TA	H 1 0 0 3 1
174	31 C&D SHELL WEB SELF ASSY	TA	H 3 0 0 0 0
175	31 C&D SHELL WEB SHELL ASSY	TA	H 4 0 0 0 1
176	31C&D SHELL WEB COLLAR CUT	TA	H 1 0 0 2 1
177	31 C&D SHELL WEB COLLAR ASSY	TA	H 4 0 0 0 1
178	31 C&D SHELL WEB BRKT CUT	TA	H 1 0 0 2 1
179	31 C&D SHELL TANK PLATE CUT	TA	H 1 0 0 1 1
180	31 C&D SHELL TANK STIFFENER CUT	TA	H 1 0 0 3 1
181	31 C&D SHELL TANK STIFFENER ASSY	TA	H 3 0 0 0 1
182	31 C&D SHELL TANK ASSY	TA	H 3 0 0 1 0
183	31 C&D SHELL TANK SHELL ASSY	TA	H 4 0 0 1 1
184	31 C&D SHELL TANK COLLAR CUT	TA	H 1 0 0 2 1
185	31 SHELL C&D STRAKE ASSY	TA	H 5 0 0 3 2
186	31 C&D SHELL WEB PLATE CUT	TA	H 1 0 0 2 1
187	31 C&D SHELL WEB FACE PLT CUT	TA	H 1 0 0 3 1
188	31 C&D SHELL WEB SELF ASSY	TA	H 3 0 0 0 0
189	31 C&D SHELL WEB SHELL ASSY	TA	H 4 0 0 0 1
190	31 C&D SHELL WEB COLLAR CUT	TA	H 1 0 0 2 1
191	31 C&D SHELL WEB COLLAR ASSY	TA	H 4 0 0 0 1
192	31 C&D SHELL WEB BRKT CUT	TA	H 1 0 0 2 1
193	31 C&D SHELL TANK PLATE CUT	TA	H 1 0 0 1 1
194	31 C&D SHELL TANK STIFFENER CUT	TA	H 1 0 0 3 1
195	31 C&D SHELL TANK STIFFENER ASSY	TA	H 3 0 0 0 1
196	31 C&D SHELL TANK ASSY	TA	H 3 0 0 1 0
197	31 C&D SHELL TANK SHELL ASSY	TA	H 4 0 0 1 1
198	31 C&D SHELL TANK COLLAR CUT	TA	H 1 0 0 2 1

199	31 SHELL C&D STRAKE ASSY	TA	H 5 0 0 3 2
200	31 C&D SHELL WEB PLATE CUT	TA	H 1 0 0 2 1
201	31 C&D SHELL WEB FACE PLT CUT	TA	H 1 0 0 3 1
202	31 C&D SHELL WEB SELF ASSY	TA	H 3 0 0 0 0
203	31 C&D SHELL WEB SHELL ASSY	TA	H 4 0 0 0 1
204	31 C&D SHELL WEB COLLAR CUT	TA	H 1 0 0 2 1
205	31 C&D SHELL WEB COLLAR ASSY	TA	H 4 0 0 0 1
206	31 C&D SHELL WEB BRKT CUT	TA	H 1 0 0 2 1
207	31 C&D SHELL TANK PLATE CUT	TA	H 1 0 0 1 1
208	31 C&D SHELL TANK STIFFENER CUT	TA	H 1 0 0 3 1
209	31 C&D SHELL TANK STIFFENER ASSY	TA	~~H 3 0 0 0 1~~
210	31 C&D SHELL TANK ASSY	TA	H 3 0 0 1 0
211	31 C&D SHELL TANK SHELL ASSY	TA	H 4 0 0 1 1
212	31 C&D SHELL TANK COLLAR CUT	TA	H 1 0 0 2 1
213	31 SHELL C&D STRAKE ASSY	TA	H 5 0 0 3 2
214	31 DK GRTG SPRTS PT 1 CUT	TA	H 1 0 0 3 1
215	31 DK GRTG SPRTS PT 2 CUT	TA	H 1 0 0 3 1
216	31 DK GRTG SPRTS PT 3 CUT	TA	H 1 0 0 3 1
217	31 DK GRTG SPRTS PT & CUT	TA	H 1 0 0 3 1
218	31 DK GRTG SPRTS PT 8 CUT	TA	H 1 0 0 3 1
219	31 DK GRTG SPRTS PT 11 CUT	TA	H 1 0 0 3 1
220	31 DK GRTG SPRB PT 12CUT	TA	H 1 0 0 3 1
221	31 DK GRTG SPRTS PT 231 CUT	TA	H 1 0 0 3 1
222	31 DK GRTG SPR3 PT 14	TA	Z 1 0 0 2 1
223	31 DK GRTG SPRTS PT 15	TA	Z 1 0 0 2 1
224	31 DK GRTG SPRTB PT 13 CUT	TA	H 1 0 0 3 1
225	31 DK GRTG SPRTS PT 13 ROLL	TA	H 1 0 0 3 2
226	31 DK GRTG SPRTS PT 5 CUT	TA	H 1 0 0 2 1
227	31 DK GRTG SPRTS PT 12 CUT	TA	H 1 0 0 3 1
228	31 DK GRTG SPRTS ASSM 17 ASSYS1	TA	H 4 0 0 0 2
229	31 DK GRTG SPRTS INST 17 ASSYS	TA	Z 4 0 0 0 3
230	31 DK GRTG SPRTS ASSM TRANSITIONPCS	TA	Z 4 0 0 0 3
231	31 GRTG ACCESS HANDLE CUT	TA	H 1 0 0 3 1
232	31 GRTG ACCESS HANDLE BEND	TA	H 1 0 0 3 2
233	31 GRTG ACCESS LATCH PTS 20, 20 & 23	TA	Z 1 0 0 1 0
234	31 GRTG ACCESS HINGES	TA	Z 1 0 0 1 0
235	31 GRTG ACCESS LATCH PTS 22 &24	TA	H 1 0 0 2 1
236	31 GRTG ASCCESS LATCH PT ASSY	TA	H 2 0 0 0 0
237	31 GRTG ACCESS ASSY	TA	H 3 0 0 1 1
238	31 GRTG ACCESS INSTALL	TA	H 4 0 0 0 1
239	31 DK GRTG MATL PROCUREMENT	TA	Z 1 0 0 1 1
240	31 DK GRTG CUT	TA	H 2 0 0 0 0
241	31 DK PLATE CUT	TA	H 1 0 0 3 1
242	31 DK PLATE DRILLING	TA	H 1 0 0 3 1
243	31 DK GRTG SPRTS PT 202 CUT	TA	H 1 0 0 3 1
244	31 DK GRTG SPRTS PT 227 CUT	TA	H 1 0 0 3 1
245	31 DK GRTG SPRTS PT 209 CUT	TA	H 1 0 0 3 1
246	31 DK GRTG SPRTS PT 212 CUT	TA	H 1 0 0 3 1
247	31 DK GRTG SPRTS PT 210 CUT	TA	H 1 0 0 3 1
248	31 DK GRTG SPRTS PT [125 CUT	TA	H 1 0 0 3 1
249	31 DK GRTG SPRTS PT 203 CUT	TA	H 1 0 0 3 1
250	31 DK GRTG SPRTS PT 204 CUT1	TA	H 1 0 0 3 1
251	31 DK GRTG PT 205 CUT	TA	H 1 0 0 3 1
252	31 DK GRTG PT 205 ASSM	TA	H 2 0 0 1 0
253	31 DK GRTG PT 206 CUT	TA	H 1 0 0 3 1
254	31 DK GRTG PT 2106 BEND	TA	H 1 0 0 3 2
255	31 DK GRTG PT 19 PROCUREMENT	TA	Z 1 0 0 2 1
256	31 DK GRTG INSTALL	TA	Z 4 0 0 0 2
257	31 DK PLATE INSTALL	TA	Z 4 0 0 0 2
258	31 DK GRTG SPRTS PT 207 PROCUREMENT	TA	Z 1 0 0 1 1
259	31 DK GRTG SPRTS PT 208 CUT	TA	H 1 0 0 3 1
260	31 HANDRAILS PT 192 CUT	TA	H 1 0 0 3 1
261	31 HANDRAILS PT 220 CUT	TA	H 1 0 0 3 1
262	31 HANDRAILS PT 191 WT	TA	H 1 0 0 3 1
263	31 HANDRAILS PT 195 PROCUREMENT	TA	Z 1 0 0 2 1
264	31 HANDRAILS PT 193 PROCUREMENT	TA	Z 1 0 0 2 1
265	31 HANDRAILS PT 194 PROCUREMENT	TA	Z 1 0 0 2 1
266	31 HANDRAILS PT 224 PROCUREMENT	TA	Z 1 0 0 2 1
267	31 HANDRAILS PT 225 PROCUREMENT	TA	Z 1 0 0 2 1
268	31 HANDRAIS PT 226 PROCUREMENT	TA	Z 1 0 0 2 1
269	31 HANDRAILS PT 223 CUT	TA	H 1 0 0 3 1
270	31 HANDRAILS PT 223 BEND	TA	H 1 0 0 3 2
271	31 HANDRAILS PT 197 CUT	TA	H 1 0 0 3 1
272	31 HANDRAILS PT 198 CUT	TA	H 1 0 0 2 1
273	HANDRAILS PT 199 CUT	TA	H 1 0 0 2 1
274	31 HANDRAILS PT 111 CUT	TA	H 1 0 0 3 1
275	31 HANDRAILS PT 113 CUT	TA	H 1 0 0 3 1
276	31 HANDRAILS PT 125 CUT	TA	H 1 0 0 3 1
277	31 HANDRAILS PT 126 CUT	TA	H 1 0 0 3 1
278	31 HANDRAILS PT 112 CUT	TA	H 1 0 0 3 1
279	31 HANDRAILS PT 116 PROCUREMENT	TA	Z 1 0 0 2 1
280	31 HANDRAILS PT 114 PROCUREMENT	TA	Z 1 0 0 2 1
281	31 HANDRAILS PT 115 PROCUREMENT	TA	Z 1 0 0 2 1
282	31 HANDRAILS PT 116 DRILL	TA	Z 2 0 0 1 0
283	31 HANDRAILS PT 125 DRILL	TA	Z 2 0 0 1 0
284	31 HANDRAILS PT 127 DRILL	TA	Z 2 0 0 1 0
285	31 HANDRAILS PT 112 DRILL	TA	Z 2 0 0 1 0
286	31 HANDRAILS PT 113 DRILL	TA	Z 2 0 0 1 0
287	31 HANDRAILS PT 111 DRILL	TA	Z 2 0 0 1 0
288	31 HANDRAILS PT 198 DRILL	TA	Z 2 0 0 1 0
289	31 HANDRAILS PT 219 DRILL	TA	Z 2 0 0 1 0
290	31 HANDRAILS PT 195 DRILL	TA	Z 2 0 0 1 0
291	31 HANDRAILS PT 198 CUT	TA	H 1 0 0 3 1
292	31 HANDRAILS PT 219 CUT	TA	H 1 0 0 3 1
293	31 HANDRAILS ASSM PTS 191/195	TA	H 3 0 0 0 0
294	31 HANDRAILS ASSM PTS 224/195	TA	H 3 0 0 0 0

295	31 HANDRAILS ASSM PTS 191/194	TA	H 3 0 0 0 0
296	31 HANDRAILS ASSM PTS 220/194	TA	H 3 0 0 0 0
297	31 HANDRAILS ASSM PTS 191/198	TA	H 3 0 0 0 0
298	31 HANDRAILS ASSM PTS 220/219	TA	H 3 0 0 0 0
299	31 HANDRAILS ASSM PTS 111/116	TA	H 3 0 0 0 0
300	31 HANDRAILS ASSM PTS 111/115	TA	H 3 0 0 0 0
301	31 HANDRAILS ASSM PTS 112/118	TA	H 3 0 0 0 0
302	31 HANDRAILS ASSM PTS 112/111	TA	H 3 0 0 0 0
303	31 HANDRAILS ASSM PTS 113/115	TA	H 3 0 0 0 0
304	31 HANDRAILS ASSM PTS 113/114	TA	H 3 0 0 0 0
305	31 HANDRAILS ASSM PTS 111/126	TA	H 3 0 0 0 0
306	31 HANDRAILS ASSM PTS 113/125	TA	H 3 0 0 0 0
307	31 HANDRAILS PT 118 CUT	TA	H 1 0 0 3 1
308	31 HANDRAILS INSTALL	TA	H 4 0 0 0 1
309	31 HANDRAILS INST. 120, 121,122,AND 123	TA	H 4 0 0 0 1
310	31 HANDRAILS ASSM PTS 124/126	TA	H 3 0 0 0 0
311	31 HANDRAILS ASSM PTS 219/221	TA	H 3 0 0 0 0
312	SPECIAL TOOL STWG -STO CAB CUT FDN PCS	TA	H 1 0 0 3 1
313	SPECIAL TOOL STWG -STO CAB ASSM FDN PCS	TA	H 3 0 0 0 0
314	SPECIAL TOOL STWG-STO CAB INST FDN	TA	H 5 0 0 3 2
315	SPECIAL TOOL STWG -STO CAB CUT CABINET	TA	Z 1 0 0 0 1
316	SPECIAL TOOL STWG -STO CABBEND CABINET	TA	Z 2 0 0 1 0
317	SPECIAL TOOL STWG -STO CAB ASSM CAB	TA	Z 2 0 0 1 0
318	SPECIAL TOOL STWG -STO CAB INST CABINET	TA	Z 4 0 0 1 2
319	SPECIAL TOOL STWG -STO CAB PRIME MAT'L	TA	P 2 0 2 2 2
320	SPECIAL TOOL STWG-STO CAB PREP FDN	TA	P 3 2 1 5 0
321	SPECIAL TOOL STWG -STO CAB PAINT FDN	TA	P 3 2 1 5 3
322	SPECIAL TOOL STWG-STO CAB PAINT CABINET	TA	P 2 0 1 3 2
323	EMER PITCH HND PUMP CUT FDN PCS	TA	H 1 0 0 3 1
324	EMER PITCH HAND PUMP ASSM FDN PCS	TA	H 3 0 0 0 0
325	EMER PITCH HAND PUMP INST FDN	TA	H 5 0 0 3 2
326	EMER PITCH HAND PUMP PRIME MAT'L	TA	P 2 0 2 2 2
327	EMER PITCH HAND PUMP PREP FDN	TA	P 3 2 1 5 0
328	EMER PITCH HAND PUMP PAINT FDN	TA	P 3 2 1 5 3
329	EMER PITCH HAND PUMP INST PUMP	TA	Z 4 0 2 1 2
330	SSDG FUEL PRIMING PMP STWG CUT FDN PCS	TA	H 1 0 0 3 1
331	SSDG FUEL PRIMING PMP STWG ASSM FDN PCS	TA	H 3 0 0 0 0
332	SSDG FUEL PRIMING PMP STWG INST FDN	TA	H 5 0 0 3 2
333	SSDG FUEL PRIMING PMP STWG STRP PROCUREMENT	TA	Z 1 0 0 1 1
334	SSDG FUEL PRIMING PMP STWG TOOL BOX PROCUREMENT	TA	Z 1 0 0 2 1
335	SSDG FUEL PRIMING PMP STWG INST TOOL BOX	TA	Z 4 0 0 1 2
336	SSDG FUEL PRIMING PMP STWG PRIME MAT'L	TA	P 2 0 2 2 2
337	SSDG FUEL PRIMING PMP STWG PREP FDN	TA	P 3 2 1 5 0
338	SSDG FUEL PRIMING PMP STOW PAINT FDN	TA	P 3 2 1 5 3
339	SSDG FUEL PRIMING PMP STWG PAINT TOOL BOX	TA	P 4 1 0 3 2
340	FUEL OIL PURIFIER CUT FDN PCS	TA	H 1 0 0 3 1
341	FUEL OILPURIFIER BEND FDN PCS	TA	H 1 0 0 3 2
342	FUEL OIL PURIFIER ASSM FDN PCS	TA	H 2 0 0 1 1
343	FUEL OIL PURIFIER HARDWARE PROCUREMENT	TA	Z 1 0 0 2 2
344	FUEL OIL PURIFIER -PURIFIER PROCUREMENT	TA	Z 1 0 0 2 2
345	FUEL OIL PURIFIER INST FDN	TA	H 5 0 0 3 2
346	FUEL OIL PURIFIER PRIME FDN PCS	TA	P 2 0 2 2 2
347	FUEL OIP PURIFIER PREP FDN	TA	P 3 2 1 5 0
348	FUEL OIL PURIFIER PAINT FDN	TA	P 3 2 1 4 3
349	FUEL OIL PURIFIER INST PURIFIER	TA	Z 6 0 0 0 2
350	TEE (#386) WRENCH STOW CUT PCS	TA	H 1 0 0 2 1
351	TEE (#386) WRENCH STOW BEND PC 63	TA	H 1 0 0 2 2
352	TEE (#386) WRENCH STOW ASSEM PCS	TA	H 3 0 0 1 0
353	TEE (#386) WRENCH STOW INST STOWAGE	TA	H 4 0 0 1 1
354	TEE (#386) WRENCH STOW PRIME STOWAGE	TA	P 2 0 2 2 2
355	TEE (#386) WRENCH STOW PREP STOWAGE	TA	P 2 0 1 0 0
356	TEE (#386) WRENCH STOW PAINT STOWAGE	TA	P 2 0 1 0 2
357	TEE (#0386) WRENCH STOW FINAL PAINT STOWAGE	TA	P 4 1 1 3 3
358	TEE (#386) WRENCH STOW WRENCH PROCUREMENT	TA	Z 1 0 0 2 2
359	TEE (#386) WRENCH STOW INST WRENCH	TA	Z 6 0 0 0 2
360	WRENCH (#54) STOWAGE CUT PCS	TA	H 1 0 0 2 1
361	WRENCH (#54) STOWAGE BEND PC 59	TA	H 1 0 0 2 2
362	WRENCH (#54) STOWAGE ASSM PCS	TA	H 3 0 0 1 0
363	WRENCH (#54) STOWAGE INST STOWAGE	TA	H 4 0 0 1 1
364	WRENCH (#54) STOWAGE PRIME STOWAGE	TA	P 2 0 2 2 2
365	WRENCH (#54) STOWAGE PREP STOWAGE	TA	P 2 0 1 0 0
366	WRENCH (#54) STOWAGE PAINT STOWAGE	TA	P 2 0 1 0 2
367	WRENCH (#54) STOWAGE FINAL PAINT STOWAGE	TA	P 4 1 1 3 3
368	WRENCH (#54) STOWAGE WRENCH PROCURMENT	TA	Z 1 0 0 2 2
369	--	TA	Z 6 0 0 0 2
370	(43) DRY CHEM FIRE EXT STWG CUT FDN PC	TA	H 1 0 0 3 1
371	(4) DRY CHEM FIRE EXT STWG PR ME PC	TA	P 2 0 2 2 2
372	(4) DRY CHEM FIRE EXT STWG INST FDN	TA	H 5 0 0 3 2
373	(4) DRY CHEM FIRE EXT STWG PREP FDN	TA	P 3 2 1 4 0
374	(4) DRY CHEM FIRE EXT STWG PAINT FDN	TA	P 3 2 1 4 3
375	(4) DRY CHEM FIRE EXT STWG FINAL PAINT FDN	TA	P 4 2 1 3 3
376	(4) DRY CHEM FIRE EXT STWG EXISTING & HARDWARE PROCUREMENT	TA	Z 1 0 0 2 2
377	(4) DTRY CHEM FIRE EXT STWG INST EXT	TA	Z 4 0 0 1 2
378	GTRB SPECIAL TOOLS STWG CUT FDN PCS	TA	H 1 0 0 3 1
379	GTRB SPECIAL TOOLS STWG ASSM FDN PCS	TA	H 3 0 0 0 0
380	GTRB SPECIAL TOOLS STWG INST FDNS	TA	H 5 0 0 3 2
381	GTRB SPECIAL TOOLS STWG STRAP PROCUREMENT	TA	Z 1 0 0 1 1
382	GTRB SPECIAL TOOLS STWG TOOL BOX PROCUREMENT	TA	Z 1 0 0 2 1
383	GTRB SPECIAL TOOLS STWG INST TOOL BOX	TA	Z 4 0 0 1 2
384	GTRB SPECIAL TOOLS STWG PRIME MAT'L	TA	P 2 0 2 2 2
385	GTRB SPECIAL TOOLS STWG PREP FDNS	TA	P 3 2 1 5 0
386	GTRB SPECIAL TOOLS STWG PAINT FDNS	TA	P 3 2 1 5 3
387	GRRB SPECIAL TOOLS STWG PAINT TOOL BOX	TA	P 4 1 0 3 2
388	CAS PWR CABLE RACK CUT PCS	TA	H 1 0 0 3 1
389	CAS PWR CABLE RACK BEND PCS 1 & 7	TA	H 1 0 0 3 2
390	CAS PWR CABLE RACK ASSM PCS 1 & 3	TA	H 3 0 0 1 0

391	CAS PWR CABLE RACK PRIME PCS	TA	P 2 0 2 2 2
392	CAS PWR CABLE RACK INST HDRS	TA	H 4 0 0 1 2
393	CAS PWR CABLE RACK INST RACK	TA	H 4 0 0 1 1
394	CAS PWR CABLE RACK PREPPCS	TA	P 3 2 0 0 0
395	CAS PWR CABLE RACK PAINT RACK	TA	P 4 2 0 0 3
396	CAS PWR CABLE RACK INST CABLE	TA	Z 6 0 0 0 3
397	WRENCH (#53) STOWAGE CUT PCS	TA	H 1 0 0 2 1
398	WRENCH (#53) STOWAGE BEND PC 59	TA	H 1 0 0 2 2
399	WRENCH (#53) STOWAGE ASSM PCS	TA	H 3 0 0 1 0
400	WRENCH (#53) STOWAGE INST STOWAGE	TA	H 4 0 0 1 1
401	WRENCH (#53) STOWAGE PRIME STWG	TA	P 2 0 2 2 2
402	WRENCH (#53) STOWAGE PREP STWG	TA	P 2 0 1 0 0
403	WRENCH (#53) STOWAGE PAINT STWG	TA	P 2 0 1 0 2
404	WRENCH (#53) STOWAGE FINAL PAINT STOWAGE	TA	P 4 1 1 3 3
405	WRENCH (#53) STOWAGE WRENCH PROCURMENT	TA	Z 1 0 0 2 2
406	WRENCH (#53) STOWAGE INST WRENCH	TA	Z 6 0 0 0 2
407	TEE (#385) WRENCH STOW CUT PCS	TA	H 1 0 0 2 1
408	TEE (#385) WRENCH STOW BEND PC 63	TA	H 1 0 0 2 2
409	TEE (#385) WRENBCH STOW ASSM PCS	TA	H 3 0 0 1 0
410	TEE (#385) WRENCH STOW INST STWG	TA	H 4 0 0 1 1
411	TEE (#385) WRENCH STOWAGE PRIME STWG	TA	P 2 0 2 2 2
412	TEE (#85) WRENCH STOWAGE PREP STWG	TA	P 2 0 1 0 0
413	TEE (#385) WRENCH STOW PAINT STWG	TA	P 2 0 1 0 2
414	TEE (#385) WRENCH STOW FINAL PAINT STOW	TA	P 4 1 1 3 3
415	TEE (#385) WRENCH STWG WRENCH PROCUREMENT	TA	Z 1 0 0 2 2
416	TEE (#385) WRENCH STWG INST WRENCH	TA	Z 6 0 0 0 2
417	CONTAMINANT DRUM STWG CUT PCS	TA	H 1 0 0 2 1
418	CONTAMINANT DRUM STWG BEND STRAP ANCHORS	TA	H 1 0 0 2 2
419	CONTAMINANT DRUM STWG ASSM PCS	TA	H 3 0 0 0 0
420	CONTAMINANT DRUM STWG PRIME STWG	TA	P 2 0 2 2 2
421	COPNTAMINANT DRUM STWG INST STWG	TA	H 5 0 0 3 2
422	CONTAMINAT DRUM STWG PREP STWG	TA	P 3 2 1 1 0
423	CONTAMINANT DRUM STWG PAINT STWG	TA	P 3 2 1 1 3
424	CONTAMINANT DRUM STWG FINAL PAINT STWG	TA	P 4 2 1 3 3
425	CONTAMINANT DRUM STWG DRUM PROCUREMENT	TA	Z 1 0 0 0 0
426	CONTAMINANT DRUM STWG DRUM INSTALLATION	TA	Z 6 0 0 0 0
427	CONTAMINANT DRUM STWG DRUM PAINT	TA	P 4 1 0 3 2
428	CAS PWR CABLE RACK CUT PCS	TA	H 1 0 0 3 1
429	CAS POWER CABLE RACK BEND PCS 1 & 7	TA	H 1 0 0 3 2
430	CAS PWR CABLE RACK ASSM PCS 1 & 3	TA	H 3 0 0 1 0
431	CAS POWER CABLE RACK PRIME PCS	TA	P 2 0 2 2 2
432	CAS PWR CABLE RACK INST HDRS	TA	H 4 0 0 1 2
433	CAS POWER CABLE RACK INST RACK	TA	H 4 0 0 1 1
434	CAS POWER CABLE RACK PREP PCS	TA	P 3 2 0 0 0
435	CAS POWER CABLE RACK PAINT RACK	TA	P 4 2 0 0 3
436	CAS POWER CABLE RACK INST CABLE	TA	Z 6 0 0 0 3
437	CAS POWER CABLE RACK CUT PCS	TA	H 1 0 0 3 1
438	CAS POWER CABLE RACK BEND PCS 1 & 7	TA	H 1 0 0 3 2
439	CAS POWER CABLE RACK ASSM PCS 1 & 3	TA	H 3 0 0 1 0
440	CAS POWER CABLE RACK PRIME PCS	TA	P 2 0 2 2 2
441	CAS POWER CABLE RACK INST HDRS	TA	H 4 0 0 1 2
442	CAS POOWER CAPLE RACK INST RACK	TA	H 4 0 0 1 1
443	CAS POWER CABLE RACK PREP PCS	TA	P 3 2 0 0 0
444	CAS POWER CABLE RACK PAINT RACK	TA	P 4 2 0 0 3
445	CAS POWER CABLE RACK INST CABLE	TA	Z 6 0 0 0 3
446	CAS POWER CABVLE RACK CUT PCS	TA	H 1 0 0 3 1
447	CAS POWER CABVLE RACK BEND PCS 1 & 7	TA	H 1 0 0 3 2
448	CAS POWER CABLE RACK ASSM PCS 1 & 3	TA	H 3 0 0 1 0
449	CAS POWER CABLE RACK PRIME PCS	TA	P 2 0 2 2 2
450	CAS POWER CABLE RACK INST HDRS	TA	H 4 0 0 1 2
451	CAS POWER CABLE RACK INST RACK	TA	H 4 0 0 1 1
452	CAS POWER CABLE RACK PREP PCS	TA	P 3 2 0 0 0
453	CAS POWER CABLE RACK PAINT RACK	TA	P 4 2 0 0 3
454	CAS POWER CABLE RACK INST CABLE	TA	Z 6 0 0 0 3
455	CAS POWER CABLE RACK CUT PCS	TA	H 1 0 0 3 1
456	CAS POWER CABLE RACK BEND PCS 1 & 7	TA	H 1 0 0 3 2
457	CAS POWER CABLE RACK ASSM PCS 1 & 3	TA	H 3 0 0 1 0
458	CAS POWER CABLE RACK PRIME PCS	TA	P 2 0 2 2 2
459	CAS POWER CABLE RACK INST HDRS	TA	H 4 0 0 1 2
460	CAS POWER CABLE RACK INST RACK	TA	H 4 0 0 1 1
461	CAS POWER CABLE RACK PREP PCS	TA	P 3 2 0 0 0
462	CAS POWER CABLE RACK PAINT RACK	TA	P 4 2 0 0 3
463	CAS POWER CABLE RACK INST CABLE	TA	Z 6 0 0 0 3
464	MN RDGR TOOL STWG CUT FDN PCS	TA	H 1 0 0 3 1
465	MN RDGR TOOL STWG ASSM FDN PCS	TA	H 3 0 0 0 0
466	MN RDGR TOOL STWGINST FDN	TA	H 5 0 0 3 2
467	MN RDGR TOOL STWG STRAP PROCURMENT	TA	Z 1 0 0 1 1
468	MN RDGR TOOL STWG TOOL BOX PROCUREMENT	TA	Z 1 0 0 2 1
469	MN RDGR TOOL STWG INST TOOL BOX	TA	Z 4 0 0 1 2
470	MN RDGR TOOL STWG PRIME MAT'L	TA	P 2 0 2 2 2
471	MN RDGR TOOL STWG PREP FDN	TA	P 3 2 1 5 0
472	MN RDGR TOOL STWG PAINT FDN	TA	P 3 2 1 5 3
473	MN RDGR TOOL STWG PAINT TOOL BOX	TA	P 4 1 0 3 2
474	WRENCH (#49) STOWAGE CUT PCS	TA	H 1 0 0 2 1
475	WRENCH (#49) STOWAGE BEND PC 59	TA	H 1 0 0 2 2
476	WRENCH (#49) STOWAGE ASSM PCS	TA	H 3 0 0 1 0
477	WRENCH (#49) STOWAGE INST STWG	TA	H 4 0 0 1 1
478	WRENCH (#49) STOWAGE PRIME STWG	TA	P 2 0 2 2 2
479	WRENCH (#49) STOWAGE PREP STWG	TA	P 2 0 1 0 0
480	WRENCH (#49) STOWAGE PAINT STWG	TA	P 2 0 1 0 2
481	WRENCH (#49) STYOAGE FINAL PAINT STWG	TA	P 4 1 1 3 3
482	WRENCH (#49) STOWAGE WRENCH PROCURMENT	TA	Z 1 0 0 2 2
483	WRENCH (#49) STOWAGE INST WRENCH	TA	Z 6 0 0 0 2
484	(4) CO2 FIRE EXT STWGS CUT PCS	TA	H 1 0 0 3 1
485	(4) CO2 FIRE EXT STWGS BEND PC 55	TA	H 1 0 0 3 2
486	(4) CO2 FIRE EXT STWGS PROCURE HARDWARE	TA	Z 1 0 0 2 2

487	(4) CO2 FIRE EXT STWGS ASSM FDN	TA	H 3 0 0 1 0
488	(4) CO2 FIRE EXT STWGS PRIME PARTS	TA	P 2 0 2 2 2
489	(4) CO2 FIE EXT STWGS INST FDN	TA	H 5 0 0 3 2
490	(4) CO2 FIRE EXT STWGS BOTTLE PROCUREMENT	TA	Z 1 0 0 2 2
491	(4) CO2 FIRE EXT STWGSINST BOTTLE	TA	Z 6 0 0 0 2
492	(4) CO2 FIRE EXT STWGS CLEAN FDN	TA	P 3 2 0 2 0
493	(4) CO2 FIRE EXT STWGS PAIONT FDN	TA	P 3 2 0 2 2
494	(4) CO2 FIRE EXT STWGS FINAL PAINT FDN	TA	P 4 2 0 3 3
495	3 MJ DOORS PROCURE DOORS	TA	Z 1 0 0 1 1
496	3 MJ DOORS INST DOORS	TA	Z 4 0 0 1 0
497	3 MJ DOORS PREP IWD DRS	TA	P 2 1 2 2 0
498	3 MJ DOORS PAINT IWD DOORS	TA	P 2 1 2 2 0
499	3 MJ DOORS FINAL PAINT IWD DRS	TA	P 4 2 0 3 3
500	(4) CO2 FIRE EXT STWGS CUT PCS	TA	H 1 0 0 3 1
501	(4) CO2 FIRE EXT STWGS BEND PC 55	TA	H 1 0 0 3 2
502	(4) CO2 FIRE EXT STWGS PROCURE HARDWARE	TA	Z 1 0 0 2 2
503	(4) CO2 FIE EXT STWGS ASSM FDN	TA	H 3 0 0 1 0
504	(4) CO2 FIRE EXT STWGS PRIME PARTS	TA	P 2 0 2 2 2
505	(4) CO2 FIRE EXT STWGS INST FDN	TA	H 5 0 0 3 2
506	(4) CO2 FIRE EXT STWGS BOTTLE PROCUREMENT	TA	Z 1 0 0 2 2
507	(4) CO2 FIRE EXT STWGS IONST BOTTLE	TA	Z 6 0 0 0 2
508	(4) CO2 FIRE EXT STWGS CLEAN FDN	TA	P 3 2 0 2 0
509	(4) CO2 FIRE EXT STWGS PAINT FDN	TA	P 3 2 0 2 2
510	(4) CO2 FIRE EXT STWGS FIEAL PAINT FDN	TA	P 4 2 0 3 3
511	3 MJ DOORS PROCURE DOORS	TA	Z 1 0 0 1 1
512	3 MJ DOORS INST DOORS	TA	Z 4 0 0 1 0
513	3 MJ DOORS PREP IWD DOORS	TA	P 2 1 2 2 0
514	3 MJ DOORS PAINT IWD DOORS	TA	P 2 1 2 2 0
515	3 MJ DOORS FINAL PAINT IWD DOORS	TA	P 4 2 0 3 3
516	(4) CO2 FIRE EXT STWGS CUT PCS	TA	H 1 0 0 3 1
517	(4) CO2 FIRE EXT STWGS BEND PC 55	TA	H 1 0 0 3 2
518	(4) CO2 FIRE EXT STWGS PROCURE HARDWARE	TA	Z 1 0 0 2 2
519	(4) CO2 FIRE EXT STWGS ASSM FDN	TA	H 3 0 0 1 0
520	(4) CO2 FIRE EXT STWGS PRIME PARTS	TA	P 2 0 2 2 2
521	(4) CO2 FIRE EXT STWGS INST FDN	TA	H 5 0 0 3 2
522	(4) CO2 FIRE EXT STWGS BOTTLE PROCUREMENT	TA	Z 1 0 0 2 2
523	(4) CO2 FIRE EXT STWGS INST BOTTLE	TA	Z 6 0 0 0 2
524	(4) CO2 FIRE EXT STWGS CLEAN FDN	TA	P 3 2 0 2 0
525	(4) CO2 FIRE EXT STWGS PAINT FDN	TA	P 3 2 0 2 2
526	(4) CO2 FIRE EXT STWGS FINAL PAINT FDN	TA	P 4 2 0 3 3
527	3 MJ DOORS PROCURE DOORS	TA	Z 1 0 0 1 1
528	3 MJ DOORS INST DOORS	TA	Z 4 0 0 1 0
529	3 MJ DOORS PREP IWD DOORS	TA	P 2 1 2 2 0
530	3 MJ DOORS PAINT IWD DOORS	TA	P 2 1 2 2 0
531	3 MJ DOORS FINAL PAINT IWD DOORS	TA	P 4 2 0 3 3
532	(4) CO2 FIRE EXT STWGS CUT PCS	TA	H 1 0 0 3 1
533	(4) CO2 FIRE EXT STWGS BEND PC 55	TA	H 1 0 0 3 2
534	(4) CO2 FIRE EXT STWGS PROCURE HARDWARE	TA	Z 1 0 0 2 2
535	(4) CO2 FIRE EXT STWGS ASSM FDN	TA	H 3 0 0 1 0
536	(4) CO2 FIRE EXT STWGS PRIME PARTTS	TA	P 2 0 2 2 2
537	(4) CO2 FIRE EXT STWGS INST FDN	TA	H 5 0 0 3 2
538	(4) CO2 FIRE EXT STWGS BOTTLE PROCUREMENT	TA	Z 1 0 0 2 2
539	(4) CO2 FIRE EXT STWGS INST BOTTLE	TA	Z 6 0 0 0 2
540	(4) CO2 FIRE EXT STWGS CLEAN FDN	TA	P 3 2 0 2 0
541	(4) CO2 FIRE EXT STWGS PAINT FDN	TA	P 3 2 0 2 2
542	(4) CO2 FIRE EXT STWGS FINAL PAINT FDN	TA	P 4 2 0 3 3
543	JP5 FUEL BOTTLE STWG CUT PCS	TA	H 1 0 0 3 1
544	JP5 FUEL BOTTLE STWG BEND PCS 699, 706, 701, 700 & 703	TA	H 1 0 0 3 2
545	JP5 FUEL BOTLE STWG ASSM PARTS	TA	H 3 0 0 0 0
546	JP5 FUEL BOTTLE STWG PRIME FDN	TA	P 2 0 2 2 2
547	JP5 FUEL BOTTLE STWG INST UPPER FDN	TA	H 4 0 0 1 2
548	JP5 FUEL BOTTLE STWG INST LOWER FDN	TA	H 5 0 0 3 2
549	JP5 FUEL BOTTLE STWG PROCURE HARDWARE	TA	Z 1 0 0 2 1
550	JP5 FUEL BOTTLE STWGS PREP FDNS	TA	P 3 2 2 1 0
551	JP5 FUEL BOTTLE STWG PAINT FDNS	TA	P 3 2 2 1 2
552	JP5 FUEL BOTTLE STWG FINAL PAINT FDNS	TA	P 4 2 0 1 3
553	JP5 FUEL BOTTLE STWG PRCCURE BOTTLES	TA	Z 1 0 0 2 2
554	JP5 FUEL BOTTLE STWG INST BOTTLES	TA	Z 6 0 0 0 0
555	2 LO SAMPLE BOTTLE RACK CUT PCS	TA	H 1 0 0 3 1
556	2 LO SAMPLE BOTTLE RACK BEND PC 968	TA	H 1 0 0 3 2
557	2 LO SAMPLE BOTTLE RACK PROCURE HARDWARE	TA	Z 1 0 0 2 1
558	2 LO SAMPLE BOTTLE RACK ASSM PARTS	TA	H 3 0 0 0 0
559	2LO SAMPLE BOTTLE RACK PRIME FDN	TA	P 2 0 2 2 2
560	2LO SAMPLE BOTTLE RACK INST UPPER FDN	TA	H 4 0 0 1 2
561	2 LO SAMPLE BOTTLE RACK INST LWR FDN	TA	H 5 0 0 3 2
562	2 LO SAMPLE BOTTLE RACK PREP FDNS	TA	P 3 2 2 1 0
563	2 LO SAMPLE BOTTLE RACK PAINT FDNS	TA	P 3 2 2 1 2
564	2 LO SAMPLE FINAL PAINT FDNS	TA	P 4 2 0 1 3
565	2 LO SAMPLE BOTTLE RACK PROCURE BOTTLES	TA	Z 1 0 0 2 2
566	2 LO SAMPLE BOTTLE RACK INST BOTTLES	TA	Z 6 0 0 0 0
567	FO PURIFIER SPECIAL TOOL STWG CUT PCS	TA	H 1 0 0 3 1
568	FO PURIFIER SPECIAL TOOL STWG PRIME PCS	TA	P 2 0 2 2 2
569	FO PURIFIER SPECIAL TOOL STWG INST GUSSETS	TA	H 4 0 0 1 2
570	FO PURIFIER SPECIAL TOOL STWG INST FDN PCS	TA	H 4 0 0 1 1
571	FO PURIFIER SPECIAL TOOL STWG PREP FDN	TA	P 3 2 2 2 0
572	FO PURIFIER SPECIAL TOOL STWG PAINT FDN	TA	P 3 2 2 2 2
573	FO PURIFIER SPECIAL TOOL STWG FINAL PAINT FDN	TA	P 4 2 1 5 3
574	FO PURIFIER SPECIAL TOOL STWG PROCURE TOOL BOX	TA	Z 1 0 0 2 2
575	FO PURIFIER SPECIAL TOOL STWG PROCURE STRAPS	TA	Z 1 0 0 1 2
576	FO PURIFIER SPECIAL TOOL STWG INST TOOL BOX	TA	Z 6 0 0 0 2
577	FO PURIFIER SPECIAL TOOL STWG PAINT TOOL BOX	TA	P 4 1 0 3 2
578	2 LO SAMPLE BOTTLE RACK CUT PCS	TA	H 1 0 0 3 1
579	2 LO SAMPLE BOTTLE PACK BEND PC 968	TA	H 1 0 0 3 2
580	2 LO SAMPLE BOTTLE RACK PROCURE HARDWARE	TA	Z 1 0 0 2 1
581	2 LO SAMPLE BOTTLE RACK ASSM PARTS	TA	H 3 0 0 0 0
582	2 LO SAMPLE BOTTLE RACK PRIME FDN	TA	P 2 0 2 2 2

583	2 LO SAMPLE BOTTLE RACK INST UPPER FDN	TA	H 4 0 0 1 2
584	2 LO SAMPLE BOTTLE RACK INST LWR FDN	TA	H 1 0 0 3 2
585	2 LO SAMPLE BOTTLE RACK PREP FDNS	TA	P 3 2 2 1 0
586	2 LO SAMPLE BOTTLE RACK PAINT FDNS	TA	P 3 2 2 1 2
587	2 LO SAMPLE BOTTLE RACK FINAL PAINT FDNS	TA	P 4 2 0 1 3
588	2 LO SAMPLE BOTTLE RACK PROCURE BOTTLES	TA	Z 1 0 0 2 2
589	2 LO SAMPLE BOTTLE RACK INST BOTTLES	TA	Z 6 0 0 0 0
590	TEE (#380) WRENCH STWG CUT PCS	TA	H 1 0 0 2 1
591	TEE (#380) WRENCH STWG BEND PC 63	TA	H 1 0 0 2 2
592	TEE (#380) WRENCH STWG ASSM PCS	TA	H 3 0 0 1 0
593	TEE (#380) WRENCH STWG INST STWG	TA	H 4 0 0 1 1
594	TEE (#380) WRENCH STWG PRIME STWG	TA	P 2 0 2 2 2
595	TEE (#380) WRENCH STWG PREP STWG	TA	P 2 0 1 0 0
596	TEE (#380) WRENCH STWG PAINT STWG	TA	P 2 0 1 0 2
597	TEE (#380) WRENCH STWG FINAL PAINT STWG	TA	P 4 1 1 3 3
598	TEE (#380) WRENCH STWG PROCURE WRENCH	TA	Z 1 0 0 2 2
599	TEE (#380) WRENCH STWG INST WRENCH	TA	Z 6 0 0 0 2
600	TEE (#381) WRENCH STWG CUT PCS	TA	H 1 0 0 2 1
601	TEE (#381) WRENCH STWG BEND PC 63	TA	H 1 0 0 2 2
602	TEE (#381) WRENCH STWG ASSM PCS	TA	H 3 0 0 1 0
603	TEE (#381) WRENCH STWG INST STWG	TA	H 4 0 0 1 1
604	TEE (#381) WRENCH STWG PRIME STWG	TA	P 2 0 2 2 2
605	TEE (#381) WRENCH STWG PREP STWG	TA	P 2 0 1 0 0
606	TEE (#381) WRENCH STWG PAINT STWG	TA	P 2 0 1 0 2
607	TEE (#381) WRENCH STWG FINAL PAINT STWG	TA	P 4 1 1 3 3
608	TEE (#381) WRENCH STWG PROCURE WRENCH	TA	Z 1 0 0 2 2
609	TEE (#381) WRENCH STWG INST WRENCH	TA	Z 6 0 0 0 2
610	WRENCH (#50) STWG CUT PCS	TA	H 1 0 0 2 1
611	WRENCH (#50) STWG BEND PC 59	TA	H 1 0 0 2 2
612	WRENCH (#50) STWG ASSM PCS	TA	H 3 0 0 1 0
613	WRENCH (#50) STWG INST STWG	TA	H 4 0 0 1 1
614	WRENCH (#50) STWG PRIME STWG	TA	P 2 0 2 2 2
615	WRENCH (#50) STWG PREP STWG	TA	P 2 0 1 0 0
616	WRENCH (#50) STWG PAINT STWG	TA	P 2 0 1 0 2
617	WRENCH (#50) STWG FINAL PAINT STWG	TA	P 4 1 1 3 3
618	WRENCH (#50) STWG PROCURE WRENCH	TA	Z 1 0 0 2 2
619	WRNCH (#50) STWG INST WRENCH	TA	Z 6 0 0 0 2
620	TEE (#382) WRENCH STWG CUT PCS	TA	H 1 0 0 2 1
621	TEE (#382) WRENCH STWG BEND PC 63	TA	H 1 0 0 2 2
622	TEE (#382) WERENCH STWG ASSM PCS	TA	H 3 0 0 1 0
623	TEE (#382) WRENCH STWG INST STWG	TA	H 4 0 0 1 1
624	TEE (#382) WRENCH STWG PRIME STWG	TA	P 2 0 2 2 2
625	TEE (#382) WRENCH STG PREP STWG	TA	P 2 0 1 0 0
626	TEE (#382) WRENCH STWG PAINT STWG	TA	P 2 0 1 0 2
627	TEE (#383) WRENCH STWG FINAL PAINT STWG	TA	P 4 1 1 3 3
628	TEE (#383) WRENCH STWG PROCURE WRENCH	TA	Z 1 0 0 2 2
629	TEE (#382) WRENCH STWG INST WRENCH	TA	Z 6 0 0 0 2
630	TEE (#383) WRENCH STWG CUT PCS	TA	H 1 0 0 2 1
631	TEE (#383) WRENCH STWG BEND PC 63	TA	H 1 0 0 2 2
632	TEE (#83) WRENCH STWG ASSM PCS	TA	H 3 0 0 1 0
633	TEE (#383) WRENCH STWG INST STWG	TA	H 4 0 0 1 1
634	TEE (#383) WRENCH STWG PRIME STWG	TA	P 2 0 2 2 2
635	TEE (#383) WRENCH STWG PREP STWG	TA	P 2 0 1 0 0
636	TEE (#383) WRENCH STWG PAINT STWG	TA	P 2 0 1 0 2
637	TEE (#383) WRENCH STWG FINAL PAINT STWG	TA	P 4 1 1 3 3
638	TEE (#383) WRENCH STWG PROCURE WRENCH	TA	Z 1 0 0 2 2
639	TEE (#383) WRENCH STWG INST WRENCH	TA	Z 6 0 0 0 2
640	WRENCH (#51) STWG CUT PCS	TA	H 1 0 0 2 1
641	WRENCH (#51) STWG BEND PC 59	TA	H 1 0 0 2 2
642	WRENCH (#51) STWG ASSM PCS	TA	H 3 0 0 1 0
643	WRENCH (#51) STWG INST STWG	TA	H 4 0 0 1 1
644	WRENCH (#51) STWG PRIME STWG	TA	P 2 0 2 2 2
645	WRENCH (#51) STWG PREP STWG	TA	P 2 0 1 0 0
646	WRENCH (#51) STWG PAINT STWG	TA	P 2 0 1 0 2
647	WRENCH (#51) STWG FINAL PAINT STWG	TA	P 4 1 1 3 3
648	WRENCH (#51) STWG PROCURE WRENCH	TA	Z 1 0 0 2 2
649	WRENCH (#51) STWG INST WRENCH	TA	Z 6 0 0 0 2
650	HELMET STWG RACK FDN CUT PCS	TA	H 1 0 0 3 1
651	HELMET STWG RACK FDN BEND PCS 215 AND 216	TA	H 1 0 0 3 2
652	HELMET STWG RACK FDN PROCURE HARDWARE	TA	Z 1 0 0 2 1
653	HELMET STWG RACK FDN ASSM FDN	TA	H 3 0 0 0 0
654	HELMET STWG RACK FDN ASSM RACKS	TA	H 3 0 0 0 0
655	HELMET STWG RACK FDN PRIME FDN & RACKS	TA	P 2 0 2 2 2
656	HELMET STWG RACK FDN INST FDN	TA	H 4 0 0 1 1
657	HELMET STWG RACK FDN PREP FDN	TA	P 3 2 2 2 0
658	HELMET STWG RACK FDN PAINT FDN	TA	P 3 2 2 2 2
659	HELMET STWGRACK FDN ASSM RACK TO FDN	TA	H 3 0 0 0 0
660	HELMET STWG RACK FDN FINAL PAINT FDN	TA	P 4 2 0 0 3
661	RH DOOR 44 QT LO CAN RACK CUT PCS	TA	H 1 0 0 3 1
662	RH DOORN 44 QT LO CAN RACK ASSM PCS	TA	H 3 0 0 0 0
663	RH DOOR 44 QT LO CAN RACK PRIME FDN	TA	P 2 0 2 2 2
664	RH DOOR 44 QT LO CAN RACK INST FDN	TA	H 4 0 0 1 1
665	RH DOOR 44 QT LO CAN RACK PREP FDN	TA	P 3 2 2 2 0
666	RH DOOR 44 QT LO CAN RACK PAINT FDN	TA	P 3 2 2 2 2
667	RH DOOR 44 QT LO CAN RACK PROCURE HARDWARE	TA	Z 1 0 0 2 1
668	RH DOOR 44 QT LO CAN RACK ASSM RACK TO FDN	TA	Z 4 0 2 1 2
669	RH DOOR 44 QT LO CAN RACK FINAL PAINT UNIT	TA	P 4 2 0 3 3
670	LH DOOR 44 QT LO CAN RACK PROCURE HARDWARE	TA	Z 1 0 0 2 1
671	LH DOOR 44 QT LO CAN RACK INST RACK	TA	Z 4 0 2 1 2
672	LH DOOR 44 QT LO CAN RACK FINAL PAINT UNIT	TA	P 4 2 0 3 3
673	CLEAN UP CREWS LKR CUT MOUNTING PCS	TA	H 1 0 0 3 1
674	CLEAN UP CREWS LKR PRIME PCS	TA	P 2 0 2 2 2
675	CLEAN UP CREWS LKR INST MOUNTING PCS	TA	H 4 0 0 1 1
676	CLEAN UP CREWS LKR CUT LKR PCS	TA	H 1 0 0 1 1
677	CLEAN UP CREWS LKR BEND STIFFS	TA	H 1 0 0 1 2
678	CLEAN UP CREWSLKR PROCURE HARDWARE	TA	Z 1 0 0 2 1

679	CLEAN UP CREWS LKR ASSM LOCKING DEVICE	TA	Z 2 0 0 1 0
680	CLEAN UP CREWS LOCKER BEND LKR PLTS	TA	H 1 0 0 1 2
681	CLEAN UP CREWS LKR ASSM LKR	TA	Z 3 0 0 1 0
682	CLEAN UP CREWSLKR PRIME LKR	TA	P 2 0 2 2 2
683	CLEAN UP CREWS LKR PAINT LKR	TA	P 3 2 0 3 3
684	CLEAN UP CREWS LKR INST LKR	TA	Z 4 0 0 1 2
685	CLEAN UP CREWS LKR FINBAL PAINT LKR	TA	P 4 2 0 3 2
686	OPERATORS LKR STWG PROCURE HARDWARE	TA	Z 1 0 0 2 1
687	OPERATORS LKR STWG PROCURE LOCKER	TA	Z 1 0 0 2 1
688	OPERATORS LKR STWG INST LKR	TA	Z 4 0 0 1 0
689	OPERATORS LKR STWG FINAL PAINT LKR	TA	P 4 2 0 3 2
690	STWG OF DRY CHEM FIRE EXT PROCURE HARDWARE	TA	Z 1 0 0 2 1
691	STWG OF DRY CHEM FIRE EXT PROCURE EXTINGUISHER	TA	Z 1 0 0 2 1
692	STWG OF DRY CHEM FIRE EXT CUT FDN PCS	TA	H 1 0 0 3 1
693	STWG OF DRY CHEM FIRE EXT PRIME PCS	TA	P 2 0 2 2 2
694	STWG OF DRY CHEM FIRE EXT INST FDN	TA	H 4 0 0 1 1
695	STWG OF DRY CHEM FIRE EXT INST EXT	TA	Z 4 0 0 1 2
696	STWG OF DRY CHEM FIRE EXT PAINT FDN	TA	P 3 2 1 0 2
697	STWG OF DRY CHEM FIRE EXT FINAL PAINT	TA	P 4 2 1 3 3
698	GTRB SPECIAL TOOLS STWG CUT LKR PCS	TA	H 1 0 0 1 1
699	GTRB SPECIAL TOOLS STWG BEND LKR PCSA	TA	H 1 0 0 1 2
700	GTRB SPECIAL TOOLS STWG PROCURE HARDWARE	TA	Z 1 0 0 2 1
701	GTRB SPECIAL TOOLS STWG ASSM LKR	TA	Z 3 0 0 1 0
702	GTRB SPECIAL TOOLS STWG CUT MOUNTING PCS	TA	H 1 0 0 3 1
703	GTRB SPECIAL TOOLS STWG ASSM MTG PCS TO LKR	TA	Z 3 0 0 1 0
704	GTRB SPECIOAL TOOLS STWG INST LKR	TA	Z 4 0 0 1 2
705	GTRB SPECIAL TOOLS STWG PROCURE TOOL BOXES	TA	Z 1 0 0 2 2
706	GTRB SPECIAL TOOLS STWG PROCURE STRAPS	TA	Z 1 0 0 2 2
707	GTRB SPECIAL TOOLS STWG PRIME LKR	TA	P 2 0 2 2 2
708	GTRB SPECIAL TOOLS STWG PREP LKR	TA	P 3 2 0 3 0
709	GTRB SPECIAL-TOOLS STWG PAINT LKR	TA	P 3 2 0 3 2
710	GTRB SPECIAL TOOLS STWG INST TOOL BOXES	TA	Z 6 0 0 0 2
711	BULLETIN BOARD AND FIRST AID BOX FDN CUT FDN PCS	TA	H 1 0 0 3 1
712	BULLETIN BOARD AND FIRST AID BOX FDN DRILL HOLES	TA	Z 4 0 0 0 0
713	BULLETIN BOARD AND FIRST AID BOX FDN PROCURE HARDWARE	TA	Z 1 0 0 2 1
714	BULLETIN BOARD AND FIRST AID BOX FDN AQSSH FDN	TA	H 3 0 0 1 0
715	BULLETIN BOARD AND FIRST AID BOX FDN PRIME FDN	TA	P 2 0 1 0 2
716	BULLETIN BOARD AND FIRST AID BOX FDN INST FDN	TA	H 4 0 0 1 1
717	BULLETIN BOARD AND FIRST AID BOIX FDN PREP FDN	TA	P 3 2 1 2 0
718	BULLETIN BOARD AND FIRST AID BOX FDN PAINT FDN	TA	P 3 2 1 2 2
719	BULLETIN BOARD AND FIRST AID BOX FDN FINAL PAINT FDN	TA	P 4 1 1 3 3
720	BULLETIN BOARD AND FIRST AID BOX FDN PROCURE BULLETIN BOARD	TA	Z 1 0 0 2 2
721	BULLETIN BOARD AND FIRST AID BOX FDN PROCURE FIRST AID BOX	TA	Z 1 0 0 2 2
722	BULLETIN BOARD AND FIRST AID BOX FDN INSTALL BOARD & BOX	TA	Z 6 0 0 0 0
723	FUEL PURIFIER WORKBENCH CUT PCS 63 & 99	TA	H 1 0 0 3 1
724	FUEL PURIFIER WORKBENCH DRILL HOLES	TA	Z 2 0 0 1 0
725	FUEL PURIFIER WORKBENCH PROCURE HARDWARE	TA	Z 1 0 0 2 1
726	FUEL PURIFIER WORKBENCH INST FDN PCS	TA	H 5 0 0 3 2
727	FUEL PURIFIER WORKBENCH PREP FDN	TA	P 3 2 1 0 0
728	FUEL PURIFIER WORKBENCH PAINT FDN	TA	P 3 2 1 0 2
729	FUEL PURIFIER WORKBENCH PROCURE SINK UNIT	TA	Z 1 0 0 1 1
730	FUEL PURIFIER WORKBENCH INST SINK UNIT	TA	Z 4 0 2 1 2
731	MACHINIST WORKBENCH CUT PCS 63 & 99	TA	H 1 0 0 3 1
732	MACHINIST WORKBENCH DRILL HOLES	TA	Z 2 0 0 1 0
733	MACHINIST WORKBENCH PROCURE HARDWARE	TA	Z 1 0 0 2 1
734	MACHINIST WORKBENCH INST FDN PCS	TA	H 5 0 0 3 2
735	MACHINIST WORKBENCH PREP FDN	TA	P 3 2 1 0 0
736	MACHINIST WORKBENCH PROCURE WORKBENCH	TA	Z 1 0 0 1 1
737	MACHINIST WORKBENCH INSTALL WORKBENCH	TA	Z 4 0 2 1 2
738	MACHINIST WORKBENCH PAINT FDN	TA	P 3 2 1 0 2
739	GTRB-FIXTURE LIFT BAR INLET STWG CUT PCS	TA	H 1 0 0 3 1
740	GTRB-FIXTURE LIFT BAR INLET STWG BEND PCS	TA	H 1 0 0 3 2
741	GTRB-FIXTURE LIFT BAR INLET STWG DRILL HOLES	TA	Z 2 0 0 1 0
742	GTRB-FIXTURE LIFT BAR INLET STWG PRIME PCS	TA	P 2 0 2 0 2
743	GTREB-FIXTURE LIFT BAR INLET STWG INST STWGS	TA	H 4 0 0 1 1
744	GTRB-FIXTURE LIFT BARINLET STWG PREP STWGS	TA	P 3 2 1 2 0
745	GTRB-FIXTURE LIFT BAR INLET STWG PAINT STWGS	TA	P 3 2 1 2 2
746	GTRB-FIXTURE LIFT BAR INLET STWG PROCURE LIFT BARS	TA	Z 1 0 0 2 2
747	GTRB-FIXTURE LIFT BAR INLET STWG INSTALL LIFT BARS	TA	Z 6 0 0 0 2
748	GTRB-FIXTURE LIFT BAR INLET STWG PROCURE HARDWARE	TA	Z 1 0 0 2 1
749	MN RDGR SPCL TOOLS STWG CUT PCS	TA	H 1 0 0 3 1
750	MN RDGR SPCL TOOLS STWG ASSM STWG	TA	H 3 0 0 0 0
751	MN RDGR SPCL TOOLS STWG PRIME STWG	TA	P 2 0 2 2 2
752	MN RDGR SPC TOOLS STWG INST HEADERS	TA	H 4 0 0 1 2
753	MN RDGR SPCL TOOLS STWG INST STWG	TA	H 4 0 0 1 1
754	MN RDGR SPCL TOOLS STWG PROCURE STRAPS	TA	Z 1 0 0 1 1
755	MN RDGR SPCL TOOLS STWG PROCURE TOOL BOXES	TA	Z 1 0 0 2 2
756	MN RDGR SPCL TOOLS STWG INSTALL TOOL BOXES AND STRAPS	TA	Z 6 0 0 0 2
757	MN RDGR SPCL TOOLS STWG PREP HDRS	TA	P 3 2 1 0 0
758	MN RDGR SPCL TOOLS STWG PAINT HEADERS	TA	P 3 2 1 0 2
759	MN RDGR SPCL TOOLS STWG PREP STWG	TA	P 3 2 1 1 0
760	MN RDGR SPCL TOOLS STWG PAINT STWG	TA	P 3 2 1 1 2
761	MN RDGR SPCL TOOLS STWG FINAL PAINT STWG	TA	P 4 5 1 3 3
023	FR 220 & 228 SHELL WEB PLT CUT	TA	H 1 0 0 2 1
762	GTRB EMER MNL CONT CABLE RACK CUT PCS	TA	H 1 0 0 3 1
763	GTRB EMER MNL CONT CABLE RACK BEND PCS 53 & 55	TA	H 1 0 0 3 2
764	GTRB EMER MNL CONT CABLE RACK ASS PCS 53, 54 & 57	TA	H 3 0 0 1 0
765	GTRB EMER MNL CONT CABLE RACK PRIME PCS	TA	P 2 0 2 2 2
766	GTRB EMER MNL CONT CABLE RACK INST RACK	TA	H 4 0 0 1 2
767	GTRB EMER MNL CONT CABLE RACK PREP RACK	TA	P 3 2 0 0 0
768	GTRB EMER MNL CONT CABLE RACK PAINT RACK	TA	P 3 2 0 0 2
770	GTRB EMER MNL CONT CAPLE RACK INST CAPLE	TA	Z 6 0 0 0 3
769	GTRB EMER MNL CONT CABLERACK PROCURE LASHING	TA	Z 1 0 0 2 2
771	ACOUSTIC INSUL & SHEATHING AMR 2 CUT INSUL	TA	Z 1 0 0 0 1
772	ACOUSTIC INSUL AND SHTHING AMR 2 INST INSUL	TA	Z 4 0 0 0 0
773	ACOUSTIC INSUL & SHTHING AMR 2 INST INSUL AT ERECT JOINTS	TA	Z 5 2 0 1 2

774 TA H 1 0 0 1 1
ACOUSTIC INSUL & SHTHING AMR 2 CUT SHTHING
775 TA H 1 0 0 1 2
ACOUSTIC INSUL & SHTHING AMR 2 BEND SHTHG
776 TA H 5 0 0 3 2
ACOUSTIC INSUL & SHTHING AMR 2 INST SHTHING
777 TA P 4 5 0 3 3
ACOUSTIC INSUL & SHTHING AMR 2 P\AINT INSUL SHTHING
778 TA H 1 0 0 0 1
(2) SSDG ENCL DK CHNL & FRMG (LWR) CUT PCS
779 TA H 1 0 0 0 2
(2) SSDG ENCL DK CHNL &FRMG (LWR) BEND PCS
780 TA H 5 0 0 3 1
(2) SSDG ENCL DK CHNL & FRMG (LWR) ASSM/INST DK PCW
781 TA P 2 0 2 0 2
(2) SSDG ENCL DK CHNL &FRMG (LWR) PRIME PCS

782 TA P 3 2 1 7 0
(2) SSDG ENCL DK CHNL &FRMG (LWR) PREP/DK CHANNEL
783 TA P 3 2 1 7 3
(2) SSDG ENCL DK CHNL 7 FRMG (LWR) PAINT/DK CHANNEL
784 TA P 4 5 1 3 3
(2) SSDG ENCL DK CHNL & FRMG (LWR) FINAL PAINT/DK CHANNEL
785 TA Z 1 0 0 2 1
(2) SSDG ENCL DK CHNL &FRMG (LWR) PROCURE HARDWARE
786 TA H 4 0 0 0 2
(2) SSDG ENCL DK CHNL & FRMG (LWR) ASSM/INST OVHD PCS
787 TA P 3 2 1 3 0
(2) SSDG ENCL DK CHNL & FRMG (LWR) PREP/OVHD PCS
788 TA P 3 2 1 3 3
(2) SSDG ENCL DK CHNL &FRMG (LWR) PINT/OVHD PCS
789 TA H 5 0 0 3 2
(2) SSDG ENCL DK CHNL & FRMG (LWR) INST "H" BEAM

790 TA H 1 0 0 0 1
(2) SSDG ENCL DK CHNL &FRMG (LWR) CUT PCS
791 TA H 1 0 0 0 2
(2) SSDG ENCL DK CHNL & FRMG (LWR) BEND PCS
792 TA H 5 0 0 3 1
(2) SSIDG ENCL DK CHNL &FRMG (LWR) ASSM/INST DK PCS
793 TA P 2 0 2 0 2
(2) SSDG ENCL DK CHNL & FRMG (LWR) PRIME PCS
794 TA P 3 2 1 7 0
(2) SSDG ENCL DK CHNL & FRMG (LWR) PREP/DK CHANNEL
795 TA P 3 2 1 7 3
(2) SSDG ENCL DK CHNL & FRMG (LWR) PAINT/DECK CHANNEL
796 TA P 4 5 1 3 3
(2) SSDG ENCL DK CHNL & FRMG (LWR) FINAL PAINT/DK CHANNEL
797 TA Z 1 0 0 2 1
(2) SSDG ENCL DK CHNL & FRMG (LWR) PROCURE HARDWARE

798 TA H 4 0 0 0 2
(2) SSDG ENCL DK CHNL & FRMG (LWR) ASSM /INST OVHD PCS
799 TA P 3 2 1 3 0
(2) SSDG ENCL DK CHNL & FRMG (LWR) PREP/OVHD PCS
800 TA P 3 2 1 3 3
(2) SSDG ENCL DK CHNL & FRMG (LWR) PAINT/OVHD PCS
801 TA H 5 0 0 3 2
(2) SSDG ENCL DK CHNL & FRMG (LWR) INST "H" BEAM
802 TA H 1 0 0 0 1
(2) SSDG ENCL DK CHNL & FRMG (UPPER) CUT PCS
803 TA H 1 0 0 0 2
(2) SSDG ENCL DK CHNL & FRMG (UPPER) BEND PCS
804 TA H 4 0 0 0 1
(2) SSDG ENCL DK CHNL & FRMG (UPPER) ASSM/INST DK PCS
805 TA P 2 0 2 0 2
(2) SSDG ENCL DK CHNL & FRMG (UPPER) PRIME PCS

806 TA P 3 2 1 3 0
(2) SSDG ENCL DK CHNL & FRMG(UPPER) PREP /DK CHANNEL
807 TA P 3 2 1 3 3
(2) SSDG ENCL DK CHANNEL & FRMG (UPPER) PAINT/DK CHyANNEL
808 TA Z 1 0 0 2 1
(2) SSD!G ENC!L DK CHNL & FRMG (UPPER) PROCURE HARDWARE!
809 TA H 7 0 0 2 0
(2) SSDG ENCL DK CHNL & FRMG (UPPER) INST/CURTAIN PLTS
810 TA H 7 0 0 2 0
(2) SSDG ENCL DK CHNL & FRMG (UPPER) INST "H" BEAM
811 TA P 4 5 1 3 3
(2) SSDG ENCL DK CHNL & FRMG (UPPER) FINAL PAINT
812 TA H 1 0 0 3 1
CLAY CONTAINER STWG CUT PCS
813 TA P 2 0 2 2 2
CLAY CONTAINER STWG PRIME PCS

814 TA Z 1 0 0 2 2
CLAY CONTAINER STWG PROCURE HARDWARE
815 TA H 7 0 0 2 0
CLAY CONTAINER STWG INST FDN
816 TA P 3 1 1 1 0
CLAY CONTAINER STWG PREP FDDN
817 TA P 3 1 1 1 3
CLAY CONTAINER STWG PAINT FDN
818 TA Z 6 0 0 0 0
CLAY CONTAINER STWG INST CONTAINER
819 TA P 4 5 1 1 3
CLAY CONTAINER STWG FINAL PAINT
820 TA H 1 0 0 3 1
PHONE BOOTH & LOG DESK FDN CUT PCS
821 TA H 3 0 0 1 0
PHONE BOOTH & LOG DESK FDN ASSM UPPER PC 7 TO FDN

822 TA H 4 0 0 1 1
PHONE BOOTH 7 LOG DESK FDN INST BOTTOM CLIPS
823 TA P 2 0 2 2 2
PHONE BOOTH & LOG DESK FDN PRIME PCS
824 TA Z 1 0 0 2 1
PHONE BOOTH & LOG DESK FDN PROCURE HARDWARE
825 TA H 4 0 0 1 2
PHONE BOOTH & LOG DESK FDN INST UPPER CLIP
826 TA P 4 1 1 3 3
PHONE BOOTH & LOG DESK FDN FINAL PAINT FDN
827 TA P 4 5 1 3 3
PHONE BOOTH & LOG DESK FDN PAINT CLIPS
828 TA H 7 0 0 2 0
PHONE BOOTH & LOG DESK FDN INST FDN
829 TA Z 1 0 0 1 2
PHONE BOOTH & LOG DESK FDN PROCURE PHONE BOOTH, ETC

830 TA Z 5 2 0 2 2
PHONE BOOTH & LOG DESK FDN INSTALL PHONE BOOTH, ETC.
831 TA H 1 0 0 3 1
MISC STRL CLOSE PLTS -LWR LVL CUT ANGLE
832 TA H 1 0 0 2 1
MISC STRL CLOSE PLTS-LWR LVL CUT PLT
833 TA P 2 0 2 2 2
MISC STRL CLOSE PLTS -LWR LVL PRIME PCS
834 TA H 5 0 0 3 2
MISC STRL CLOSE PLTS-LWR LVL INST PCS
835 TA P 3 2 1 5 0
MISC STRL CLOSE PLTS -LWR LVL PREP PCS
836 TA P 3 2 1 5 3
MISC STRL CLOSE PLTS -LWR LVL PAINT PCS
837 TA P 4 5 1 3 3
MISC STRL CLOSE PLTS -LWR LVL FINAL PAINT PCS

838 TA H 1 0 0 0 1
(2) SSDG ENCL DK CHNL & FRMG (UPPER) CUT PCS
839 TA H 1 0 0 0 2
(2) SSDG ENCL DK CHNL &FRMG (UPPER) BEND PCS
840 TA H 4 0 0 0 1
(2) SSDG ENCL DK CHNL & FRMG (UPPER) ASSM/INST DK PCS
841 TA P 2 0 2 0 2
(2) SSDG ENCL DK CHNL &FRMG (UPPER) PRIME PCS
845 TA H 7 0 0 2 0
(2) SSDG ENCL DK CHNL & FRMG (UPPER) INST/CURTAIN PLTS
844 TA Z 1 0 0 2 1
(2) SSDG ENCL DK CHNL & FRMG (UPPER) PROCURE HARDWARE
843 TA P 3 2 1 3 3
(2) SSDG ENCL DK CHNL & FRMG (UPPER) PAINT/DK CHANNEL
842 TA P 3 2 1 3 0
(2) SSDG ENCL DK CHANNEL & FRMG (UPPER) PREP/DK CHANNNEL

846 TA H 7 0 0 2 0
(2) SSDG ENCL DK CHNL & FRMG (UPPER) INST "H" BEAMS
847 TA P 4 5 1 3 3
(2) SSDG ENCL DK CHNL & FRMG (UPPER) FINAL PAINT
848 TA H 1 0 0 2 1
MISC STRL CLOSE PLTS -UP LVL P/S CUT PLTS
849 TA H 1 0 0 3 1
MISC STRL CLOSE PLTS -UP LVL P/S CUT SHAPES
850 TA P 2 0 1 0 2
MISC STRL CLOSE PLTS-UP LVL PS PRIME MAT'L
851 TA H 7 0 0 2 0
MISC STRL CLOSE PLTS -UP LVL P/S INST PCS
852 TA P 3 1 5 2 0
MISC STRL CLOSE PLTS -UP LVL P/S-PREP PCS
853 TA P 3 1 5 3 3
MISC STRL CLOSE PLTS -UP LVL P/S PAINT PCS
854 TA P 4 5 5 3 3
MISC STRL CLOSE PLTS -UP LVL PS- FINAL PAINT
855 TA H 1 0 0 2 1
(13) DRIP PANS CUT PLATE
856 TA H 1 0 0 2 2
(13) DRIP PANS BEND PLT
857 TA H 2 0 0 0 0
(13) DRIP PANS WELD JOINTS
858 TA H 3 0 0 1 0
(13) DRIP PANS ASSM PADS
859 TA Z 4 0 2 1 2
(13) DRIP PANS DRILL PADS
860 TA Z 4 0 2 1 2
(13) DRIP PANS INST PANS
861 TA P 2 0 2 2 2
(13) DRIP PANS PRIME PANS

862 TA P 4 5 1 3 3
(13) DRIP PANS PAINT PANS
863 TA H 1 0 0 2 1
SSDG DSECONDARY FUEL FILTER ENCL (2) CUT PLTS
864 TA H 1 0 0 3 1
SSDG SECONDARY FUEL FILTER ENCL (2) CUT SHAPES
865 TA H 1 0 0 2 2
SSDG SECONDARY FUEL FILTER ENCL (2) BEND PLTS
866 TA Z 1 0 0 1 0
SSDG DECONDARY FUEL FILTER ENCL (2) PROCURE MTG & SHIELD
867 TA Z 1 0 0 2 1
SSDG SECONDARY FUEL FILTER ENCL (2) PROCURE HARDWARE
868 TA Z 2 0 1 1 0
SSDG SECONDARY FUEL FILTER ENCL (2) ASSMEBLE ENCLOSURES
869 TA P 2 0 1 1 0
SSDG SECONDARY FUEL FILTER ENCL (2) PREP ENCL

870	SSDG SECONDARY FUEL FILTER ENCL (2) PAINT ENCL	TA	P 2 0 1 1 2
871	SSDG SECONDARY FUEL FILTER ENCL (2) INSTALL ENCLOSURES	TA	Z 5 2 2 0 1
872	SSDG SECONDARY FUEL FILTER ENCL (2) CLEAN ENCL	TA	P 3 1 1 2 1
873	SSDG SECONDARY FUEL FILTER ENCL (2) PAINT ENCL	TA	P 3 1 1 2 2
874	SSDG SECONDARY FUEL FILTER ENCL (2) FINAL PAINT ENCLOSURE	TA	P 4 5 1 3 3
875	(4) STRAINER BOXES PROCURE PLATE	TA	Z-1 0 0 2 0
876	(4) STRAINER BOXES CUT PLATE	TA	H 1 0 0 2 1
877	(4) STRAINER BOXES BEND FLANGES	TA	H 1 0 0 2 2
878	(4) STRAINER BOXES PROCURE HARDWARE	TA	Z 1 0 0 2 1
879	(4) STRAINER BOXES ASSM EXTENSION TO BOX TOP	TA	H 3 0 0 1 0
880	(4) STRAINER BOXES INST STRAINER BOXES	TA	H 5 0 0 3 0
881	(4) STRAINER BOXES PREP BOXES	TA	P 2 0 1 0 0
882	(4) STRAINER BOXES PAINT BOXES	TA	P 2 0 1 0 2
883	(4) STRAINER BOXES CLEAN AFTER INST	TA	P 2 1 1 2 1
884	(4) STRAINER BOXES PAINT AFTER INST	TA	P 2 1 1 2 2
885	(4) STRAINER BOXES FINAL PAINT BOXES	TA	P 4 5 1 1 3
886	MISC STRL CLOSE PLTS -UP LVL P/S CUT PLTS	TA	H 1 0 0 2 1
887	MISC STRL CLOSE PLTS -UP LV P/S CUT SHAPES	TA	H 1 0 0 3 1
888	MISC STRL CLOSE PLTS -UP LVL P/S PRIME MAT'L	TA	P 2 0 1 0 2
889	MISC STRL CLOSE PLTS -UP LV P/S INST PCS	TA	H 7 0 0 2 0
890	MISC STRL CLOSE PLTS -UP LVL P/S PREP PCS	TA	P 3 1 5 2 0
891	MISC STRL CLOSE PLTS -UP LVL P/S PAINT PCS	TA	P 3 1 5 3 3
892	MISC STRL CLOSE PLTS -UP LV P/S FINAL PAINT	TA	P 4 5 5 3 3
893	(13 DRIP PANS CUT PLT	TA	H 1 0 0 2 1
894	(12) DRIP PANS BEND PLT (13) DRIP PANS WELD JOINTS TA H 2 0 0 0 0 X	TA	H 1 0 0 2 2
895	(13) DRIP PANS WELD JOINTS	TA	H 2 0 0 0 0
896	(13) DRIP PANS ASSM PADS	TA	H 3 0 0 1 0
897	(13) DRIP PANS DRILL PADS	TA	Z 4 0 2 1 2
898	(1C3) DRIP PANS INST PANS	TA	Z 4 0 2 1 2
899	(13) DRIP PANS PRIME PANS	TA	P 2 0 2 2 2
900	(13) DRIP PANS PAINT PANS	TA	P 4 5 1 3 3
901	SSDG SECONDARY FUEL FILTER ENCL (2) CUT PLTS	TA	H 1 0 0 2 1
902	SSDG SECONDARY FUEL FILTER ENCL (2) CUT SHAPES	TA	H 1 0 0 3 1
903	SSDG SECONDARY FUEL FILTER ENCL (2) BEND PLTS	TA	H 1 0 0 2 2
904	SSDG SECONDARY FUEL FILTER ENCL (2) PROCURE MTG & SHIELD	TA	Z 1 0 0 1 0
905	SSDG SECONDARY FUEL FILTER ENCL (2) PROCURE HARDARE	TA	Z 1 0 0 2 1
906	SSDG SECONDARY FUEL FILTER ENCL (2) ASSEMBLE ENCLOSURES	TA	Z 2 0 1 1 0
907	SSDG SECONDARY FUEL FILTER ENCL (2) PREP ENCL	TA	P 2 0 1 1 0
908	SSDG SECONDARY FUEL FILTER ENCL (2) PAINT ENCL	TA	P 2 0 1 1 2
909	SSDG SECONDARY FUEL FILTER ENCL (2) INSTALL ENCLOSURES	TA	Z 5 2 2 0 1
910	SSDG SECONDARY FUEL FILTER ENCL (2) CLEAN ENCL	TA	P 3 1 1 2 1
911	SSDG SECONDARY FUEL FILTER ENCL (2) PAINT ENCL	TA	P 3 1 1 2 2
912	SSDG SECONDARY FUEL FILTER ENCL (2) FINAL PAINT ENCL	TA	P 4 5 1 3 3
913	(4) STRAINER BOXES PROCURE PLATE	TA	Z 1 0 0 2 0
914	(4) STRAINER BOXES CUT PLATE	TA	H 1 0 0 2 1
915	(4) STRAINER BOXES BEND FLANGES	TA	H 1 0 0 2 2
916	(4) STRAINER BOXES PROCURE HARDWARE	TA	Z 1 0 0 2 1
917	(4) STRAINER BOXES ASSM EXTENSION TO BOX TOP	TA	H 3 0 0 1 0
918	(4) STRAINER BOXES INST STRAINER BOXES	TA	H 5 0 0 3 0
919	(4) STRAINER BOXES PREP BOXES	TA	P 2 0 1 0 0
920	(4) STRAINER BOXES PAINT BOXES	TA	P 2 0 1 0 2
921	(4) STRAINER BOXES CLEAN AFTER INST	TA	P 2 1 1 2 1
922	(4) STRAINER BOXES PAINT AFTER INST	TA	P 2 1 1 2 2
923	(4) STRAINER BOXES FINAL PAINT BOXES	TA	P 4 5 1 1 3
924	(13) DRIP PANS CUT PLT	TA	H 1 0 0 2 1
925	(1C3) DRIP PANS BEND PLT	TA	H 1 0 0 2 2
926	(13) DRIOP PANS WELD JOINTS	TA	H 2 0 0 0 0
927	(13) DRIP PANS ASSM PADS	TA	H 3 0 0 1 0
928	(13) DRIP PANS DRILL PADS	TA	Z 4 0 2 1 2
929	(13) DRIP PANS INST PANS	TA	Z 4 0 2 1 2
930	(13) DRIP PANS PRIME PANS	TA	P 2 0 2 2 2
931	(13) DRIP PANS PAINT PANS	TA	P 4 5 1 3 3
932	(4) STRAINER BOXES PROCURE PLATE	TA	Z 1 0 0 2 0
933	(4) STRAINER BOXES CUT PLATE	TA	H 1 0 0 2 1
934	(4) STRAINER BOXES BEND FLANGES	TA	H 1 0 0 2 2
935	(4) STRAINER BOXES PROCURE HARDWARE	TA	Z 1 0 0 2 1
936	(4) STRAINER BOXES ASSM EXTENSION TO BOX TOP	TA	H 3 0 0 1 0
937	(4) STRAINER BOXES INST STRAINER BOXES	TA	H 5 0 0 3 0
938	(4) STRAINER BOXES PREP BOXES	TA	P 2 0 1 0 0
939	(4) STRAINER BOXES PAINT BOXES	TA	P 2 0 1 0 2
940	(4) STRAINER BOXES CLEAN AFTER INST	TA	P 2 1 1 2 1
941	(4) STRAINER BOXES PAINT AFTER INST	TA	P 2 1 1 2 2
942	(4) STRAINER BOXES FINAL PAINT BOXES	TA	P 4 5 1 1 3
943	(13) DRIP PANS CUT PLT	TA	H 1 0 0 2 1
944	(13) DRIP PANS BEND PLT	TA	H 1 0 0 2 2
945	(13) DRIP PANS WELD JOINTS	TA	H 2 0 0 0 0
946	(13) DRIP PANS ASSM PADS	TA	H 3 0 0 1 0
947	(13) DRIP PANS DRILL PADS	TA	Z 4 0 2 1 2
948	(13) DRIP PANS INST PANS	TA	Z 4 0 2 1 2
949	(13) DRIP PANS PRIME PANS	TA	P 2 0 2 2 2
950	(13) DRIP PANS PAINT PANS	TA	P 4 5 1 3 3
951	(4) STRAINER BOXES PROCURE PLATE	TA	Z 1 0 0 2 0
952	(4) STRAINER BOXES CUT PLATE	TA	H 1 0 0 2 1
953	(4) STRAINER BOXES BEND FLANGES	TA	H 1 0 0 2 2
954	(4) STRAINER BOXES PROCURE HARDWARE	TA	Z 1 0 0 2 1
955	(4) STRAINER BOXES ASSM EXTENSION TO BOX TOP	TA	H 3 0 0 1 0
956	(4) STRAINER BOXES INST STRAINER BOXES	TA	H 5 0 0 3 0
957	(4) STRAINER BOXES PREP BOXES	TA	P 2 0 1 0 0
958	(4) STRAINER BOXES PAINT BOXES	TA	P 2 0 1 0 2
959	(4) STRAINER BOXES CLEAN AFTER INST	TA	P 2 1 1 2 1
960	(4) STRAINER BOXES PAINT AFTER INST	TA	P 2 1 1 2 2
961	(4) STRAINER BOXES FINAL PAINT BOXES	TA	P 4 5 1 1 3
962	(13) DRIP PANS CUT PLATE	TA	H 1 0 0 2 1
963	(13) DRIP PANS BEND PLT	TA	H 1 0 0 2 2
964	(13) DRIP PANS WELD JOINTS	TA	H 2 0 0 0 0

965	(13) DRIP PANS ASSM PADS	TA	H30010
966	(13) DRIP PANS DRILL PADS	TA	Z40212
967	(13) DRIP PANS INST PANS	TA	Z40212
968	(13) DRIP PANS PRIME PANS	TA	P20222
969	(13) DRIP PANS PAINT PANS	TA	P45133
970	(13) DRIP PANS CUT PLT	TA	H10021
971	(13) DRIP PANS BEND PLT	TA	H10022
972	(13) DRIP PANS WELD JOINTS	TA	H20000
973	(13) DRIP PANS ASSM PADS	TA	H30010
974	(13) DRIP PANS DRILL PADS	TA	Z40212
975	(13) DRIP APNS INST PANS	TA	Z40212
976	(13) DRIP PANS PRIME PANS	TA	P20222
977	(13) DRIP PANS PAINT PANS	TA	P45133
978	(13) DRIP PANS CUT PLT	TA	H10021
979	(13) DRIP PANS BEND PLT	TA	H10022
980	(13) DRIP PANS WELD JOINTS	TA	H20000
981	(13) DRIP PANS ASSM PADS	TA	H30010
982	(13) DRIP PANSDRILL PADS	TA	Z40212
983	(13) DRIP PANS INST PANS	TA	Z40212
984	(13) DRIP PANS PRIME PANS	TA	P20222
985	(13) DRIP PANS PAINT PANS	TA	P45133
986	(13) DRIP PANS CUT PLT	TA	H10021
987	(13) DRIP PANS BEND PLT	TA	H10022
988	(13) DRIP PANS WELD JOINTS	TA	H20000
989	(13) DRIP PANS ASSM PADS	TA	H30010
990	(13) DRIP PANS DRILL PADS	TA	Z40212
991	(13) DRIP PANS INST PANS	TA	Z40212
992	(13) DRIP PANS PRIME PANS	TA	P20222
993	(13) DRIP PANS PAINT PANS	TA	P45133
994	(13) DRIP PANS CUT PLT	TA	H10021
995	(13) DRIP PANS BEND PLT	TA	H10022
996	(13) DRIP PANS WELD JOINTS	TA	H20000
997	(13) DRIP PANS ASSM PADS	TA	H30010
998	(13) DRIP PANS DRILL PADS	TA	Z40212
999	(13) DRIP PANS INST PANS	TA	Z40212
1000	(13) DRIP PANS PRIME PANS	TA	P20222
1001	(13) DRIP PANS PAINT PANS	TA	P45133
1002	(13) DRIP PANS CUT PLT	TA	H10021
1003	(13) DRIP PANS BEND PLT	TA	H10022
1004	(13) DRIP PANS WELD JOINTS	TA	H20000
1005	(13) DRIP PANS ASSM PADS	TA	H30010
1006	(13) DRIP PANS DRILL PADS	TA	Z40212
1007	(13) DRIP PANS INST PANS	TA	Z40212
1008	(13) DRIP PANS PRIME PANS	TA	P20222
1009	(13) DRIP PANS PAINT PANS	TA	P45133
1010	(13) DRIP PANS CUT PLT	TA	H10021
1011	(13) DRIP PANS BEND PLT	TA	H10022
1012	(13) DRIP PANS WELD JOINTS	TA	H20000
1013	(13) DRIP PANS ASSM PADS	TA	H30010
1014	(13) DRIP PANS DRILL PADS	TA	Z40212
1015	(13) DRILL PANS INST PANS	TA	Z40212
1016	(13) DRIP PANS PRIME PANS	TA	P20222
1017	(13) DRIP PANS PAINT PANS	TA	P45133
1018	(13) DRIP PANS CUT PLT	TA	H10021
1019	(13) DRIP PANS BEND PLT	TA	H10022
1020	(13) DRIP PANS WELD JOINTS	TA	H20000
1021	(13) DRIP PANS ASSM PADS	TA	H30010
1022	(13) DRIP PANS DRILL PADS	TA	Z40212
1023	(13) DRIP PANS INST PANS	TA	Z40212
1024	(13) DRIP PANS PRIME PANS	TA	P20222
1025	(13) DRIP PANS PAINT PANS	TA	P45133
1026	(13) DRIP PANS CUT PLT	TA	H10021
1027	(13) DRIP PANS BEND PLT	TA	H10022
1028	(13) DRIP PANS WELD JOINTS	TA	H20000
1029	(13) DRIP PANS ASSM PADS	TA	H30010
1030	(13) DRIP PANS DRILL PADS	TA	Z40212
1031	(13) DRIP PANS INST PANS	TA	Z40212
1032	(13) DRIP PANS PRIME PANS	TA	P20222
1033	(13) DRIP PANS PAINT PANS	TA	P45133
1034	EEBD TRIPLE RACK STWG PROCURE LOCKER	TA	Z10012
1035	EEBD TRIPLE RACK STWG PROCURE HARDWARE	TA	Z10022
1036	EEBD TRIPLE RACK STWG INST LKR	TA	Z52310
1037	EEBD TRIPLE RACK STWG CLEAN LKR	TA	P45131
1038	EEBD TRIPLE RACK STWG PAINT LKR	TA	P45133
1039	GTRB TOOL BOX STWG IN E.R. PROCURE MATERIAL	TA	Z10020
1040	GTRB TOOL BOX STWG IN E.R. CUT PLT	TA	H10021
1041	GTRB TOOL BOX STWG IN E.R. BEND PLT	TA	H10022
1042	GTRB TOOL BOX STWG IN E.R. PROCURE HARDWARE	TA	Z10021
1043	GTRB TOOL BOX STWG IN E.R. ASSM BOX	TA	H30000
1044	GTRB TOOL BOX STWG IN E.R. PROCURE STRAP	TA	Z10011
1045	GTRB TOOL BOX STWG IN E.R.INST BOX	TA	Z40010
1046	GTRB TOOL BOX STWG IN E.R. PREP BOX	TA	P20200
1047	GTRB TOOL BOXSTWG IN E.R. PAINT BOX	TA	P20202
1048	GTRB TOOL BOX STWG IN E.R.CLEAN STRAP INST	TA	P45121
1049	GTRB TOOL BOX STWG IN E.R. PAINT STWG	TA	P45123
1050	SSDG ENCL PANELS (P&S) PROCURE MATERIAL	TA	Z10020
1051	SSDG ENCL PANELS (P&S) CUT PLT	TA	H10021
1052	SSDG ENCL PANELS (P&S) BEND PLT	TA	H10022
1053	SSDG ENCL PANELS (P&S) PROCURE HARDWARE	TA	Z10021
1054	SSDG ENCL PANELS (P&S) ASSM PNLS	TA	Z20010
1055	SSDG ENCL PANELS (P&S) PREP PNLS	TA	P20100
1056	SSDG ENCL PANELS (P&S) PAINT PNLS	TA	P20102
1057	SSDG ENCL PANELS (P&S) INST PNLS	TA	Z40000
1058	SSDG ENCL PANELS (P&S) CLEAN ENCLS	TA	P45131
1059	SSDG ENCL PANELS (P&S) PAINT ENCLS	TA	P45133
1060	MACH WORK BENCH AHR 2 CUT CUPS	TA	H10031

1061 TA Z 1 0 0 1 1
MACH WORK BENCH AMR 2 PROCURE WORK BENCH
1062 TA Z 4 0'2 1 2
MACH WORK BENCH AMR 2 INST WORK BENCH
1063 TA P 3 2 1 0 1
MACH WORK BENCH AMR 2 CLEAN CLIPS
1064 TA P 3 2 1 0 3
MACH WORK BENCH AMR 2 PAINT CLIPS
1065 TA Z 1 0 0 2 0
SSDG ENCL PANELS (P&S) PROCURE MATERIAL
1066 TA H 1 0 0 2 1
SSDG ENCL PANELS (P&S) CUT PLT
1067 TA H 1 0 0 2 2
SSDG ENCL PANELS (P&S) BEND PLT
1068 TA Z 1 0 0 2 1
SSDG ENCL PANELS (P&S) PROCURE HARDWARE
1069 TA Z 2 0 0 1 0
SSDG ENCL PANELS (P&S) ASSM PNLS
1070 TA P 2 0 1 0 0
SSDG ENCL PANELS (P&S) PREP PNLS
1071 TA P 2 0 1 0 2
SSDG ENCL PANELS (P&S) PAINT PNLS
1072 TA Z 4 0 0 0 0
SSDG ENCL PANELS (P&S) INST PNLS
1073 TA P 4 5 1 3 1
SSDG ENCL PANELS (P&S) CLEAN ENCLS
1074 TA P 4 5 1 3 3
SSDG ENCL PANELS (P&S) PAINT ENCLS

CODE HISTOGRAM

Below is the code histogram generated by D-CLASS, which displays in parenthesis the frequency of use for each attribute. Unused attributes are not listed. Subtree "TB" refers to the hull block construction tree; "TC" to the zone outfitting tree; and, "TD" to the zone painting tree. Subtree "TA" refers to the main subtree that links subtrees "TB", "TC", and "TD" together. This Histogram is based upon the 1074 interim products listed in Appendix C.

*** DISPLAY OF SUBTREE "TA" = 495 ***

*** DATA BASE STATISTICS ***

*** SUBTREE LINIKS TO SUBTREES: ***
496 497 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0

1. (560) HULL BLOCK CONSTRUCTION -->496
2. (226) ZOHE OUTFITTING –> 497
3. (284) ZONE PAINTING –> 498

*** DISPLAY OF SUBTREE "TB" = 496 ***

*** DATA BASE STATISTICS ***

1.(290) PART FABRICATION LEVEL
1.( ) PARALLEL PART FROM PLATE
2.(18) NON-PARALLEL PART FROM P
3.(116) INTERNAL PART FROM PLATE
4.(138) PART FROM ROLLED SHAPE
1.(1) PLATE JOINING
2.(215) MARKING & CUTTING
3.(74) BENDING
2.(30) PART ASSEMBLY LEVEL
1.(25)PART
1.(5) SUB-BLOCK
1.(21) SUB-BLOCK PART
2.(9) BLIILT UP PART
1.(1) ASSEMIBLY
) BENDING
3. (105) SUB-BLOCK ASSE MBLY LEVEL
) SUB-BLOCK
1. (105) SIMILAR WORK LARGE ANT
2. (55)SIMILAR WORK SMALL QUANT
98)ASSEMBLY
1.(7) BACK - ASSMBLY
4. (76) SEMI-BLOCK ASSEMBLY LEVE
1.(76
1. (28) SIMILAR WORK LARGE OUANT
2. (48)SIMILAR WORK SHALL QUANT
1. ( ) PLATE JOINING
2. (47) ASSEMBLY
26) BACK - ASSEMBLY
5. (50) BLOCK ASSEMBLY LEVEL
)BLOCK
1.(50) SPECIAL CURVED
1. (5 5) PLATE JOINING
2.(14) FRAMING
8.(31) ASSEMBLY
7. (9 HULL ERECTION LEVEL
3. (9)ENGINE ROOM
1. (9)ERECTION

*** DISPLAY OF SUBTREE "TC" = 497 ***

*** DATA BASE STATISTICS ***

1. (110) COHPONENT PROCUREMiENT LE
1. (3) IN HOUSE HAMUF ACTURING
2. (20) OUTSIDE HANUFACTURING
3. (87) PURCHASING
1. (12) DESIGN AND HATERIAL PREP
2. (60) MANUFACTURING
3. (38) PALLETIZING
2. (19) UNIT ASSEMBLY LEVEL
1.(17) COMPONENT
2. (2) UNIT
2. (19) SMALL SIZE UNIT
1. (19) ASSEMBLY
3. (3 GRAND UNIT JOINING LEVEL
1. (3)UNIT
2. (3) NIL
1. (3) JOINING
4. (57)ON-BLOCK OUTFITTING LEVE
1. (57)BLOCK
1. (21) DECK
3.(36) MACHINERY
1.(8) COMPONENTS IN A LARGE
2. (49) COHPONENTS IN A SMALL QC
1. (13) ON CEILING FITTING
4. (2) ON FLOOR FITTING
) ON FLOOR WELDING
5. (5)ON BOARD OUTFITTING LEVE
3. (5) ENGINE ROOM
1. (2) DECK
3. (2) MACHINERY
4. (1) ELECTRICAL
1. (2) SIHILM WORK IN SHALL VO
2. (2) SIHILAR WORK IN LARGE VO
3. (1) SIHUAR WORK BY HIGH SKI
1. (1) OPEN SPACE FITTING
2. (2) OPEN SPACE WELDING
3. (2) CLOSED SPACE FITTING
6. (32)OPERATION AND TEST LEVEL
1. (6)DECK
3.(20) MACHINERY
4.(6) ELECTRICAL

*** DISPLAY OF SUBTREE "TD" = 498 ***

*** DATA BASE STATISTICS ***

```
2. ( 119      ) PRIMER LEVEL
   1. ( 105     ) COMPONENT
   2. ( 14      ) BLOCK
   2. ( 50      ) EPOXY
   3. ( 69      ) IHORGANIC ZINC SILICATE
   1. ( 44      ) ONE COAT / NOMINAL AREA
   2. ( 4       ) ONE COAT / POSITIONAL DI
   3. ( 1       ) ONE COAT / POST PAINT BU
                ) ONE COAT / NEED TO MAINT
   1: (26       ) SURFACE PREP
   2. ( 4       ) CLEANING
   3. ( 89      ) PAINTING
3.( 95       ) FINISH UNDERCOAT PAINT L
   2. ( 10      ) UNIT TO BE FITTED AT ON
   3. ( 75      ) COMPONENT FITTED ON-BLOC
   1. ( 18      ) NO SCAFFOLD READ / CONVE
   2. ( 51      ) NO SCAFFOLD READ / EPOXY
   3. ( 12      ) NO SCAFFOLD READ / INORG
   6. ( 4       ) SCAFFOLD READ / EPOXY
   1. ( 16      ) ONE COAT / NOMINAL AREA
   2. ( 12      ) ONE COAT / POSITIONAL DI
   3. ( 24      ) ONE COAT / POST PAINT BU
   4. ( 13      ) ONE COAT / NEED TO MAINT
   5. ( 3       ) HULTIPLE COATS / NOMINAL
   6. ( 13      ) MULTIPLE COATS / POSITIO
   9. ( 4       ) HULTUIPLE COATS / NEED T
   1. ( 41      ) SURFACE PREP
   2. ( 3       ) CLEANING
   3. ( 21      ) TOUCH UP
   4. ( 20      ) PAINTING
4. ( 80      ) FINISH PAINT LEVEL
   2. ( 18      ) UNIT TO BE FITTED AT ON
   3. ( 24      ) COMPONENT FITTED ON-BLOC
   6- ( 38      ) ON BOARD / ENGINE ROOMl
   1.( 26       ) NO SCAFFOLD READ / CONVE
   2.( 52       ) NO SCAFFOLD READ / EPOXY
   6.( 2        ) SCAFFOLD READ EPOXY
   1. ( 6       ) ONE COAT / NOMINAL AREA
   2. ( 8       ) ONE COAT / POSITIONAL DI
   3. ( 2       ) ONE COAT / POST PAINT BU
   4. ( 63      ) ONE COAT / NEED TO MAINT
   4. ( 1       )MULTIPLE COATS / POSITIO
   2. ( 4       ) CLEANING
   3. ( 7       ) TOUCH UP
   4: ( 69      ) PAINTING
```

Introduction
to Comments by
Charles Stark Draper Laboratory, Inc.

The enclosed comments, prepared by the Charles Stark Draper Laboratory, Inc., were commissioned by Todd Seattle as a part of its performance of the project Product Work Classification and Coding. They discuss the approach and findings of this project.

As the project reached its mid-point, it became apparent that to produce a viable classification and coding system within the alloted time and budget parameters, it would be necessary to make certain decisions which limited its scope and content. At the time those decisions were made, Todd Seattle and the SP-4 Panel members agreed to the value of enlisting a consultant to evaluate the potential effect these decisions might have on the long term utilization of Group Technology by the shipbuilding industry. The search began for a consultant which possessed a broad understanding of Group Technology, and an acquaintance with the goals and methods of modern shipbuilding. The Charles Stark Draper Laboratory was chosen as that consultant. Its representatives, Dr. Whitney and Dr. De Fazio, were briefed on the methods and goals of the project, and furnished with its results as they became available. Their comments, presented here, contain both endorsements and criticisms of the project. In all cases they reflect

The authors of the manual Product Work Classification and Coding, and the SP-4 Panel feel these comments form a valuable addition to the project. Some of the differences in opinion reflect the fact that Draper looked beyond the immediate confines of the authors' charter in order to see how PWCC might be extended and integrated into U.S. shipbuilding. The authors understand the basis for these differences and generally feel that Draper's commentary provides an effective counterpoint to the decisions made during the project and, in the long run, will lead to more productive utilization of Group Technology.

Comments on

“PRODUCT WORK CLASSIFICATION AND CODING”

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Prepared for

Todd Pacific Shipyards Corporation
Seattle Division

Contract No. Ps 111711

September 18, 1986

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COMMENTS ON "PRODUCT WORK CLASSIFICATION AND CODING"

I. Introduction

This report is a comment on and critique of "Product Work Classification and Coding" (PWCC). This critique was commissioned by the author of PWCC in October, 1985 with the following statement of work:

1. Meet directly with the author to determine the scope and nature of his work on PWCC.

2. Comment on the organization and scope of the project.

3. Critique the project in terms of its relevance to producibility.

4. Make a written report.

Originally it was intended that Draper take an active, albeit minor, role in writing the PWCC handbook, but scheduling difficulties on the part of the author, as well as the unavailability of results of a test of the code at Todd Los Angeles, prevented this. Instead, Draper is providing this critique of the final draft of the PWCC handbook dated June 1986, which was received at Draper in late August, 1986.

Our report is organized as follows:

Section II: Discussion of the Original Goals of the PWCC **project.**

Section **III: General Comment on the Handbook.**

Section **IV: Draper's View of Group Technology, including code design** options **and various ways GT can impact producibility**

Section **V: Relation Between PWCC and GT Possibilities**

II. Goals of the PWCC Project

The PWCC project was sponsored by Panel SP-4-Design/Production Integration--of the Ship Production Commnittee with the general goals of introducing Group Technology (GT) into U. S. shipyards and demonstrating the potential uses of GT. An additional goal was to produce something that could be computerized. An important constraint was that the code not be so specific that some yards could not use it.

Additionally, it was desired to produce a code that would reinforce and be compatible with ongoing efforts to use product-oriented shipbuilding methods in U. S. yards. This resulted in the code being oriented heavily toward the IHI PWBS method of shipbuilding, which was developed mainly for commercial shipbuilding. The result (see below) is certain emphases and omissions in the code.

Finally, it was recognized that this project was part of a broader effort by SP-4 to systematize and computerize several aspects of shipyard planning activities. These include Computer-aided process planning (CAPP), long term scheduling, short term load leveling, and so on.

III. General Comments

The PWCC Handbook is a clear, well-written report that conveys the nature of GT and explains how GT could be used in shipbuilding. The report contains examples and illustrations of how GT, in connection with other techniques, has improved the operation of other industries, notably those involved in manufacturing. The code itself is clearly presented, and the example computer dialogs provide an easy way to prove to the reader that the system really can be used to code interim products. Strictly speaking, PWCC codes the transitions or work steps that transform one part or interim product to another. It does not code the parts or interim products themselves. This is discussed in the next section. The author does a good job showing how to extend the code in various ways to cover omissions that seem to him to be the result of trying to keep the code general enough for all U. S. yards to use.

There is a gap in the report that may be inherent in GT, at least in shipbuilding where the use of GT is new. It is hard for the reader to believe that GT will really be useful or make a real change in how a yard operates. The use of GT can actually be an entire way of doing business, so its use goes well beyond the act of coding. In the case of shipyards, GT has the potential to influence the design of ships and the design of yards. The extent to which these potentials can be realized will depend on how both the yards and their customers react to the opportunities. In this respect, as the following sections discuss, the present report may not go far enough. Since the report meets the requirements initially set for it, the sponsor might consider follow-on projects that fill the gaps discussed here.

The report does not say enough about how the code might be adopted and used by a yard and what other methods should be adopted at the same time (or in a coordinated plan) so that the advantages can be obtained. This process would certainly be different at each yard, but a model of how adoption might proceed would be useful. The paper from Boeing is very helpful in this regard but it applies to manufacturing and may not be sufficiently relevant to shipbuilding.

The next two sections of this commentary develop these ideas more fully.

IV. Draper's View of Group Technology

A. General Issues

Group Technology (GT) involves coding various entities by characterization of their features. Entities that are similar will have the same code, and dissimilar entites will have different codes. Subsequently one may use the coding to sort for similar entities. This is done for many purposes, including, say, avoiding duplication of design effort or for the grouping of entities to be fabricated or processed.

Group Technology originated in Russia in the late 1930's. It was created in order to increase the utilization of the small number of machine tools available to Russian shop managers. Part groups were identified for which common fixturing could be designed. The frequency of setups was reduced, and machine utilization increased, as a result of using such fixtures and rearranging schedules so that parts in one group were made in a long series.

Subsequently, GT has been applied to focus on any scarce or valuable resource, such as a region of a shop, a time frame, a skilled work crew, etc. The implication is that it makes sense to group things some other way than by a time sequence (for final installation or initial material delivery, for example). A further implication is that later regrouping may again be necessary so that final installation or delivery constraints can be met.

While the entities coded are often and typically parts (Opitz), they are not so limited (Beeby & Thompson) and may include assemblies of parts, capital equipment, computer software, & c. Figure IV-1 shows three different kinds of codes. When one considers GT codes, one must keep in mind what class of entities is being coded. Thus, for example, while a code that codes parts may be applied at the completion of a design stage, a code that codes assemblies ("interim products") may not be applied until a process, fabrication, and assembly sequence has been worked out. In particular, in the publication under discussion, "Product Work Classification & Coding," one is concerned with the interim product. More precisely, PWCC codes the transitions, or the fabrication or assembly processes, that carry one interim product to the next. Thus the coding under discussion can be applied only after both design and process, fabrication, and assembly sequence have been worked out.

Consider coding interim products associated with the erection of the hull of two nominally identical ships built at two different yards. At one yard, hull plates are welded together on templates, with frames

ONE MAY CODE ON:	CODE EXAMPLES	CODING MAY BE DONE FOLLOWING	CODING CAN BE USEFUL FOR
COMPONENT PARTS THIS USES A PART CODE (P. C.)	OPITZ CODE BOEING BUCCS-3	DEFINITION OF PRODUCT AND PARTS BY DESIGN	AVOIDING DUPLICATION IN PARTS DESIGN GROUPING SIMILAR PARTS FOR ORDERING OR FABRICATION
INTERIM PRODUCTS THIS USES AN INT. PROD. CODE (1. P. C.)	OPITZ CODE BOEING BUCCS-2,4 NASSCO PIPESHOP	DEFINITION OF RELEVANT INTERIM PRODUCTS BY DESIGN AND BY PROCESS SEQUENCE DECISIONS	GROUPING SIMILAR PRODUCTS OR ASSEMBLIES FOR ORDERING OR MANUFACTURING GROUPING SIMILAR PRODUCTS FOR SHOP LOADING ESTIMATES
PART OR INTERIM PRODUCT TRANSITIONS THIS USES A TRANSITION CODE "(T.C.)	PROPOSED PWCC	DEFINITION OF RELE- VANT INTERIM PROD- UCTS AND OF PROCESSES BY DESIGN AND BY PROCESS SEQUENCE AND CONTENT DECISIONS	GROUPING SIMILAR FAB PROCESSES FOR PROCESS LANE CREATION OR ESTIMATING SHOP OR PROCESS LOADING OR TIME/AREA/TOOL NEED EST. OR PROCESS PLANNING

FIGURE IV-1. DISTINCTIONS BETWEEN THREE TYPES **OF** GT CODING and longitudinals added subsequently; at another yard, hull plates are placed over and welded to frames and longitudinals which have already been fabricated on jigs. Even though the ships are nominally identical, the assembly sequences are different, the interim products are different, and code sequences that represent these interim products would be different. Thus generally a code, such as PWCC, representing interim products, cannot be applied until not only design, but also process, fabrication, and assembly sequence have been worked out.

Shipbuilding is almost unique, by virtue of the following characteristics:

1. The size of the product, characterized by, say, component part count.

2. The reduction by welding fabrication of a huge number of steel parts into a monolithic structural entity.

3. The level or degree of integration of various ships' systems is very large, making both design and fabrication planning both critical and quite difficult.

Other products which come to mind which share these characteristics are buildings that house modern hospitals, communication centers, or extensive modern manufacturing.

A ship, in comnon with most industrial products, is a fabrication and assembly of a number of component parts. In assembling a fractional horse-power electric motor, a manufacturer may be concerned with tens of parts; with hundreds or thousands in the fabrication and assembly of an automobile. A yard may be concerned with hundreds of thousands of parts while fabricating and assembling a ship.

It is common that a fleet of nominally identical ships is produced by a plurality of yards, and that details of procedure are different from yard to yard. Thus, where two yards may produce cruisers of a given class, and while there may be a close correspondence between the component parts used by either yard to fabricate members of the class, there is often little or no correspondence between class members at different yards during the fabrication and assembly stage. Where, for example, one yard may produce pre-outfitted blocks for assembly and mating into a ship on the ways, another may assemble ship's structure into grand blocks of the order of one-third of the ship to do both structural integration and outfitting subsequently. On a more detailed level, one yard may shop-prime steel structure before cutting, fabricating, and welding, while another may cut, fabricate, and weld structure before blasting and priming; one yard may do extensive detailed outfitting, finishing, wiring, testing, and **painting of** blocks, while another may launch a complete hull quite unfinished and devoid of outfit. Thus it is likely that two or more yards will start with similar or identical parts "kits," finish with similar or identical ships, but have very different "interim products" at any stage during construction.

It is these characteristics which permit the interim products of a particular class of ship to differ so greatly from yard to yard. One would not expect such differences in interim product in the manufacture, for example, of one design of small motor at several plants, or even in the manufacture of one automobile at different plants.

An important conclusion is that different yards will likely code interim products quite differently, even if they are built into the same ship design.

B. Possible Uses for GT Codes

GT codes have been used in the past to aid two general manufacturing tasks, design and production. Codes developed for one purpose may or may not be suitable for the other. Coding is based on identifying similarities, which may be difficult to do until one knows what use the code will be put to. What similarities matter? How different can things be and still be considered similar enough to get the same code?

A better way to state the problem is to say that the code should represent the differences that matter. For example, a code that is based on finding similar part shapes to aid in production planning must distinguish shape differences that would force a different process to be used. Another example is the NASSCO pipe shop code, which is used to approximately level-load the shop and plan workpiece **routing. This code** notes **if** large diameter **pipe** must be bent but does not distinguish diameters of small pipe that must be bent. The reason is that **small bending dies can be** changed very quickly, whereas it takes an hour to change a large die. Thus the size of pipe can be ignored if it is small because die changing won't impact overall processing time very much.

Classical uses **for GT** codes are as follows:

1. **For** design--
   - design retrieval
   - standardization and control of proliferation of designs for almost the same part
   - saving time during design, by retrieving process plans, purchasing data, etc.

generative design, in which the designer enters a code and the computer creates a trial design

critiques: a group of designs can be analyzed to see which types (codes) recur a lot, which only a little, or to compare designs with the same code to find the most effective designs

2. For production--

to aid in scheduling of shops, by grouping orders for a certain balance or work content, or to meet operating criteria like due date, or to identify parts or jobs that do or do not utilize certain scarce resources like materials, skills or machines

critiques: to see how many jobs with similar process requirements exist, so that process lanes can be designed to meet those needs, as well as to reduce the number of jobs that cannot be put on such lanes

generative process planning

The preceding subsection stated that the PWCC is unusual in seeking to code the changes that happen to a work package or interim product as it makes its way through the shipbuilding process. Tables IV-1 and IV-2 compare typical scenarios for how GT might be used in a manufacturing company and in a shipyard. From these tables, certain differences can be seen that are important for PWCC and how it might be used.

The first major difference is that in manufacturing, the designer plays the main role in defining the part and the code it will be given. This code remains the same until the part is made. A scheduler or planner may use the code for identifying or launching work packages, but he does not recode the items. In competitive shipbuilding, design really is largely planning, once concept design is complete. This is why yards and detail designers should work closely together. There is not one but several designers, as well as several planners. They must work together to identify what the interim products ought to be. As interim products evolve and move through the construction process, they get new codes. Thus there is continual involvement by the planner.

The second major difference is that shipbuilding can be quite exploratory on the first ship of a type. Thus the identity of the interim products and the coding can be expected to change for subsequent ships. In manufacturing there may be more stability of part type, materials, processes, and so on. The result is that a shipbuilding code should be linked to a data gathering activity so that poor coding can be identified and corrected, and so that new process lane opportunities can be found and implemented.

C. Uses for GT Codes in Shipbuilding

The tables and discussion of the previous subsection are a response to a possible reaction to PWCC, namely that coding would consist merely of ratifying someone else's decisions regarding identification of zones or work packages. If that were the case, coding would have no real use, and could in fact become a nuisance because new codes must be created all the time as interim products move through the yard.

On the contrary, the act of coding can be seen as a way of systematizing the process of designing the ship from a producibility point of view. As designers analyze the codes that result from transition design, they can see if simple designs predominate, or if like-size work packages result, or if enough information exists to make good decisions regarding the timing of work package launches.

On the assumption that a shipbuilding code should aid producibility analysis and yard work definition and scheduling, it seems to us that a code should include the following things that matter:

1. work content in terms of time
2. explicit or implicit information on skills needed
3. explicit or implicit information on the itemt's location at the time work will be done
4. schedule due date
5. explicit or implicit information on ancillary equipment needed
6. description of the type of work, materials, and tools needed

Each of these is consistent with a transition code (TC) which PWCC is.

If such information were available, one could sort interim product transitions in useful ways. For example, one could find packages that use painters at the aft end of the ship three weeks from today. Or one could find packages with HY-80 steel that will need primer removed before welding.

DESIGNER DEFINES PART, AT LEAST CONCEPTUALLY

↓

DESIGNER WRITES CODE FOR PART

↓

COMPUTER SEARCHES FOR SIMILAR DESIGNS, OR CREATES A DESIGN

↓

DESIGNER ADAPTS/ADOPTS COMPUTER'S OUTPUT, OR DESIGNS IT HIMSELF IF THE COMPUTER CAN'T HELP HIM

PLANNER OR SCHEDULER USES CODE TO GROUP THE PART WITH OTHER PARTS, OR TO DEFINE PROCESS LANES

CAPP IS USED TO WRITE PROCESS PLANS FOR THE PARTS

↓

TABLE IV-1. POSSIBLE SCENARIO FOR USE OF GROUP TECHNOLOGY IN MANUFACTURING CODING IS ASSUMED TO BE DONE BY PART

DESIGNERS DEFINE ENTIRE SHIP, A LEAST CONCEPTUALLY

DIFFERENT DESIGNERS PARTITION THE SHIP INTO PARTS, AND OTHER DESIGNERS PARTITION THOSE PARTS INTO STILL SMALLER PARTS AND INTERIM PRODUCTS --BUT "PART" DEFINITION IS PROVISIONAL AND IN SOME CASES ARBITRARY

DESIGNERS AND/OR PLANNERS CODE THESE ITEMS

TRIAL GROUPINGS OF PARTS ARE MADE BASED ON WORK PACKAGE, DUE DATE, SKILL LEVEL, ETC., TO SEE IF CODING IS ADEQUATE AND TO SEE IF PARTS ARE SUITABLE. COMPUTER HELPS BY SEEKING SIMILAR PACKAGES AND DESIGNS IN TERMS OF COST, WEIGHT, SIZE, ETC.

WORK PACKAGES ARE CREATED BY SORTING GROUPS, KEEPING TO THE MASTER BUILD SCHEDULE BUT LOADING THE SHOPS, SKILLS, AND PROCESS LANES EVENLY

ACTUAL TIMES, CHARGES, AND WORK CONTENTS ARE RECORDED AND USED TO UPDATE THE DATA BASES AND CAPP PROGRAMS

TABLE IV-2. POSSIBLE USES FOR GROUP TECHNOLOGY CODING IN SHIPBUILDING

V. Relation Between PWCC and GT Possibilities

This section compares the PWCC and the possible uses for GT discussed in the previous section. The section covers aims, structure, and uses for the code.

A. Aims

The report could be strengthened by stating the aims of the code more precisely. Perhaps the need to make the code general inhibited the author from stating the aims in other than general terms. We believe that a clearer statement of the code's applicability to sorting for production control, for example, would be helpful. SP-4 might well consider this issue in follow-on projects. The following subsections expand on this topic.

B. Structure

The code follows the IHI PWBS arrangement and thus contains IHI's emphases on commercial ships. Two major results are that type of steel or other construction material is not called out (although type of paint is), and testing is not shown as a continuing process during outfitting.

Yet we know that Navy ships are made of several distinct materials that require very different processing, skills, times (to heat up before welding, for example), preparation, inspection, and so on. These differences metter because they change timing, personnel, equipment, etc. They will be especially important for implementing the extensions to Process Selection that are discussed in Section 4.7 of PWCC.

The IHI PWBS seems to look" upon outfitting as a process of welding things up on the ship, whereas in complex ships outfitting to a large degree amounts to installation and test of equipment. These tests proceed in hierarchies and can take a very long time. Other work may interfere with them, and they may extend over large portions of the ship. For these reasons, tests occur often during outfitting, and the code needs to recognize this. In particular, Test definitely should be a stage in Unit Level Assembly, given that machinery units are an important type of unit, and they are thoroughly tested in the shop before installation.

Another reflection of the IHI point of view is that neither vent nor pipe is coded. This is a result of the author's code design decisions. IHI doesn't make any vent in the yard. However, it has carefully categorized pipe piece designs, and these could be coded separately to help a yard's shop make them, much as NASSCO has done.

C. Uses for the Code

The report and the computer examples give the impression that the act of coding really amounts to the planner exploiting his knowledge of how his yard operates. He "knows" (page 70) that a certain work package contains too many items, so he proceeds to divide it up. Neither the code nor the report show what other information is needed to do a good job in such cases. Yet there is great potential here to improve shipbuilding as well as to provide knowledge to planners (rather than depend on them to have it already).

The report also does not do enough to show coding in the context of shipbuilding. The job of coding seems to be a sterile, isolated act that merely states in numbers that a particular item has certain characteristics which anyone looking at it could see without the code. What is needed, perhaps in followup projects, is a way to link coding to CAD models **of** interim products (so planners could visualize the items they were coding) as well as to schedules and work sequences for building, transporting, installing, and working on them. These steps would help to expand knowledge of how to plan shipbuilding and would create better, less idiosyncratic plans. Figure V-1 diagrams how coding might interact with these other sources of information.

To serve these purposes, the code would have to be expanded over its current size. This expansion may **have to be** done by each yard in order to express its unique way of building ships.

D. Other Comments

The (PWCC) has the following salient features with the following associated *circumstances* and consequences.

PWCC codes almost exclusively transitions from part to interim product or from interim product to interim product. It cannot be used for parts coding and rarely or not at all for interim product coding. That is, it codes types of work rather than types of parts or interim products. Thus it is applicable only after assembly and process sequences have been worked out in detail as well as after design is completed. In this regard, it may be considered to be a code to be invoked substantially later in the process than parts-coding, if any. Assembly and process sequences are often worked out fairly late in the construction of a lead ship, so that PWCC appears to be a tool suited to planning the second and subsequent ships of a class moreso than the lead ship. Additionally, to the extent that significant effort and investment is implied by use of PWCC, it can consequently help enforce a certain rigidity, lack of flexibility, or reluctance to change or

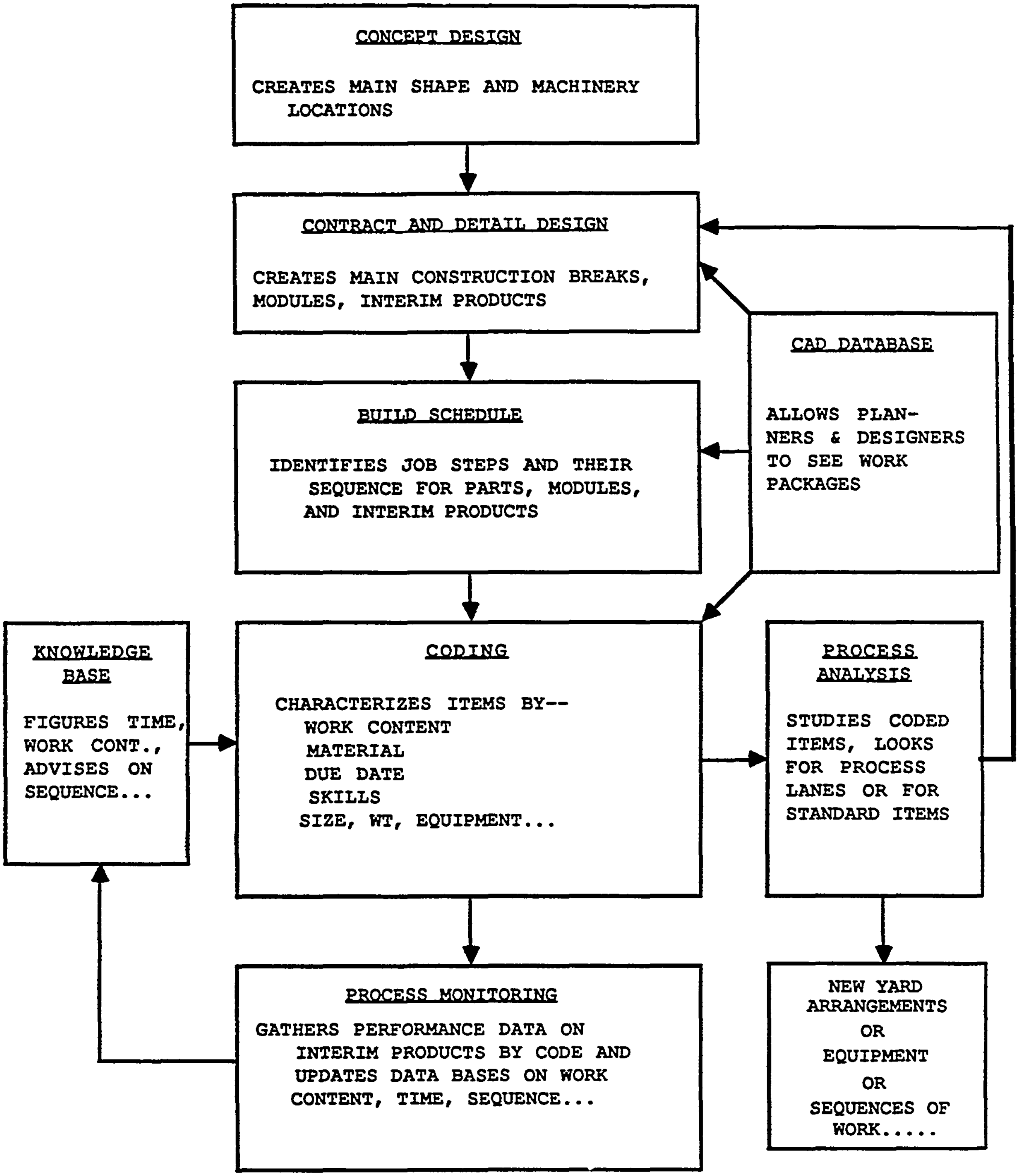

FIGURE V-1. HOW CODING MIGHT FIT INTO THE SHIP DESIGN/PLANNING PROCESS evolve construction processes. As construction processes change, the sequences and the PWCC coding and procedures set up on the basis of sorting or other code operations must also change.

The PWCC Code as presented is quite lean while the construction of a ship's hull can be very rich. The leanness is by consideration and design, yielding a fairly simple six-character code which a user can quickly learn to interpret without a codebook. However, the code is lean to the extent that various potential uses of transition coding (TC) are precluded. The leanness of the chosen code can be seen in the difference between attributes considered for coding (P. 31) and the PWBS attributes chosen for coding (P. 33). These are listed in Figure *v-2.* For example, a transition coding which included estimated task time would be more useful for scheduling exercises than one which omits task times. A coding of any type (PC, IPC, or TC) which includes information breakdown in detail is much more useful in planning steel welding processes. In this regard remember that mild steel, HSLA steel, and high-yield steel (e.g. HY80) are treated quite differently in details of welding; whether primers may be welded over or not, whether pre-heating is needed or not, and so forth.

The issue of what to include and what to omit in GT coding is recognized by the author of PWCC and the pros and cons are mentioned; that if a code is rich in the detail it admits, it's more complicated, more prone-to *error* and less easily used than it might be; if simple and easy to use, it is less prone to error but lacking in discrimination. One can accept the proposed code as a compromise *to* address a particular set of circumstances, but perhaps *not as a* code suitable for steel hull construction at every yard.

This suggests that there is some utility to ad hoc generation of G.T. codes to fit the needs, designs, ship, yard, and shop of the moment. Such codes may be tailored to the immediate situations to discriminate amongst differences that are important. A disadvantage of hoc code generation is that it leads to a plethora of individual codes which take no advantage of potential commonality or standard. A reasonable compromise may well be to permit the accretion of a series of extensive standard codes, which the potential user could choose from. The series of codes may include ones to address part and interim product coding, ones to address transitions coding; suitable to inside-shop applications, to block and zone application, and so forth. The user would pick the extensive standard code to his applications by coding only on those characteristics and attributes important to his applications and by enforcing a null entry on unimportant attributes. The result is specialization within a small collection of extensive standard codes.

A worthwhile topic for future SP-4 projects would be to build on the PWCC base, providing routes by which individual yards might particularize it to their needs and methods.

References

Beeby, W.D., and Thompson, A.R., "A Broader View of Group Technology," Boeing Commercial Airplane Co.

Opitz, H., A Classification System to Describe Workpieces, Pergamon Press, Oxford, ca. 1967.

POSSIBLE ATTRIBUTES FOR INTERIM PRODUCT CONTROL	**CODE TYPE**	ATTRIBUTES CHOSEN **FOR PWCC**	CODE TYPE
SIZE	PC/IPC	WORK TYPE	TC
SHAPE	PC/IPCI	MANUFACTURING LEVEL	TC
WEIGHT	PC/IPC	ZONE	IPC/TC
CONFIGURATION	PC/IPC	PROBLEM AREA	IPC/TC
POSITION	PC/IPC	STAGE	TC
LOCATION	PC/IPC		
SKILL REQUIREMENTS	TC		
LABOR TYPE	TC		
LABOR QUANTITY	TC		
MATERIAL TYPE	PC/IPC		
MATERIAL QUANTITY	PC/IPC		
PROCUREMENT CHARACTERISTICS	PC/IPC		
FABRICATION CHARACTERISTICS	TC		
ASSEMBLY CHARACTERISTICS	TC		
ERECTION CHARACTERISTICS	TC		
TEST CHARACTERISTICS	TC		

KEY: PC = PARTS CODING, IPC = INTERIM PRODUCT CODING, TC = TRANSITION CODING

FIGURE V-2. COMPARISON OF POSSIBLE ATTRIBUTES ON WHICH TO CODE AND THOSE CHOSEN FOR PWCC