SPECIFICATION-DRIVEN PIPE DETAIL DESIGN

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FINAL REPORT

SPECIFICATION-DRIVEN PIPE DETAIL DESIGN

I. EXECUTIVE SUMMARY

Traditional shipyard piping design begins with a piping system diagram. The piping system diagram is a drawing, at a level of detail which gives guidance and basic limiting parameters. Consequently the detailed design products which follow may contain errors, unintended differences frcm and contradictions to the system level design specifications.

This study was authorized to determine the feasibility and examine the implications of creating a computer-controlled environment in which the system-level design can be prcgrammatically correlated to the detail design. The approach taken would be to create, up-front, computer-resident sets of piping specifications and design rules. These sets would for the basis for ccmputer software processes and checks, to ensure that detail design practices are not allowed to deviate from the intent of the system design. Perfoming piping design in such a ccmputer-controlled environment has been titled specification-driven design.

This study was intended to address several issues:

1. Is such a system technically feasible?

2. What are some of the benefits of such a system?

3. What are the constraints to creating and using such a system?

4. Can such a system be developed that would be generic to the shipbuilding industry, or must it be user-specific?

The answer to this first question is yes. Such a system is technically feasible. Development has progressed in three-dimensional CAD/CAM technology to the point that assembling a ccmplete toolkit to build such a system is possible. Accordingly, during the course of this study, a prototype system was built that demonstrates the characteristics of a "specification-driven" environment

In answer to the second question, some of the benefits such a system would provide include:

Elimination of out-of-specification materials or material incompatibilities.

Geometric consistency between design intent and final product.

Reduction or elimination of change paperwork.

smaller design teams, as a result of combining of functions.

- Achievement of “mature” design in a shorter period of time.

- Maintenance of currency between details, BOM’s, and manufacturing Paper.

- Extraction of manufacturing data from the ccmputer-resident design model.

Although the “specification-driven” system is perceived to be both feasible and beneficial, there are some constraints which apply to the creation and use of such a system. Also there are technical and organizational issues which cannot be overlooked.

From a technical standpoint, few shipyards use exactly the same set of Computer tools. Consequently they do not all have exactly the same requirements for data, data types, entities, or graphic representations. In a software-driven environment, responsiveness to change on the order of magnitude required by a specification-driven system turns out to be a major consideration.

From the organizational standpoint, it is recognized that the flow and dispersal of data throughout yard organizations differ from yard to yard. Traditional workflow sequences will be strongly affected by the implementation of a specification-driven system.

The specifications themselves present a significant Challenge, owing to their size, number, complexitty, and interrelationships. The degree of success met in identifying, formatting, organizing, and storing the specifications on the computer, will determine the magnitude of other requirements, such as manning, time, and ccmputer resources.

The ccmputer resources aspect merits special mention here. The approach used in creating the prototype (specifically, creating a 3-D versus a 2-D system diagram, fleshing it out, and successively refining it with 3-D details) is a viable concept, and one which can be applied on any 3-D CAD system. But each implementation of that approach on distinct vendor systems will differ in substance, because the vendor systems do not all define the same elements and entities in the same way. Even identical entities are frequently stored or used differently on different systems. This means that even though the approach is transportable between different vendor Systems, an implementation of it on a given system will still contain non-transportable elements. No clear way of avoiding this situation has been identified, short of eliminating the use of differing systems.

Can then a generic specification-driven pipe detail design system be developed for shipyard industry use? The present study indicates that there are unavoidable user-specific aspects embedded in any implementation of a specification-driven system. There seems to be no ccmmon denominator to apply across the industry for a generic system.

The prototype developed in this study proves that the technology is available to develop such a capability on a given vendor system. But at the same time, the study also indicates that certain assumptions must be made and certain conditions must be in place for the system to work. Though there may be many similarities between yam%, no two facilities are known at the present to to have such conditions in common. Ultimately, this means that development and usefulness of this type of pipe detail design system must be determined by individual yards, based on:

Ž their commitment to making the necessary changes to their organizational structure; and

Ž their ability to project savings over their workload.

II. PURPOSE

The purpose of this study was twofold:

1) To investigate the feasibility of producing, on a CAD/CAM system, a detailed pipe design driven by the specifications for the system; and

2) If such a design system were deemed feasible, to generate a prototype system which demonstrates the characteristics of being specification-driven.

As stated in the foregoing Executive Summary, both purposes were accomplished. However, it is important to note that this study does not constitute development of a production system, nor is it an economic analysis of the development of such a system. Rather it is a demonstration, by actual construction of a prototype, that building a specification-driven pipe detail design system is technically feasible and achievable.

III. THE SPECIFICATIONS

It is a considerable task to implement a fully specification-driven system, considering the size of the body of data that comprise the specifications and the varying forms they assure. The ultimate goal is a system in which theoretically it is impossible for a detail designer to generate details containing discrepancies, inaccuracies, misused material, or other out-of-spec conditions. In practicality, such a system is still only as ccmplete, accurate, and up-to-date as its database (s) of specifications and design rules.

Much of the initial effort in this study was devoted to determining the exact composition of what is collectively called "The Specifications." One of the problems involved in developing a specification-driven system is that all the specifications for piping systems on a given ship type and contract are widely dispersed among a number of sources and are themselves sub ject to revision.

The various sources we have identified include:

- The Ship Specification document
- Contract Drawings
- project-peculiar documents
- Guidance drawings

- Standard drawings
- Type drawings
- Design data sheets
- Goverment Standards (MIL-STD and MIL-SPEC)
- Industry Standards
- Installation control drawings
- Sub-tier references
- Any requirements set forth by any other recogonized authority

Most of these sources are not self-contained, in that they refer to Other documents and drawings which involve additional requiremmts or specifications. For example, steam piping system design specifications are contained in the Ship Specification document in at least 22 separate sections, with multiple external references. AS another example, MIL-STD-777D breaks out into 69 individual categories of pipe systems, according to function, service, material, and so forth. These categories also further break down into multiple sub-tier references. In the prototype system there is no hierarchically arranged system of accessing sub-tier references. This is a topic which deserves further in-depth study on its own.

mother level of complexity is added by specifications that change from ship type to ship type, from contract to contract, and sometimes during a given contract. The prototype system addresses this problem by restricting the datafiles, which are built into the 3-D model, to a chosen contract, hull, and Ship Work Breakdown Structure (SWBS) group.

It is also necessary to include into the system the design rules governing overall system design, such as maintaining proper slopes and clearances, avoiding low points, inserting vents and drains in the proper locations, proper sequencing, avoiding penetrations into electronic spaces, and so forth. These design rules are themselves prescribed by the ship's specification or other reference, and by standard design procedures. Not all of these design rules were implemented in the demonstration system because of time.

After identifying the composition of the specifications, this mass of information must be condensed into subsets of manageable size end (more importantly) into computer-usable form for storage and retrieval. The prototype is a cut-down, restricted-access, purposefully small system, selected from an actual assembly of an actual ship design. This makes it possible to work with a specific set of specifications, properties, materials, descriptions and design rules.

By definition, a “totally” specification-driven system does not exist until the totality of the specifications is entered and stored in a usable form in a computer database.

For this reason, the primary effort was directed toward generating the prototype system of small and manageable proportions, to demonstrate an approach to be taken as a step toward the ultimate goal. This prototype system seines to show what is presently feasible and achievable on today’s 3-D CAD/CAM system.

IV. DEVELOPMENT AND PRESENT STATE OF THE ART

The development of the 3-dimensional geometric database for CAD (where the D is for design, rather than drafting) has been accompanied by the evolution of more intelligent software and data. This means that attributes and characteristics such as material, thickness, weight, CG, etc. , can be associated with an entity in addition to its geometric qualities. As a result of these data having become available, software can be used to define and implement design rules. These rules can check not only items such as compatible materials coming together or correctness of fitting sizes for mating pieces, but can also be invoked to ensure manufacturability. Using an intelligent 3-D pipe model, a software interface can extract manufacturing data from the model and pass it on to CAM systems, such as a DNC pipe bender. Checking the length of straight pipe between bends to ensure that in-house equipment can accomplish bends as specified is an example of a manufacturing design rule check.

Design and manufacturing rule checks are made possible not only by software development, but by the presence and use of associable data. Data elements, like software, are often not in place because of the economic trade-offs between creation costs and benefits. At the present time no computer correlation between the schematic diagrams for piping and the detail design is done at a contractor's yard.

In the usual detail design, the data it takes to make the crosscheck are not available at the time the crosscheck should be made; or else it is available, but not stored on a computer. The cost of capturing and storing these data -- in terms of manpower and budget resources, as well as the major organizational restructuring it would require -- has been perceived as prohibitive. The cost of capture would exceed the benefit derived.

However, if the decision is made to pursue full development of a Specification-driven pipe detail design system in a true 3-D mode, then that decision dictates that the data must be made available. Hence steps must be taken to identify and capture these data.

At most shipyards, absent elements are included among the following:

- System diagrams are only 2-D functionally representative drawings.

- System diagrams are not truly scaled or completely dimensioned. This imposes immediate limitations on the level of completeness which can be achieved for true geometry.

- System diagrams do not contain all components (tees, ells, bends, sleeves, etc.). This limits correlation with the detail design, and is the reason for the absence of some of the dimensional data which are created in detail design as a function of component selection and insertion.

- Major functional items, such as valves, are located on the diagram only generally, not specifically in ship coordinates with orientation of hand wheels.

- Many compnents are selected that not only meet, but in fact exceed, specification. This adds to the complexity of correlation because the exact substitution is not identified until late in the developmental flow.

What can be done to counter these problems?

Some of the steps taken to offset these disadvantages include the following:

- A master property file has been created on which resides all MIL-STD-777D components and attributes associated with these entries. In conjunction with the property file, a corresponding master material file and a description file have also been created.

- Restricted subsets of each masterfile have been extracted, which are specific to the contract, hull, and - level for each model.

- ŽAny substitutions of the “meets-or-exceeds specs” nature are eliminated at the start by having the cognizant system engineer and material sourcing personnel cooperate in creating the restricted master files, before the model itself is created. Thus any substitutions which may be necessary because of inventory levels, supply problems, cost factors, or company-specified preferences can be put into the restricted files as original entries, not modification. A data element stored within the model itself identifies the files from which the model was created and disallows any attempts to access components, materials, fittings, etc. from other files.

- Ž Routing is done in a ship coordinate system that is dimensionally accurate to the fitting level and all fittings are included within the model as a software function, selected from the restricted files, thereby ensuring accuracy and compatibility.

- Ž The bill of material feature is assured of having valid and correct selections and quantities because it accesses a model. created from the restricted files.

2-D vs 3-D System Diagram

The piping system diagram traditionally is the common origin from which the detail design proceeds. Accordingly, this study began with the creation and development of the system diagram

The conventional 2-D system diagram cannot provide computer-aided correlation between itself and the associated detail design except in a very limited sense. Traditionally piping detail design has been developed from a previously prepared 2-D system diagram. Figure 1 depicts a typical 2-D partial piping system diagram. It is evident from the diagram that the 2-D representation lacks locating dimension data, as well as some component identifications, such as. elbows, bends, and tees. The general route of the pipe and the locations of the valves are indicated, but only in a general sense, not oriented to any specific reference point.

Since no capability exists programmatically to utilize the 2-D diagrammatic in a checking capacity for the detail design, the designer has to manually extract the system requirements from the diagram and all the documentation comprising “the specs. ” Clearly this practice does not programmatically ensure either correctness or consistency between the system diagram and detail design.

Analysis indicates that specification-driven pipe detail design is best accomplished by preparing the system diagram on the computer in a 3-D CAD/CAM environment. This is a major departure from standard shipyard procedures. The advantage of this approach is that it lays the foundation for such functions as assured compatibility between the system diagram and detail drawing, including:

- proper sequencing of piping components.
- correct material/component selection.
- correct piping arrangement/routing.
- design rule checking.

Also, when used in conjunction with the models from other ship disciplines, interference checking is made possible.

An isometric view of the 3-D Product Definition Model gives some clear advantages over the conventional system diagram as a workable tool. Visually it provides a much better understanding of the system requirements and layout including routing. It is invaluable in early identification of conflicts in congested areas, and as a troubleshooting guide. The 3-D model contains graphics and intelligence that far exceed the requirements of a system diagram. The 3-D model thus eliminates the need for a 2-D representation, and may possibly require a redefinition of the present system diagram as a contract deliverable item. The 3-D model would be the logical entity to take its place. Then, by issuing appropriate commands on the CAD system, the intelligence that is in the model drives the detail design.

Arrangements

The Piping Product Definition Model is dependent upon the compartment arrangement and structural models being completed prior to its development. This is a shift in the standard design approach, wherein arrangements and structures are generally prepared in parallel with the piping system and detail design phases. Assumptions can be made based on the information contained in the contract package. The logical approach seems to be to schedule structure and arrangements to be done first.

System Sequencing

With a full implementation of a specification-driven design system, each shipboard piping system will have its own designated product Definition Model. This necessitates the adoption of control mechanisms on the part of design management. Piping models cannot all be developed concurrently (like 2-D system diagrams) when multiple systems access the same compartment. Actual pipe routing is completed at the model stage, so ordering criteria must be established for building the models. Piping systems will have to be prioritized according to sequence to prevent piping impacts. An ordering that seems to work fairly well in the contractor's yard, at least in limited applications, is structure first, then HVAC and Electrical, then Pipe. System sequencing is not a new approach; it simply must begin at an earlier stage.

At this point it is pertinent to ask for the rationale behind this approach. What led us in this direction? In the sequel this question is addressed.

V. THE PROTOTYPE SYSTEM DESCRIPTION

The Approach

Originally it was felt that the best approach would be to first create a 3-D model and generate -- with some small effort — a 2-D system diagram from that model. This would be done by rotating into the plan view, turn off edgeviews, turn on centerline display, snap a picture and thus obtain a drawing. This is still possible and it can be done whenever desired.

However the choice was made not to do it, because it results in a very cluttered and confusingly "busy" product, particularly against a background of other ship submodels -- HVAC, Electrical, Hull Structure, and so on. Even after blanking out all the unwanted portions of the background models, the remaining centerline representation still is not really satisfactory. Symbols must be created and inserted to represent components. Annotations must still be added. Changes in the vertical dimension are not clear in the 2-D representation. Neither are the symbols for the components. The 3-D model loses its clarity when it drives a 2-D diagram.

Ultimately, if the 3-D model is allowed to drive a 2-D schematic diagram, the resultant of feet is that of merely automating the production of the system diagram, and the pipe detail designer ends up with exactly what he had in the first place: a 2-D diagram on a sheet of paper. From this he must do his routing, insert fittings and valves, generate material lists, and submit to the composite function to determine interferences to be resolved. All his results must then be recreated in 3-D to get then back into the model.

So, the reverse approach was taken. Since it was necessary in any case to establish points in space in an arbitrary coordinate system, and then create a rough pipe route between them, it seemed foolish not to go ahead and perform the task in generally arranged 3-D Ship space. This way the rough-route of the pipe and all the associated points are saved and are available to the detailer. The points are in true ship coordinates in an intelligent model on the CAD workstation, not just on a piece of paper. Having these points established in the model does not mean that some of them cannot later be changed by the detailer, but it <u>does</u> mean he has a true ship-coordinate 3-D starting model to work with.

In actuality the only really “fixed” points he has are the starting points and ending points. These must remain fixed because usually they are the entry points into and exit points out of the modeled zone. There is not enough storage on almost any given existing CAD/CAM system to hold an entire stem-to-stern 3-D model on-line. Because of these size limitations, ship models are broken up into zones. Entry points and exit points are kept fixed because of the accuracy control required to make each zone match up with its mating assemblies. These points could be controlled to the level of requiring approval for movement.

This is where the demonstration of the prototype model begins, with a set of points in 3-space in ship coordinates, a set of restricted associated material and property files, and a centerline diagram displayed in 3-D in several views. These views include the plan view, which resembles the 2-D schematic the detailer is accustomed to seeing. The pipe model (a firemain, SWBS 521) was selected from a live assembly in work at the time of this writing, and the background of live sub-models from other ship disciplines -- HVAC, Electrical, Hull -- is included in the model. They are blanked out for the sake of clarity.

It should be stated that the demo system is restricted, tailored and highly structured. Because of the pressures of budget and time, sane aspects of the system are “hard-wired,” but the tools and machinery are there to do a full implementation, if such should be directed and funded in the future.

The System Structure

There are three primary master files in the system:

1) The master property file (MIL-STD-777D, Category D-1)
2) The master material file
3) The master description file

Figures 2 and 3 show how these files fit into the system structure. (Figures 2 and 3 also correspond roughly to the cognizant piping system engineer's job and the detailer's job, respectively.) Figures 4, 5, and 6 are samples of the contents of these files.

From these master files, three restricted rester files have been extracted. The prototype system is intentionally limited to these restricted files. The basic premise is that a model built from restricted files containing only legal components and materials will yield a correct detail design. Into these restricted master files have been placed only properties, fittings, valves and materials which meet the specifications for the selected pipe system. Doing this ensures that the detailer cannot use any out-of-spec components or materials. Additionally the current production piping layout package has been tailored by restricting it to a subset of its full capabilities, and a number of design rule checks and error stops have been added.

For demonstration purposes, the restricted files were created and loaded using only available system utilities -- extracts, sorts, and edits — but in a fully-implemented system, this process should be done under programmatic control. A high-level macro should drive creation and loading of the restricted files, which are then specific to a given contract, hull, and SWBS group. This could be done by making a set of computer-resident Specification-constraint matrices, cross-indexed by SWBS number and MIL-STD-777D category. The macro would direct the program to extract from the master property files only those components and materials it finds that meet the conditions set forth in the constraint matrices, and load then into the restricted master files for the given piping system. These matrices could be structured to parallel those laid out in the MIL-STD-777D document (Figure 7) .

Producing this macro program and a full set of constraint matrices would be a large undertaking, since many of the selection criteria are not in easily translated computer-sensible form. Wherever, for example, the number of allowable exceptions or substitutions outweighs a given criterion itself, or when it is more trouble to force the criteria into a computer-cmpatible form than it is to make a manual selection, the attempt may turn out to be counterproductive. A combination of computer-based and manual efforts could turn out to be the easiest, quickest and most efficient way of making some selections, and this approach should not be dismissed for being "tainted" by manual methods. As a matter of fact, the mixed method approach is in wide use today. It should definitely be recognized, however, as a source of admitting or introducing out-of-spec -tries, the situation our system attempts to avoid. Further study may shed light on ways to avoid the use of mixed methcds In the meantime, the mixed method approach continues to be a popular and widely used tactic on most installed CAD systems, and the practice, while it admits of error, is not likely to be abandoned unless there is a clearly superior replacement.

The Functional Breakdown

Analysis of the structure of the restricted system resulted in the identification and isolation of certain tasks involved in three separate functions: that of the material sourcing analyst, that of the cognizant piping system engineer, and that of the pipe detail designer. In attempting to isolate the functions, one observation has been that some of them could be logically combined to take full advantage of a specification-driven system. If these functions remain separate, then much closer coordination and cooperation among these three is necessary before an implementation of a specification-driven system could be successfully used. Following are the functions considered in the analysis:

1) <u>Material Sourcing Analyst Functions</u>

The Material Sourcing Analyst:

- Identifies specific vendor-supplied materials and components
- Supplies company stock numbers and/or national stock numbers.
- Has access to inventory information, purchasing information, and lists of equivalent acceptable components and materials.
- Has input on specifications from the cognizant piping System engineer.
- Based on this information, decides specifically which among the various acceptable equivalents will actually be used. *
- Loads these specific items to the piping master files. This must be done before the cognizant piping system engineer can construct the restricted files and the model tied to them

* (Usually at this point the items would be turned over to purchasing to be bought . Under a new specification-driven system, it would be possible to wait until the model is built and the design is fixed to order the material and components used in the model.)

2) <u>Cognizant System Engineer Functions</u>

The Cognizant System Engineer:

- Knows the system specifications and advises the material sourcing analyst on specifications.

- Using this knowledge, builds the restricted files for a given model on-the CAD system

- Coordinates with material sourcing personnel to insure restricted files contain only valid entries — identifies and inputs substitutions and equivalents up front.

- Models the system diagram in centerline mode using the restricted files, placing pipe and valves only. This establishes a rough route of the pipe run. Entry and exit points must be fixed for accuracy control purposes.

- At some point, places a “lock” on the model and stores it, including in the model itself a data element which ties it to the restricted files.

To perform the task of creating the system diagram in 3-D, the Cognizant System Engineer has available a software toolkit. The toolkit is a collection of prepared and selected programs and options on the CAD system. Some come with the vendor-supplied package, some are vendor-supplied and custom-tailored in-house, and others are developed and written in-house from scratch. The kit includes many of the same tools used by the detail-— the point location/creation tools, the verification tools, the measuring and calculating functions, the analysis and utility functions, the geometry and placement functions. The Cognizant System Engineer has no real need to place anything other then pipe and valves, if his function is kept separate from the detailing function. But he could conceivably be given the entire detailing toolkit as well, and could perform the detailing too, in this new approach to pipe design.

The Cognizant System Engineer is permitted several capabilities denied to the detailer. He can insert, delete, and interchange valves; specify tolerances and limits; set default fitting types; lock the diagram model onto the restricted files; lock in the sequence and count of the valves; and set the entry and exit points into and out of the given zone, for accuracy of module mating.

But all these functions are follow-ons to the requisite file building and loading that must take place beforehand, in order to make this approach to a spcification-driven system work. The Cognizant Engineer must be responsible for identifying all the components and materials that are legal ("within spec") for a given SWBS number and MIL-STD-777D category. He must interact closely with the material sourcing analyst, to identify AT THE BEGINNING OF A CONTRACT, what specific materials and components will be used in that contract. The material sourcing analyst should be responsible for seeing that these materials and components are loaded to the MIL-STD-777D master files. Macro procdures should be written to control the loading and maintenance of these master files by category.

The Cognizant Engineer should be responsible for extracting from these master files the restricted files specific to contract, hull, and SWBS number. The engineer should have an extract program available in his toolkit to assist him in creating these restricted files.

This extract program has already been alluded to in the foregoing section entitled "The System Structure. " Writing a general, all-purpose, case-cmprehensive program to do the extract would not be a trivial task. One of the major difficulties is to determine a workable, computer-sensfile from for ALL the specification constraints (or at least, as many as a given yard might want). Many of them be stored and accessed in forms similar to the category tables in the MIL-STD-777D document. Hcwever, no all-encompassing scheme has yet been invented whereby EVERYTHING -- subtier and external references included — will fit neatly into a computer-compatible format.

3) <u>Detail Designer Functions</u>

The Detail Designer:

- Retrieves the "locked" model by specifying proper contract identifier, hull identifier, and SWBS number.

- Runs the startup procedure, which attaches that model to the files the cognizant engineer used to generate the model (and <u>only</u> those!).

- Runs the detailed routing package to "flesh out" the diagram with fittings, final routing, etc. and stores the detailed model under a separate name.

- Runs postprocessor functions as desired.

Analysis indicates that the material sourcing analyst is the logical choice to load into the master files the items approval by the cognizant piping engineer. The cognizant engineer should create the restricted files, then begin building the 3-D system diagram. Also, it would be just as easy for the cognizant system engineer to go ahead and invoke the same procedures on the CAD workstation that the detail designer would use. Since the cognizant engineer would already be at the workstation, logged in, and using the package, it seems logical to essentially merge the detail design task into the cognizant system engineer’s realm of responsibility. With a sufficiently friendly user interface to assist him in this task, he could produce fully detailed pipe runs as easily and in generally the same time frame as he formerly spent on 2-D centerline diagrams, and he would do it with fewer errors in materials and components.

Some of the detail design functions then would move upstream to the system engineer, while some of the system engineer’s material/component specification functions move upstream to the material. sourcing analyst. With intelligent models (of the other disciplines, besides pipe) to merge the piping system with, and with an efficient trustworthy interference checking program, the traditional composites drawing function could conceivably be eliminated.

Here, however, encroachment begins upon the departmental organizational structures and functional charters at most yards. This is where the impact on organizational. structure begins to become- disruptive to the “normal” workflow sequence the organization is accustomed to following. Not many yards are receptive to the idea of entire departments disappearing with the implementation of a specification-driven pipe detail design system. In the final analysis management must decide if implementation is worth all this change.

The Demonstration — Description and Agenda

The demonstration is a highly structured session, not a flexible "what if" instrument. It is intended to show how detail design can be accomplished from a 3-D system diagram with restricted files and a software tool kit with custom tailored error checks and stops. In the demonstration the emphasis is shifted toward detail design rather than drawing. The drawing part is easy. Any reasonably sophisticated 3-D CAD/CAM system has extensive drawing capability. At the end of the demonstration, drawings made from our live model are exhibited, such as those in Figures 10 through 18.

First an explanation of naming conventions and notation is in order. Notation is one of the unavoidable vendor-specific aspects of the demo system. This vendor's file management system maintains files in directories and subdirectories and addresses them by a pathname. The pathname consists of the root directory and all subdirectory branches, down to the filename level. The system denotes the root directory in a pathname by a double slash (//) and delimits other branches in the pathname by a single slash (/).

The root and branches can be named arbitrarily. Therefore, for the restricted system, root and branch subdirectory names have been selected to correspond to contract identifier and hull identifier, and file names to identify the SWBS number and the model type.

In general, the naming standard is:

// Contract / Hull / Model SWBS

For the demo they are called

// SP4 / SP4/ MDIA521 (diagram model)
and // SP4 / SP4/ MDET521 (detailed model)

The 'MDIA' and 'MDET' are automatically inserted by software so that the user has to input only the SWBS number.

There are two primary functions which take place in producing a detailed pipe run. These are the functions of the cognizant piping system engineer and that of the detail designer. (For a further description of these functions, see the Functional Breakdown section of thiS document. In a specification-driven system these two functions could very well be done by one individual, the cognizant engineer.)

The demonstration begins with the task of the detailer, but some discussion of what takes place prior to the detailing function is called for, because that controls what the detailer gets to work with.

The cognizant engineer has the prime responsibility for designing the system to specifications. In the demonstration system, it is assumed that the cognizant engineer has already, in cooperation with the material sourcing department, identified at the start all the materials and components to be used in this particular system, according to its SWBS number (521) and its MIL-STD-777D category (D-1). These components and materials have been loaded into the three master files and the cognizant engineer has created from the master files a set of three restricted files for our model. He has created a 3-D system diagram, using pipes and valves from the restricted files, and roughly routed it in "centerline mode in the given zone space. He has reached the point where he is satisfied with the diagrammatic model and has filed (stored) it with a "lock" (a data element which is in the model itself) on the restricted files and on the sequence of the pipe run elements.

The model is then ready for detailing, and the cognizant engineer can either do it himself or pass it on to a detailer. This is the point at which the graphics demonstration begins. The role of the detailer is played throughout. He will flesh out the diagram with details, routing around and thru the zone, placing bends, elbows, fittings, and so on as required, and rerouting the diagrammatic path if necessary. Intentional errors are injected throughout the process, to demonstrate the appropriate error handling features.

A major point is that the detailer has the latitude to do whatever is necessary within the confines of what the cognizant engineer Specified in his "locked" model — the detailer cannot change the functionality of the system, nor can he get out of the restricted files. His software tool kit has been further restricted to four major commands. A simplified diagram of the detailer's capabilities reveals his task to be as follows:

SP4RMD	Retrieve locked model of system diagram
IPISTART	Initialize for changes (from the restricted files only)
IPLROUTE	Detailed routing with breaks, bends, fittings, etc.
SP4FLE	File the detailed model (with validity checks built-in)

These four functions must be invoked in order. This is one of the checks that have been installed.

If the detailer does not supply the proper contract identifier, hull identifier and SWBS number to the SP4RMD retrieval command, the detailer cannot get at the model.

Once IPLSTART is entered, the model is locked into the restricted files for the changes to be effected by the detailer.

If the detailer forgets to run IPLSTART before invoking IPLROUTE, the system responds with an error prompt and refuses to process further.

IPLROUTE is the primary driver, providing menus of functions available under its control. Figure 8 is a sample of the top level menu for IPLROUTE listing the options. The menus have been hard-coded for this demo, but could be dynamically created by the driver progra, depending on the type of piping system, adding or eliminating functions or options as required. Consider for example a pneumatic tube system where only long radii, e.g. , 24D , are allowed. Then on the menu where the bend radius is now hard-wired to select either 2D, 3D or 5D, the 24D could be displayed as the only menu selection available for bend radius in that system

When the locked diagram model is retrieved, the graphics screen comes up with a display of 5 windows. Each window contains a view of this model. The largest window contains an isometric view of the 3-D system diagram. The lower left window is the plan view, which resembles the 2-D diagram the designer is accustomed to seeing. The other views, in the column on the right are, in order from top to bottom, a smaller isometric view, a front view, and a smaller plan view. Other screen layouts, windows and views can be easily defined. Of course whatever is done in any given view happens to the entire model, and the software utility tool kit the detailer has (option 10 on the top-level menu) allows zooming, panning, and Other functions to obtain better views of the work area.

The Agenda

STEP 1: ENTER SP4RMD (To retrieve the diagram)

(a) Error check entry

SP4/SP4/531 YIELDS ERROR MESSAGE

(b) Enter correct names

SP4/SP4/521

MODEL BEING RETRIEVED. PLEASE WAIT

STEP 2: ENTER MDV (Model verify)

To show model name is

//SP4/SP4/MDIA521

STEP 3: • Turn off centerline display

• Turn on edgeview display

STEP 4: <u>PLVERIFY</u>

(a) 4" Pipe

(b) VER prop for that 4" pipe

(c) 1/2" valve

(d) VER prop for 1/2" valve

STEP 5: Turn edgeviews back off and continue.

Turn centerline display back on.

STEP 6: <u>ENTER IPLROUTE</u>

(ERROR — Model not initialized for detailing

Program IPLSTART must be run prior to detailing)

STEP 7: ENTER IPLSTART

No prompts — IPLSTART executes without intervention.

- Points at restricted files

- Sets tolerance environment, e. g. weld gap less than .01″

STEP 7A: DO PLDEFLT

Select centerline display

STEP 8: Immediately create Auxiliary Point (explain rationale)

STEP 9: Now IPLROUTE

MENU

STEP 10: Ž Select menu option

1 - generate pipe

• Digitize an existing 4" pipe to pick up attributes.

• Route 4" pipe

Pick up points in dif ferent views l

(Note how pipe shows UP in edgeview)

STEP 11: • DIG 1/2″ pipe

• ROUTE 1/2″ pipe

STEP 11A: Rotate 1/2″ pipe -- rotate valve handle

STEP 12: DELETE schematic now (to avoid clutter)

STEP 13: Select Fitting option 2

Ž Place 90 degree LR Elbow (make material error.)

Ž Place it in 4" pipe.

Error Message Displays

STEP 14: Now correctly place all of the 1st 3 LR Elbows

(watch system trim pipe to handle the fitting)

STEP 15: <u>FIND PENETRATION POINT</u>

Use another (better) view.

STEP 16: BREAK PIPE AT PENETRATION POINT

STEP 17: PLACE PENETRATION

STEP 18: PLACE 90 DEGREE ELBOW

(make schedule 300 error)

Error Message

STEP 19: Place correct 90 degree LR Elbow

(schedule 200)

STEP 20: Place two 3- Diameter bends correctly (no intentional error)

STEP 21: Place SOCKOLET (no error)

STEP 22: Utility ZOOM for 1/2″ run

STEP 23: Place 2D. BLEND OF 4″ PIPE on 1/2″ run (international error)

ERROR MESSAGE: ENGRG SPEC VIOLATED, 4″ PIPE IN 1/2″ RUN

STEP 24: Place CORRECT 2D 1/2″ BEND

STEP 25: Place two 2D BENDS (no error)

STEP 26: Place two 3D BENDS (no error)

STEP 27: Place one 45 DEGREE LR ELBOW (no error)

STEP 28: Place one 90 DEGREE SR ELBCW (no error)

STEP 29: Place SLEEVE

STEP 30: BREAK 4" pipe end place 4" valve

(This is an intentional error which will be caught later.)

STEP 31: IPLSLOPECHK

(Explain errors)

STEP 32: DISPLAY ALL

ZOOM ON VARIOUS AREAS

(** BE SURE TO RPS!! **)

STEP 33: QBOM PIPE (IPIQBOM)

(Quick Validity check – real BOM is a drawing)

STEP 34: INTERFERENCE CHECK

- Run-live (will take 5 or 6 minutes)

Ž Discussions while running

Ž Ž Batch vs dynamic

Ž• Show all hits we know we have

STEP 35: Ž Explanation of Interferences

- Reclassifications (from unacceptable to acceptable)

(Recap -- just before filing)

STEP 36: SP4FLE

SP4

SP4

521

ERROR! MODEL NOT FILED: BAD VALVE COUNT/SEQ

ZOOM&HIGHLIGHT THE BAD VALVE

STEP 37: DELETE BOGUS VALVE

STEP 38: QBOM - show valve gone

STEP 39: SP4FLE correctly

SP4/SP4/521

STEP 40: Model Verify

Show model filed was MDET521

STEP 41: Discuss drawings

STEP 42: Slide show

VI. CONCLUSIONS AND OBSERVATIONS

In summary, attention is again directed to the ccmments in the Executive Summary section of this paper, and further observations are listed below:

A specification-driven pipe detail design system is feasible and achievable using the approach we have identified.

- The full development and implementation is lengthy, costly, and complicated. There are no substantive data on which to base a cost justification.

- Some aspects of any implemenation remain vendor-specific and possibly non-transportable.

- Reorganizational impacts should be expected.

- Work flow prioritizing and resequencing is mandatory.

- The primary benefit of a specification-driven system is realized when the system is invoked at the beginning of a new contract. The effect of isolatig legal components and materials in restricted files at the front end of a contract is diminished if it is attempted in mid-contract.

- Management must decide if the benefits are worth the cost and effort.

- The tools and machinery are available to do the task if the order to proceed were given and funding were available.

Our Basic Premise:

A valid model, created from restricted files, using tailored software tools, perforce yields valid details. (This means it is crucial to get all the entries in the restricted files correct. The cognizant engineer is the touchstone.)

Our Demo system Approach in Summary

- Dispense with the 2-D system diagram

- Use a 3-D system diagram (leading to a product definition model in 3-D) .

- Resequence/prioritize work flow.

- Move some of the detail design responsibility upstream to the cognizant system engineer.

- Get the cognizant engineer and material sourcing analyst together at the start, to build and load restricted files.

- Create a 3-D system diagram, locked onto the restricted files.

- Force the detailer to use only what the cognizant engineer specified, by giving him a restricted software tool kit.

VII. GLOSSARY OF TERMS AND ABBREVIATIONS

BOM - Abbreviation for Bill of Material

CAD/CAM - Computer-Aided Design/Computer Aided Manufacturing

cognizant engineer - the piping system design engineer, responsible for designing the system to specification. The authoritative interpreter of the specifications.

CRT - Cathode Ray Tube — a computer's video display screen .

diagram - see schematic.

〈DIG〉 - Abbreviation for digitize.

digitize - to select an item from the CRT display by means of a digitizing instrument such as a stylus or mouse.

directory see pathname

edgeview (mode) - A graphics display mode in a 3-D CAD/CAM system, which shows the outer contours (the edges) of 3-dimensional objects in any given spatial orientation.

IGES - Initial Graphics Exchange Specification. A “standard” means of transmitting graphics information from one type of CAD/CAM system to another.

Model - A computer-generated, computer-resident representation of a ship system, complete with geometry, text items, and other intelligence. It is the product defintion database, containing all attribute data, both physical and descriptive, of all items contained within a predefined physical ship’s space.

pathname - A method of identifying computer disk files organized in a tree structure – root (directory) and branches (subdirectories) .

PDM - Product Definition _Model -- see Model.

schematic - refers to a 2-dimensional single-line drawing depicting a functional symbolic representation of a piping system.

screen layout - the pattern of the windows on the CRT.

subdirectory - see pathname.

SWBS - Ship Work Breakdcm Structure. Refers to the method of categorizing ship systems by a 3-digit number identifying the functional characteristics of the unit.

system diagram - see schematic

window - a partition of a computer's graphic screen (CRT) layout.

VIII. FIGURES

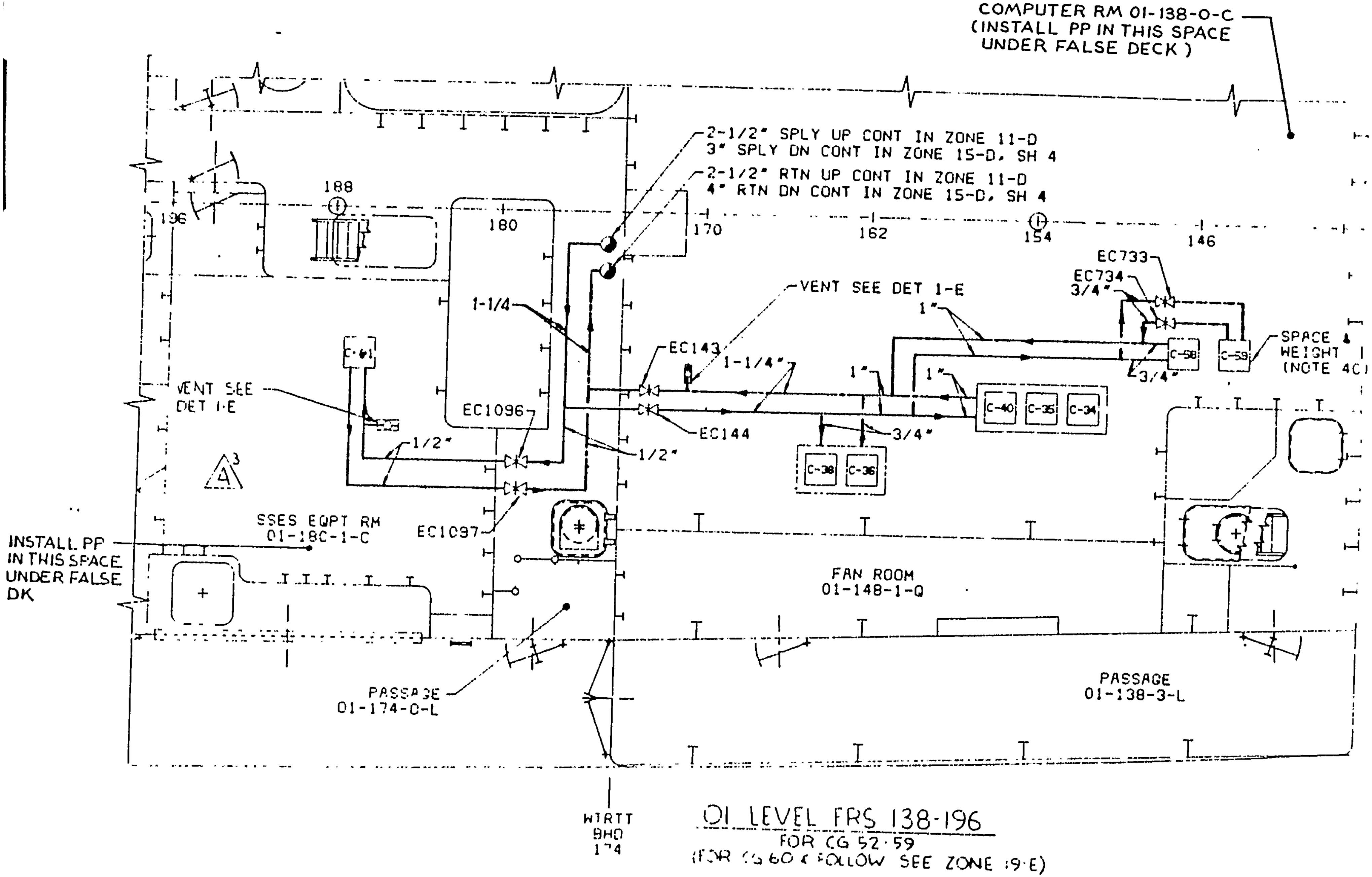
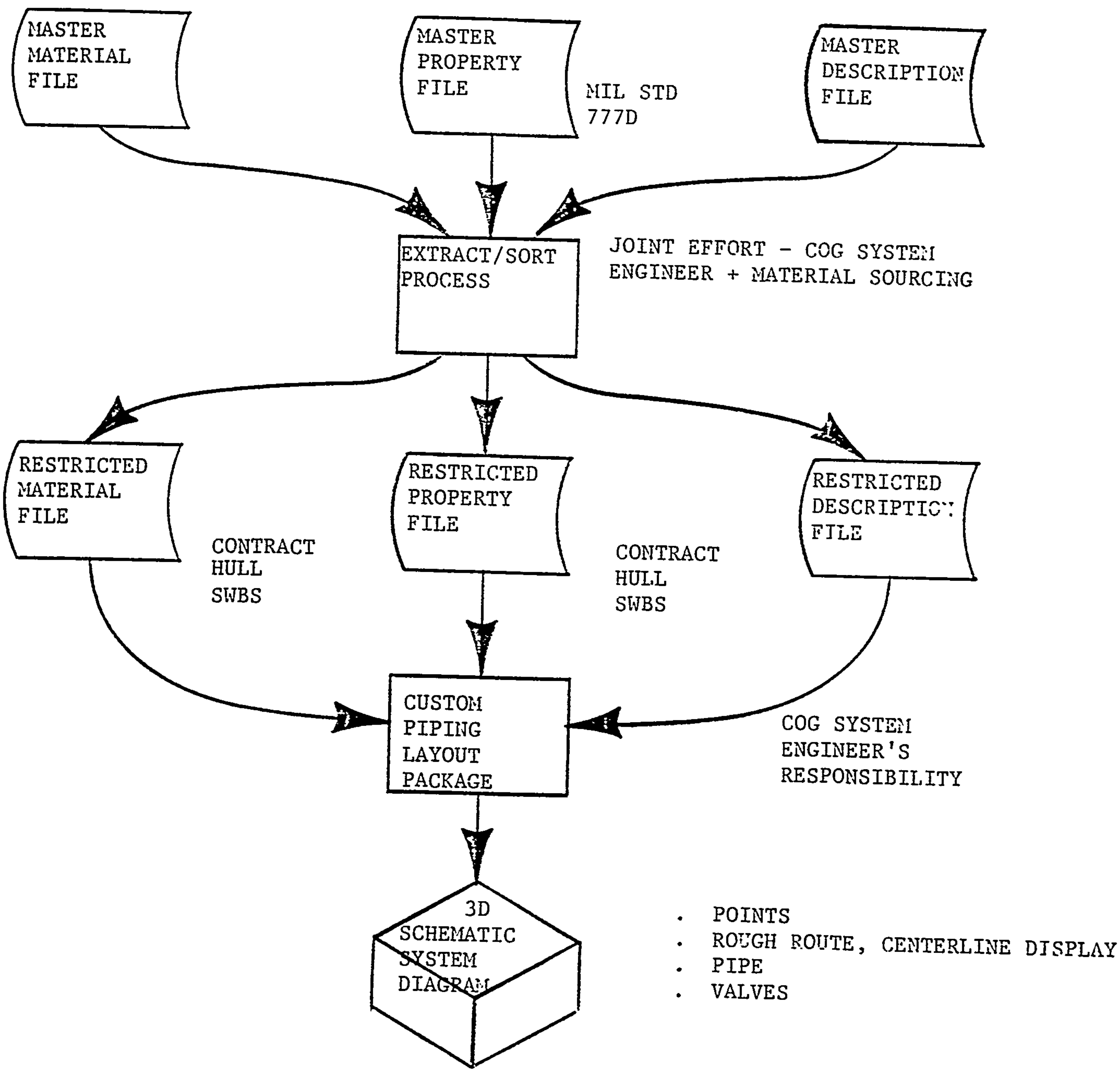


FIGURE 1: TYPICAL 2-D PARTIAL PIPING SYSTEM DIAGRAM

SPECIFICATION-DRIVEN PIPE DETAIL DESIGN

SYSTEM STRUCTURE



- COG SYSTEM ENGINEER "LOCKS" MODEL WHEN HE IS FINISHED. MODEL IS LIMITED TO THE FILES THE COG ENGINEER BUILT AND USED.

- COG ENGINEER'S JOB ENDS HERE.

- DETAILER'S JOB BEGINS HERE WITH THE 3-D SCHEMATIC. (THE DETAILER AND THE SYSTEM ENGINEER COULD CONCEIVABLY BE ONE AND THE SAME INDIVIDUAL)

FIGURE 2

SPECIFICATION-DRIVEN PIPE DETAIL DESIGN

SYSTEM STRUCTURE

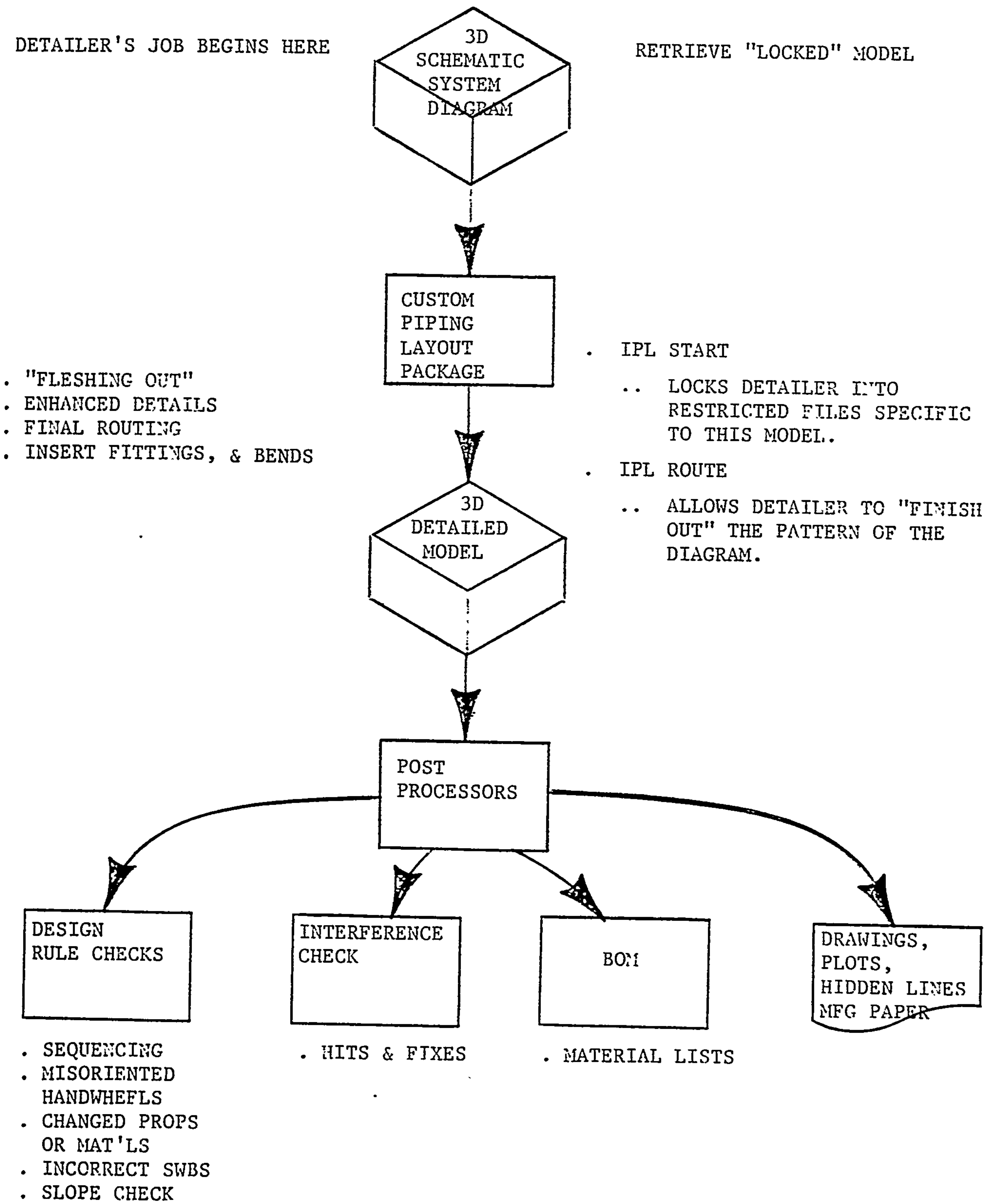


FIGURE 3

```
REC          =      4
MCC/SPEC     = A                  LENGTH 1 = 8          STRESS        = 0
SCHEDULE     = .109/2D            LENGTH 2 = 4.5        Sx            = 0
NPS (I)      =  4.000             LENGTH 3 = 0          Sy            = 0
THK (I)      =   .109             LENGTH 4 = 0          Sz            = 0
NPS (O)      =  4.000             LENGTH 5 = 0          FLEX FCTR     = 0
THK (O)      =   .109             CONN LTH = 0          T CONSTANT    = 0
ESID         =  111               FLNGE OD = 0          SHEAR FCTR    = 0
MATERIAL     = MT16420-200I1-91   F WEIGHT = 5.83       Ix            = 0
SCN          = 4710-DA0-139020    X AREA   = 0          Iy            = 0
                                  S AREA   = 0          Iz            = 0
4"
              TUBING, SMLS, 4.500" OD X .109" MIN WALL

REC          =      5
MCC/SPEC     = A                  LENGTH 1 = 12         STRESS        = 0
SCHEDULE     = .109/3D            LENGTH 2 = 4.5        Sx            = 0
NPS (I)      =  4.000             LENGTH 3 = 0          Sy            = 0
THK (I)      =   .109             LENGTH 4 = 0          Sz            = 0
NPS (O)      =  4.000             LENGTH 5 = 0          FLEX FCTR     = 0
THK (O)      =   .109             CONN LTH = 0          T CONSTANT    = 0
ESID         =  111               FLNGE OD = 0          SHEAR FCTR    = 0
MATERIAL     = MT16420-200I1-91   F WEIGHT = 5.83       Ix            = 0
SCN          = 4710-DA0-139020    X AREA   = 0          Iy            = 0
                                  S AREA   = 0          Iz            = 0
4"
              TUBING, SMLS, 4.500" OD X .109" MIN WALL

REC          =      6
MCC/SPEC     = A                  LENGTH 1 = 4          STRESS        = 0
SCHEDULE     = 0130               LENGTH 2 = 5.688      Sx            = 0
NPS (I)      =  4.000             LENGTH 3 = 0          Sy            = 0
THK (I)      =   .250             LENGTH 4 = 0          Sz            = 0
NPS (O)      =  4.000             LENGTH 5 = 0          FLEX FCTR     = 0
THK (O)      =    250             CONN LTH = 3.25       T CONSTANT    = 0
ESID         =  197               FLNGE OD = 0          SHEAR FCTR    = 0
MATERIAL     = SP485006           F WEIGHT = 0          Ix            = 0
SCN          = 4850-SP0-06-0130   X AREA   = 0          Iy            = 0
                                  S AREA   = 0          Iz            = 0
4"
              STUFFING TUBE, TYPE I
```

FIGURE 4

SAMPLE PROPERTY FILE CONTENTS

DATE. 03/31/87 SP4 RESTRICTED MATERIAL FILE

1	Material name	:	MT16420-200I1-91
2	Stock code number	:	NONE
3.	2-D material symbol name	:	NONE
4	Material short description	:	CNA 90-10
5	Material long description : MIL-T-16420 TYPE I CL 200 GR 1		
6.	Modulus of elasticity	:	0
7.	Shear modulus	:	0
8.	Poisson's ratio	:	0
9.	Mass density	:	0
10.	Coefficient of thermal expansion	:	0
11.	Reference temperature for thermal expansion	:	0
12.	Structural element damping coefficient	.	0
13.	Stress limit for tension	:	0
14.	Stress limit for compression	:	0
15.	Stress limit for shear	:	0
16.	Ultimate strength for tension	:	0
17	Ultimate strength for compression	:	0
18.	Ultimate strength for shear	:	0
19.	Yield strength for tension	.	0
20.	Yield strength for compression		0
21	Yield strength for shear	:	0
22	Available		
23.	Available		
24	Available		
25	Available		
26.	Available		
27	Available		

FIGURE 5

SAMPLE CONTENTS MATERIAL FILE

DATE: 03/24/87 SP4 RESTRICTLD DESCRIPTION FILE

RECORD COUNT	DDM ESID	2-D DDM SYMBOL NAME		SHORT DESCRIPTION
1	1		Pipe - Butt Welded	PIPE
2	101	PL101 S1	90 Degree Long Radius Elbow - Butt Welded	ELBOW 90 LR
3	102	PL102. S1	90 Degree Short Radius Elbow - Butt Welded	ELBOW 90 SR
4	106	PL106. S1	45 Degree Long Radius Elbow - Butt Welded	ELBOW 45 LR
5	111		Bend - Butt welded	BEND
6	197	MPM164. S1	Stuffing Tube	STUFFNG TUBE
7	230	PL230. S1	Gate Valve - Flanged	VALVE GATE
8	328	MPM810. S1	Outlet Branch - Socket Welded	SOCKOLET
9	330	MPM019. S1	Gate Valve - Socket Welded	VALVE GATE

FIGURE 6

SAMPLE CONTENTS - DESCRIPTION FILE

Category and group	Services	Design gage pressure lb/in^2	Maximum temperature °F	Remarks
D-1	Sea water, (See note D-1-3)	250	150	

Item	Types	Material	Applicable documents	Remarks
Pipe	Seamless or welded	90-10 copper-nickel	MIL-T-16420 K, class 200	
Valves	Globe, 2-½ inches and above	Bronze	Dwg 803-1385623 G Dwg 803-1385541 F	See enclosure IV See note D-1-1
	Globe, angle, ¼ to 2 inches		Dwg 803-4384536 E	
	Gate, 2-½ inches and above		Dwg 803-2177917 C	Flanged ends 12 inches and smaller
			Mil-V-1189 C, AMD 3, Class 2	Flanged ends larger than 12 inches
	Gate, ¼ to 2 inches		Dwg 803-1385714 P	
	Swing check, 2-½ inches and above		Dwg 803-1385637 F	Flanged ends 12 inches and smaller
			MIL-V-17547 -, AMD 4, type A, class 2, 250 lbs/in^2	Flanged ends larger than 12 inches
	Swing check, ¼ to 2 inches		Dwg 803-1385721 N	
	Relief		MIL-V-24332 -, AMD 2	Flanged or union ends
	Pressure-reducing		MIL-V-2042 D, AMD 3	
	Hose		Dwg 803-1385711 E Dwg 803-1385712 F	
	Ball, ¼ inch-2½ inch		Dwg 803-5001003 A	
	Ball, 3 inches - 6 inches		Dwg 803-5001004 A	See para. 3.40

FIGURE 7

SAMPLE MIL-STD-777D SPECIFICATION

Category and group	Services	Design gage pressure lb in²	Maximum temperature °F	Remarks
D-1, cont'd	Sea water	250	150	See note D-1-3

Item	Types	Material	Applicable documents	Remarks
Fittings	Silver-brazing, (including unions and union end fittings)	Bronze	MIL-F-1183 G	
	Welding	90-10 copper-nickel	Dwg 810-1385880 D	
	Welded base by silver-brazing and outlet boss	90-10 or 70-30 copper-nickel	Dwg 810-1385912 B	Welded to pipe run
Flanges	Silver-brazing	Bronze	MIL-F-20042 C, AMD 7, class plain	
			Dwg 820-1385982 B	
	Butt weld, socket weld	Copper-nickel	Dwg 810-1385992 B Dwg 810-4715319 -	
Gaskets	Sheet	Synthetic rubber	MIL-G-1149 B MIL-R-21252 A	See note D-1-2 and para. 3.37
		Cloth, inserted rubber	HH-P-151 E	
Flange bolting	Bolts or bolt-stud	Carbon steel Coatings shall be as required by para. 3.12 (g).	MIL-S-001222 G, AMD 3, grade 2	
	Nuts			

NOTES:

D-1-1 One hundred pound globe and angle valves may be used in systems not exceeding 150 lb/in² (pump shut-off) providing valves pass the seat tightness tests to 150 lb/in² and stregth and porosity tests to 200 lb/in².

D-1-2 For use in piping systems subject to acid flush path.

D-1-3 Main drainage, secondary drainage and oily ballast systems that are subject to firemain pressure, oil water seperators, and oily waste transfer discharge.

FIGURE 7 (continued)

CHOOSE OPTION:

1 - GENERATE PIPE

2 - INSERT FITTINGS

3 - VERIFY PIPE

4 - BREAK PIPE

5 - DELETE PIPE

6 - DELETE SCHEMATIC RUN

7 - UNDO PIPE/FITTINGS

8 - MODIFY ANGLE

9 - ANALYSIS

10 - UTILITIES

C/C - CANCEL OPERATION

ENTER SELECTION ==>

FIGURE 8

SAMPLE TOP LEVEL MENU - IPLROUTE

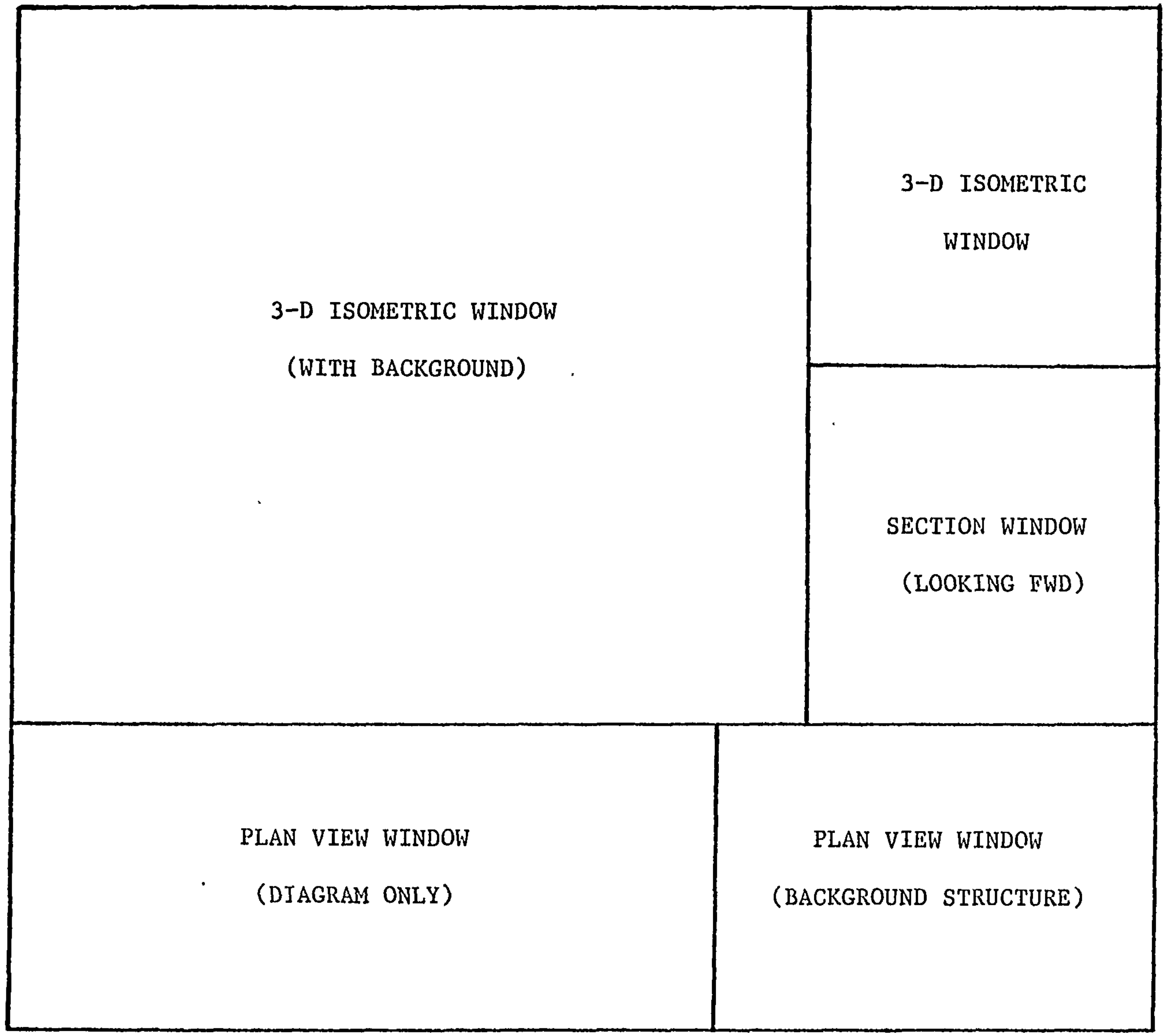


FIGURE 9

SAMPLE USER-DEFINED WINDOW ARRANGEMENT

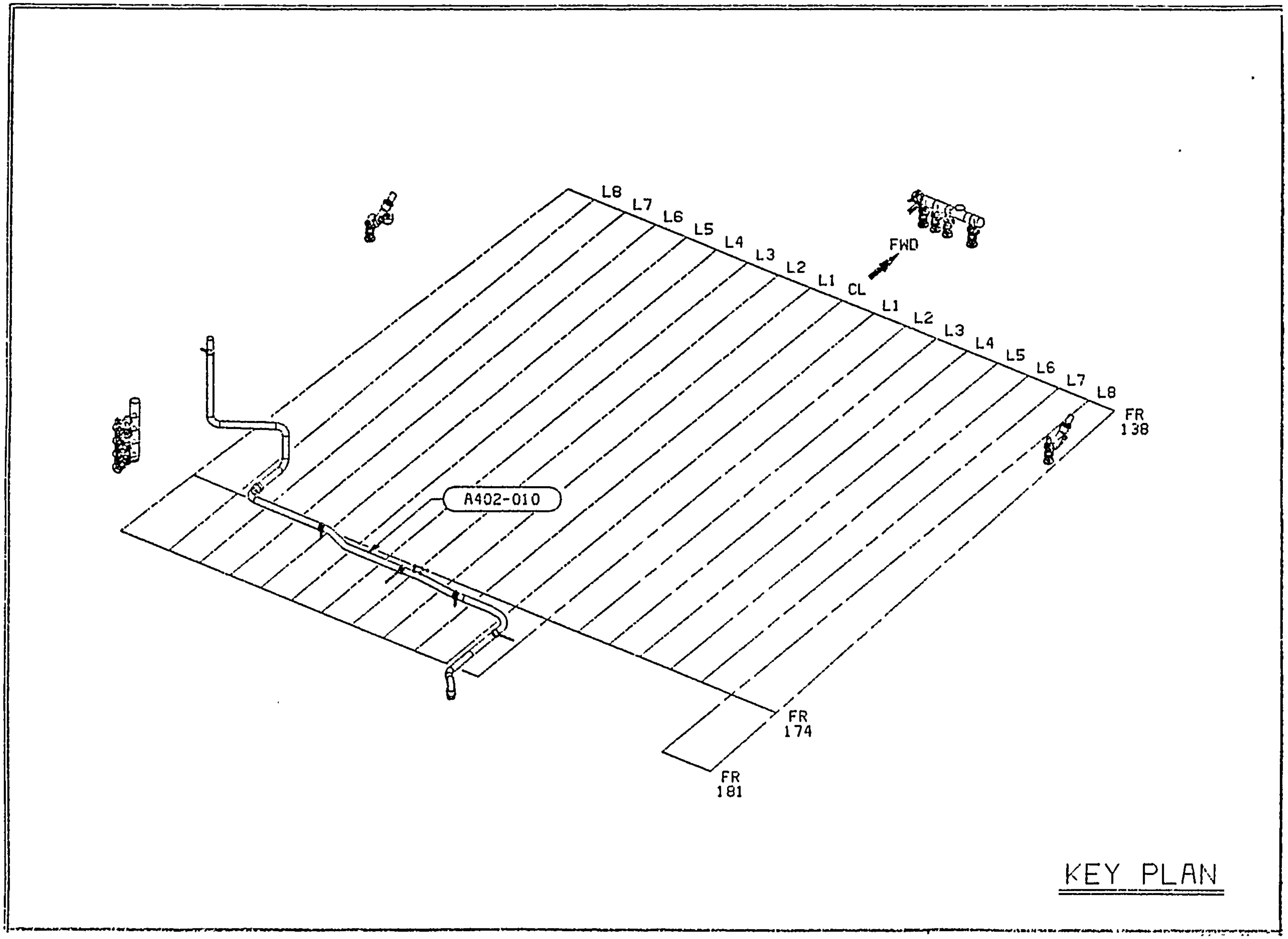


FIGURE 10 - PIPE INSTALLATION SKETCH

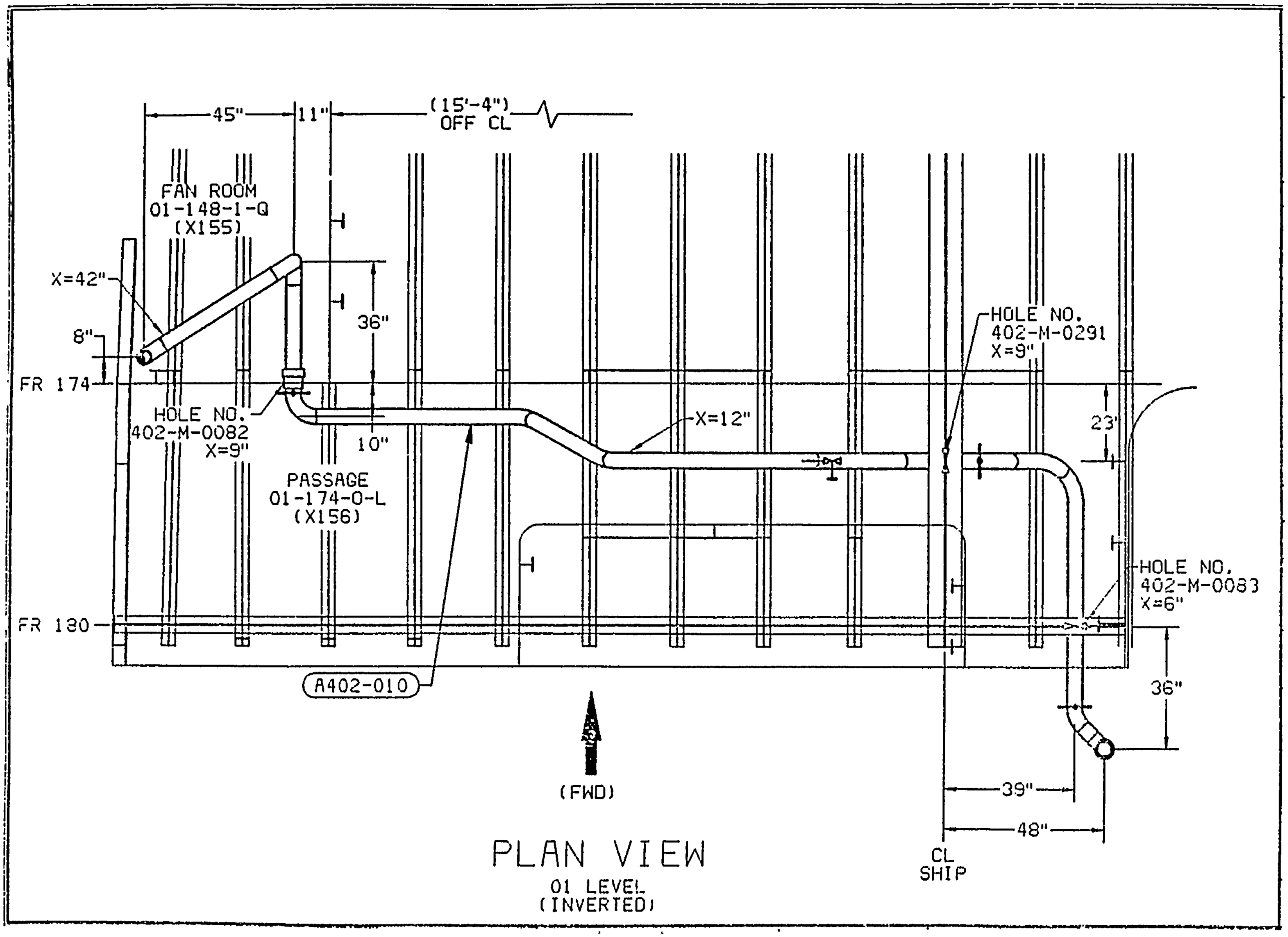


FIGURE 11 - PIPE INSTALLATION SKETCH

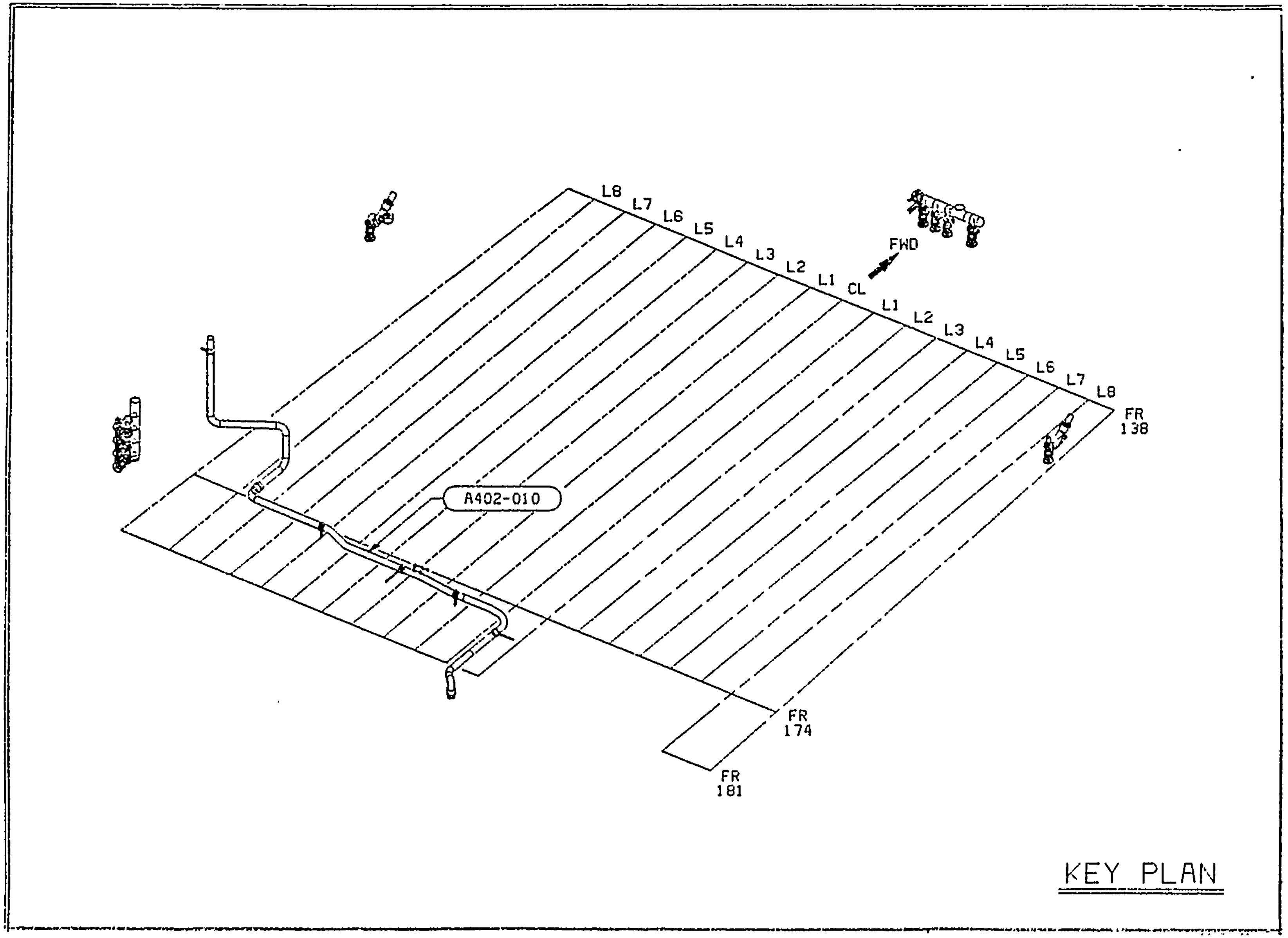
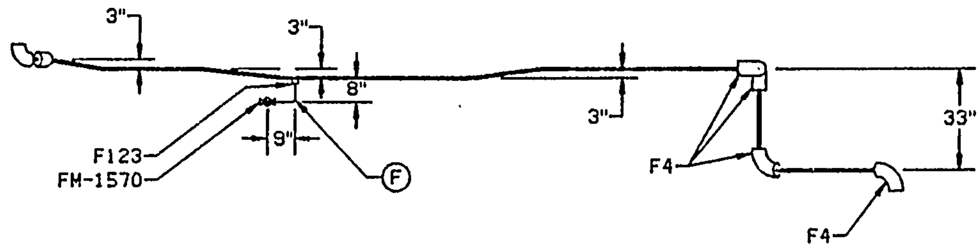
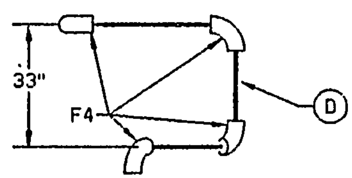


FIGURE 10 - PIPE INSTALLATION SKETCH



SECTION B-B



ELEVATION A-A

FIGURE 13 - PIPE FABRICATION SKETCH

NUMBER	QTY	DESCRIPTION	SOURCE NUMBER	MATERIAL	MAT REQ NO	STORE RH LOCATION	STATUS
P4	33'-0"	TUBING, 4.500" OD X .109" MIL-T-16420	4710-DA0-139020	CNA 90-10			
P4A	0'-4 1/4"	TUBING, 4.500" OD X .109" MIL-T-16420	4710-DA0-139020				
P4B	16'-3 1/2"	TUBING, 4.500" OD X .109" MIL-T-16420	4710-DA0-139020				
P4C	2'-9 1/16"	TUBING, 4.500" OD X .109" MIL-T-16420	4710-DA0-139020				
P4D	1'-7 1/16"	TUBING, 4.500" OD X .109" MIL-T-16420	4710-DA0-139020				
P4E	3'-3 1/16"	TUBING, 4.500" OD X .109" MIL-T-16420	4710-DA0-139020				
P4G	9'-8 7/8"	TUBING, 4.500" OD X .109" MIL-T-16420	4710-DA0-139020				
P30	2'-0"	TUBING, .840" OD X .065" MIL-T-16420	C07-297432				
P30F	1'-2 13/16"	TUBING, .840" OD X .065" MIL-T-16420, CL 200	C07-297432				
F4	4 EA	ELBOW, 4", 90 °, LR, BTWLD, 200 # 810-1385880	4730-DA0-139033				
F21	1 EA	ELBOW, 4", 45 °, LR, BTWLD, 200 # 810-1385880	4730-DA0-216117				
F58	1 EA	ELBOW, 4", 90 °, BTWLD, 200 # 810-1385880	4730-DA0-225245				
F123	1 EA	6-2 1/2" X 1/2", SOCKOLET, RDCR, WELD BASE X SB	A35-691772	CNA 90-10			
FM1570	1 EA	1/2", VALVE, GATE, 400 PSI, SBU ENDS 810-1385714, LOW POINT DRAIN	4820-DA0-C01386	BRZ, MONEL TRIM			

FIGURE 14 - PIPE BILL OF MATERIAL

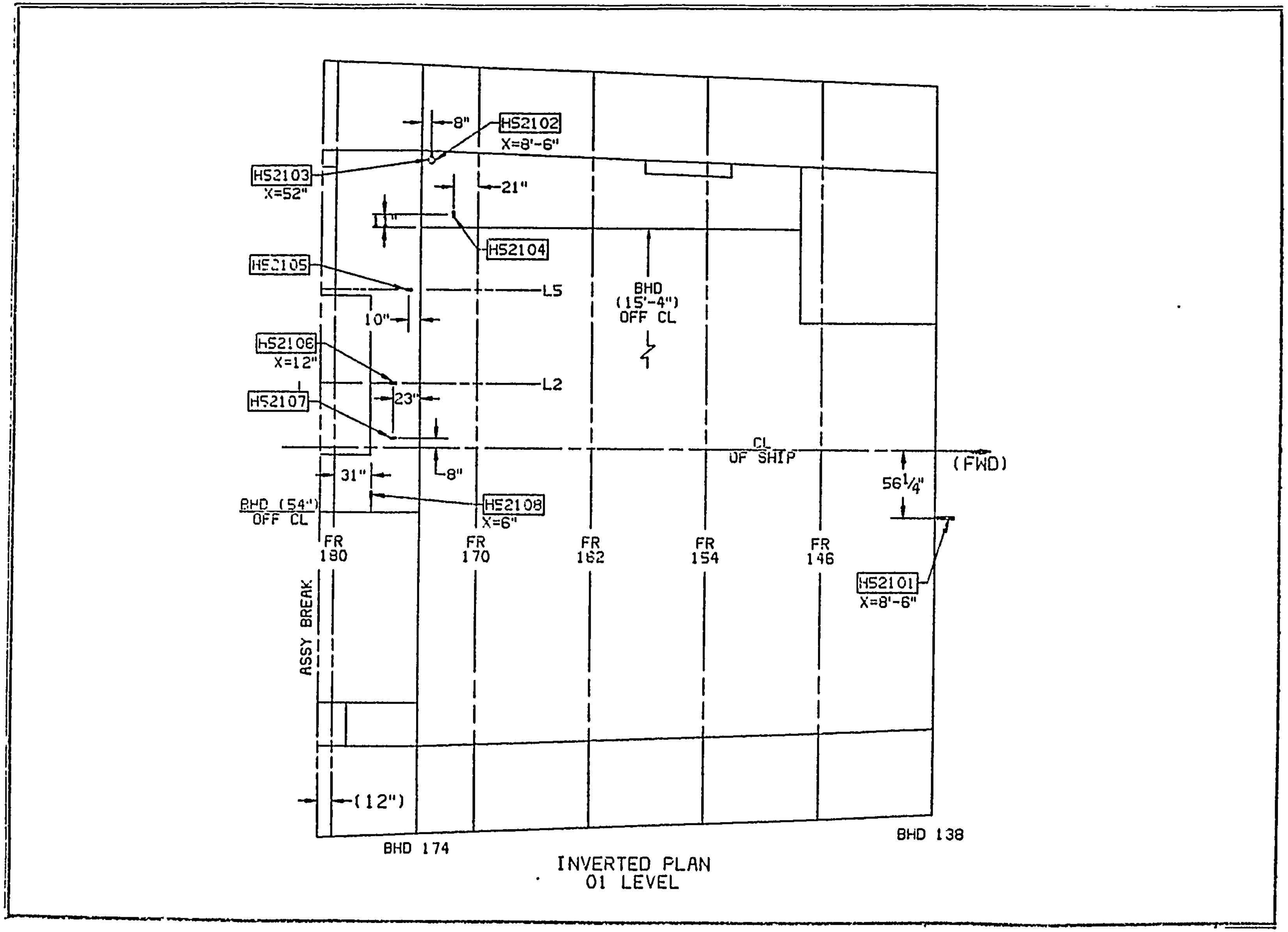


FIGURE 15 - HANGER INSTALLATION SKETCH

NUMBER	QTY	DESCRIPTION	SOURCE NUMBER	MATERIAL	MAT REQ NO	STORE RM LOCATION	STATUS
H52101	1	H-08	1104-195-2	ALUM			
H52102	1	H-58	1104-195-2	ALUM			
H52103	1	H-58	1104-195-2	ALUM			
H52104	1	H-59	1104-195-2	ALUM			
H52105	1	H-58	1104-195-2	ALUM			
H52106	1	H-58	1104-195-2	ALUM			
H52107	1	H-58	1104-195-2	ALUM			
H52108	1	H-58	1104-195-2	ALUM			

FIGURE 16 - HANGER INSTALLATION BILL OF MATERIAL

HANGER NO	HANGER TYPE	SIZE & DIE CODE	LEG PRE-CUT LENGTH	LEG CUT LENGTH
H52102	H-58	4B	12"	6-13/16"
H52103	H-58	4B	12"	6-13/16"
H52104	H-58	4B	12"	8-11/16"
H52105	H-58	4B	12"	8-11/16"
H52106	H-58	4B	24"	8-11/16"
H52107	H-58	4B	12"	8-11/16"
H52108	H-58	4B	18"	14-11/16"

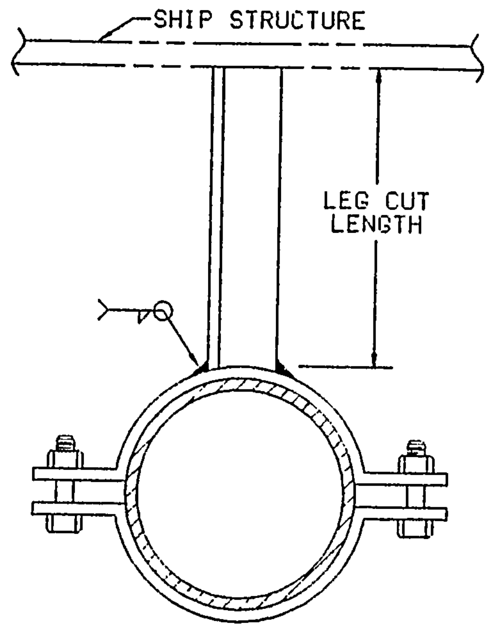


FIGURE 17 - HANGER FABRICATION SKETCH

HANGER NO	HANGER TYPE	SIZE & DIE CODE	LEG PRE-CUT LENGTH	LEG CUT LENGTH
HS2101	H-08	68	12"	11-7/16"

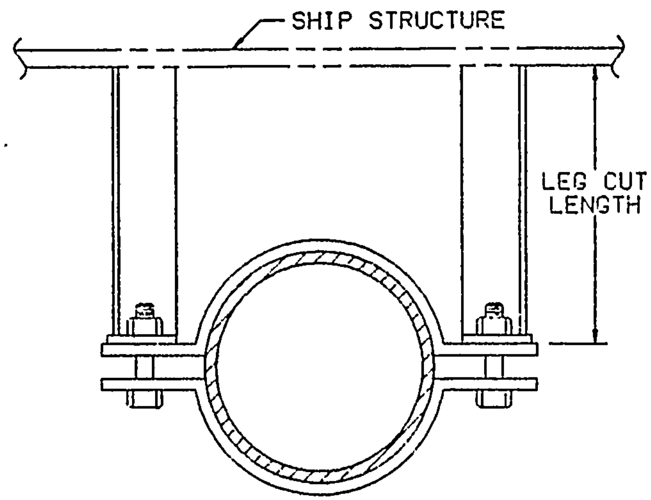


FIGURE 18 - HANGER FABRICATION SKETCH

```
****************************************
       INTERFERENCE CHECKING
          CONFLICT REPORT

PROJECT NAME        : SP4/SP4IFC
REPORT DATE         : 87/04/02    14:14:16
CONFLICTS REPORTED  : 14

****************************************
```

CONFLICT ATTRIBUTES
****

TIME PERIOD	:	ALL DATES/TIMES
GEOMETRIC VOLUME	:	ALL PROJECT SPACE
MODELS	:	SP4/MDET521
ITEM TYPES	:	ALL ITEM TYPES
ENVELOPE INTRUSION TYPES	:	ALL ENVELOPE INTRUSION TYPES
ENVELOPE TYPES	:	ALL ENVELOPE TYPES
ACCEPTABILITY	:	BOTH
USERS	:	ALL USERS

FIGURE 19A

```
**** CONFLICT NO.  1 ****

TIME CONFLICT WAS IDENTIFIED : 04/01/87  14:02
CONFLICT ACCEPTABILITY       : UNACCEPTABLE

MODEL NAME    : SP4/MDET521          MODEL NAME    : S152402T174
DESCRIPTION   : SLEEVE               DESCRIPTION   : PLANE SURFACE
CREATOR       : YOH189               CREATOR       : YOH189
MIN. EXTENTS  : X = 192.1560         MIN. EXTENTS  : X = -248.0058
                Y = 612.1560                         Y = 507.5000
                Z = 2086.0002                        Z = 2088.0002
MAX. EXTENTS  : X = 197.8440         MAX. EXTENTS  : X = 248.0058
                Y = 617.8440                         Y = 624.0000
                Z = 2090.0002                        Z = 2088.0002
ENVELOPE TYPE : HARD ITEM            ENVELOPE TYPE : HARD ITEM


**** CONFLICT NO.  2 ****

TIME CONFLICT WAS IDENTIFIED : 04/01/87  14:02
CONFLICT ACCEPTABILITY       : UNACCEPTABLE

MODEL NAME    : SP4/MDET521          MODEL NAME    : SP4/MDET521
DESCRIPTION   : ROUND TUBE (PIPE)    DESCRIPTION   : ROUND TUBE (PIPE)
CREATOR       : YOH189               CREATOR       : YOH189
MIN. EXTENTS  : X = 43.0000          MIN. EXTENTS  : X = 42.5800
                Y = 609.7500                         Y = 605.0000
                Z = 2108.7500                        Z = 2110.5801
MAX. EXTENTS  : X = 99.8477          MAX. EXTENTS  : X = 43.4200
                Y = 619.2500                         Y = 610.0000
                Z = 2113.2500                        Z = 2111.4199
ENVELOPE TYPE : HARD ITEM            ENVELOPE TYPE : HARD ITEM


**** CONFLICT NO.  3 ****

TIME CONFLICT WAS IDENTIFIED : 04/01/87  14:02
CONFLICT ACCEPTABILITY       : UNACCEPTABLE

MODEL NAME    : SP4/MDET521          MODEL NAME    : SP4/MDET521
DESCRIPTION   : ROUND TUBE (PIPE)    DESCRIPTION   : ROUND TUBE (PIPE)
CREATOR       : YOH189               CREATOR       : YOH189
MIN. EXTENTS  : X = 38.4600          MIN. EXTENTS  : X = 42.5800
                Y = 609.7500                         Y = 605.0000
                Z = 2108.7500                        Z = 2110.5801
MAX. EXTENTS  : X = 43.0000          MAX. EXTENTS  : X = 43.4200
                Y = 614.2500                         Y = 610.0000
                Z = 2113.2500                        Z = 2111.4199
ENVELOPE TYPE : HARD ITEM            ENVELOPE TYPE : HARD ITEM
```

FIGURE 19B

```
**** CONFLICT NO.  4 ****

TIME CONFLICT WAS IDENTIFIED . 04/01/87  14:02
CONFLICT ACCEPTABILITY       . UNACCEPTABLE

MODEL NAME    : SP4/MDET521             MODEL NAME    : S152402D02
DESCRIPTION   : ROUND TUBE (PIPE)       DESCRIPTION   : TEE SHAPE
CREATOR       : YOH189                  CREATOR       : YOH189
MIN. EXTENTS  : X = -20.0068            MIN. EXTENTS  : X = -5.0000
                Y = 612.7500                            Y = 606.0000
                Z = 2108.7500                           Z = 1656.0000
MAX. EXTENTS  : X = 11.5400             MAX. EXTENTS  : X = 5.0000
                Y = 617.2500                            Y = 624.0000
                Z = 2113.2500                           Z = 2166.0000
ENVELOPE TYPE : HARD ITEM               ENVELOPE TYPE : HARD ITEM


**** CONFLICT NO.  5 ****

TIME CONFLICT WAS IDENTIFIED : 04/01/87  14:02
CONFLICT ACCEPTABILITY       : UNACCEPTABLE

MODEL NAME    : SP4/MDET521             MODEL NAME    : S152402D02
DESCRIPTION   : ROUND TUBE (PIPE)       DESCRIPTION   : TEE SHAPE
CREATOR       : YOH189                  CREATOR       : YOH189
MIN. EXTENTS  : X = -41.2500            MIN. EXTENTS  : X = -54.0000
                Y = 615.7500                            Y = 612.0000
                Z = 2117.9690                           Z = 2157.2849
MAX. EXTENTS  : X = -36.7500            MAX. EXTENTS  : X = 0.0000
                Y = 620.2500                            Y = 624.0000
                Z = 2183.6296                           Z = 2162.2849
ENVELOPE TYPE : HARD ITEM               ENVELOPE TYPE : HARD ITEM


**** CONFLICT NO.  6 ****

TIME CONFLICT WAS IDENTIFIED : 04/01/87  14:02
CONFLICT ACCEPTABILITY       : UNACCEPTABLE

MODEL NAME    : SP4/MDET521             MODEL NAME    : SP4ELSP402
DESCRIPTION   : ELBOW 90 LR             DESCRIPTION   : USER-DEFINED EQUIPMENT
CREATOR       : YOH189                  CREATOR       : YOH189
MIN. EXTENTS  : X = 192.6925            MIN. EXTENTS  : X = 151.0847
                Y = 579.3299                            Y = 504.0000
                Z = 2049.6580                           Z = 2016.0001
MAX. EXTENTS  : X = 202.2796            MAX. EXTENTS  : X = 226.0000
                Y = 588.9691                            Y = 624.0000
                Z = 2057.8713                           Z = 2176.0000
ENVELOPE TYPE : HARD ITEM               ENVELOPE TYPE : HARD ITEM
```

FIGURE 19C

```
**** CONFLICT NO.  7 ****

TIME CONFLICT WAS IDENTIFIED : 04/01/87  14:02
CONFLICT ACCEPTABILITY       : UNACCEPTABLE

MODEL NAME     : SP4/MDET521              MODEL NAME     : SP4ELSP402
DESCRIPTION    : ELBOW 90 LR              DESCRIPTION    : USER-DEFINED EQUIPMENT
CREATOR        : YOH189                   CREATOR        : YOH189
MIN. EXTENTS   : X = 192.7500             MIN. EXTENTS   : X = 151.0847
                 Y = 609.0309                              Y = 504.0000
                 Z = 2049.6707                             Z = 2016.0001
MAX. EXTENTS   : X = 197.2500             MAX. EXTENTS   : X = 226.0000
                 Y = 617.3293                              Y = 624.0000
                 Z = 2058.9690                             Z = 2176.0000
ENVELOPE TYPE : HARD ITEM                 ENVELOPE TYPE : HARD ITEM


**** CONFLICT NO.  8 ****

TIME CONFLICT WAS IDENTIFIED : 04/01/87  14:02
CONFLICT ACCEPTABILITY       : UNACCEPTABLE

MODEL NAME     : SP4/MDET521              MODEL NAME     : SP4ELSP402
DESCRIPTION    : ROUND TUBE (PIPE)        DESCRIPTION    : USER-DEFINED EQUIPMENT
CREATOR        : YOH189                   CREATOR        : YOH189
MIN. EXTENTS   : X = 192.7500             MIN. EXTENTS   : X = 151.0847
                 Y = 158.9690                              Y = 504.0000
                 Z = 2049.7500                             Z = 2016.0001
MAX. EXTENTS   : X = 197.2500             MAX. EXTENTS   : X = 226.0000
                 Y = 608.0310                              Y = 624.0000
                 Z = 2054.2500                             Z = 2176.0000
ENVELOPE TYPE : HARD ITEM                 ENVELOPE TYPE : HARD ITEM


**** CONFLICT NO.  9 ****

TIME CONFLICT WAS IDENTIFIED : 04/01/87  14:02
CONFLICT ACCEPTABILITY       : UNACCEPTABLE

MODEL NAME     : SP4/MDET521              MODEL NAME     : SP4ELSP402
DESCRIPTION    : ROUND TUBE (PIPE)        DESCRIPTION    : USER-DEFINED EQUIPMENT
CREATOR        : YOH189                   CREATOR        : YOH189
MIN. EXTENTS   : X = 192.7500             MIN. EXTENTS   : X = 151.0847
                 Y = 612.7500                              Y = 504.0000
                 Z = 2058.9690                             Z = 2016.0001
MAX. EXTENTS   : X = 197.2500             MAX. EXTENTS   : X = 226.0000
                 Y = 617.2500                              Y = 624.0000
                 Z = 2089.2502                             Z = 2076.0000
ENVELOPE TYPE : HARD ITEM                 ENVELOPE TYPE : HARD ITEM
```

FIGURE 19D

**** CONFLICT NO. 10 ****

TIME CONFLICT WAS IDENTIFIED : 04/01/87 14:02
CONFLICT ACCEPTABILITY : UNACCEPTABLE

MODEL NAME	: SP4/MDET521	MODEL NAME	: SP4ELSP402
DESCRIPTION	: ROUND TUBE (PIPE)	DESCRIPTION	: USER-DEFINED EQUIPMENT
CREATOR	: YOH189	CREATOR	: YOH189
MIN. EXTENTS	: X = 192.7500	MIN. EXTENTS	: X = 151.0847
	Y = 612.7500		Y = 504.0000
	Z = 2086.7502		Z = 2016.0001
MAX. EXTENTS	: X = 197.2500	MAX. EXTENTS	: X = 226.0000
	Y = 617.2500		Y = 624.0000
	Z = 2093.0310		Z = 2176.0000
ENVELOPE TYPE	: HARD ITEM	ENVELOPE TYPE	: HARD ITEM

**** CONFLICT NO. 11 ****

TIME CONFLICT WAS IDENTIFIED : 04/01/87 14:02
CONFLICT ACCEPTABILITY : UNACCEPTABLE

MODEL NAME	: SP4/MDET521	MODEL NAME	: SP4ELSP402
DESCRIPTION	: SLEEVE	DESCRIPTION	: USER-DEFINED EQUIPMENT
CREATOR	: YOH189	CREATOR	: YOH189
MIN. EXTENTS	: X = 192.1560	MIN. EXTENTS	: X = 151.0847
	Y = 612.1560		Y = 504.0000
	Z = 2086.0002		Z = 2016.0001
MAX. EXTENTS	: X = 197.8440	MAX. EXTENTS	: X = 226.0000
	Y = 617.8440		Y = 624.0000
	Z = 2090.0002		Z = 2176.0000
ENVELOPE TYPE	: HARD ITEM	ENVELOPE TYPE	: HARD ITEM

**** CONFLICT NO. 12 ****

TIME CONFLICT WAS IDENTIFIED : 04/01/87 14:02
CONFLICT ACCEPTABILITY : UNACCEPTABLE

MODEL NAME	: SP4/MDET521	MODEL NAME	: SP4ELSP402
DESCRIPTION	: ELBOW 90 LR	DESCRIPTION	: USER-DEFINED EQUIPMENT
CREATOR	: YOH189	CREATOR	: YOH189
MIN. EXTENTS	: X = 190.0310	MIN. EXTENTS	: X = 151.0847
	Y = 612.7500		Y = 504.0000
	Z = 2093.0310		Z = 2016.0001
MAX. EXTENTS	: X = 197.3294	MAX. EXTENTS	: X = 226.0000
	Y = 617.2500		Y = 624.0000
	Z = 2100.3293		Z = 2176.0000
ENVELOPE TYPE	: HARD ITEM	ENVELOPE TYPE	: HARD ITEM

FIGURE 19E

```
**** CONFLICT NO.  13 ****

TIME CONFLICT WAS IDENTIFIED : 04/01/87  14:02
CONFLICT ACCEPTABILITY       : UNACCEPTABLE

MODEL NAME     : SP4/MDET521           MODEL NAME      SP4ELSP402
DESCRIPTION    : ROUND TUBE (PIPE)     DESCRIPTION     USER-DEFINED EQUIPMENT
CREATOR        : YOH189                CREATOR         YOH189
MIN. EXTENTS   : X = 199.7284          MIN. EXTENTS    X = 151.0847
                 Y = 579.7500                          Y = 504.0000
                 Z = 2053.7712                         Z = 2016.0001
MAX. EXTENTS   . X = 235.2716          MAX. EXTENTS    X = 226.0000
                 Y = 584.2500                          Y = 624.0000
                 Z = 2078.2288                         Z = 2176.0000
ENVELOPE TYPE : HARD ITEM              ENVELOPE TYPE   HARD ITEM


**** CONFLICT NO.  14 ****

TIME CONFLICT WAS IDENTIFIED : 04/01/87  14:02
CONFLICT ACCEPTABILITY       : UNACCEPTABLE

MODEL NAME     : SP4/MDET521           MODEL NAME      SP4ELSP402
DESCRIPTION    : ROUND TUBE (PIPE)     DESCRIPTION     USER-DEFINED EQUIPMENT
CREATOR        : YOH189                CREATOR         YOH189
MIN. EXTENTS   : X = 127.1523          MIN. EXTENTS    X = 151.08447
                 Y = 612.7500                          Y = 504.0000
                 Z = 2095.7500                         Z = 2016.0001
MAX. EXTENTS   : X = 190.0310          MAX. EXTENTS    X = 226.0000
                 Y = 617.2500                          Y = 624.0000
                 Z = 2100.2500                         Z = 2176.0000
ENVELOPE TYPE : HARD ITEM              ENVELOPE TYPE   HARD ITEM
```

FIGURE 19F

IX. <u>APPENDICES</u>

A - CREATING THE PIPING MASTER PROPERTY FILE (PMPF)

B - CREATING THE PIPING MASTER MATERIAL FIIE (PMMF)

c - CREATING THE PIPING MASTER DESCRIPTION FILE (PMDF)

APPENDIX A

CREATION OF
THE PIPING MASTER PROPERTY FILE (PMPF)

The MPF is created by a proprietary vendor-supplied utility program named PLSORT. Any yard attempting to implement master files organized as they are in this demo system will need to have its own functional equivalent of PLSORT. In the sequel, references to “PLSORT” should be interpreted to mean “the generic functional equivalent of PLSORT".

Input to PLSORT consists of 80-byte records, which themselves may be either created by direct editing, or generated via an in-house user-interface program. The contracting yard has developed such a proprietary user-interface program It is menu-driven and directs the building of the input file in response to prompts.

The MPF for MIL-STD-777D is quite large (several thousands of records) and is the result of several years of accumulated data entry. It is by no means comprehensive, despite its size, for it contains only the properties needed by the contracting yard, not all possible properties specified in the MIL-STD-777D document.

The MPF is output by the PLSORT module, from the 80-byte records in the input file. The 80 bytes consist of 79 data bytes, plus a carriage return byte. It takes several 80-byte records to make up one large MPF record. AS a specific example, the length of the records in the MPF in our demo system is 240 bytes. There are three 80-byte input records per each 240-byte master file record. Two are prescribed by the vendor-supplied piping layout package, the third is an optional user-defined line. The number of user-defined lines is a user-specified variable.

The first 80-byte input record is a header record, defining the formats for the property definition records to follow. The header record is laid out as follows:

PMPF Header Record Layout

- Eleven (11) required entries
- 12th entry is supplied by the PLSORT program
- Free format, but psitional
- Delimited by blanks

ENTRY NO:	SAMPLE VALUE	MEANING
1	1	Flag indicating model dimensional units (complete list follows)
2	1	Number of user lines per record.
3	3	Total number of 80-byte lines per master file record.
4	8	Field width (in characters) for Spec/MCC field.
5	8	Field width for schedule field.
6	6.3	Field descriptor for NPS (inlet).
7	6.3	Field descriptor for inlet wall thickness.
8	6.3	Field descriptor for NPS (outlet).
9	6.3	Field descriptor for outlet wall thickness.
10	4	Field width for ESID number - fixed at 4.
11	16	Material key field width.
12 (col 74-79; fixed)	6	System generated sort sequence key.

DIMENSIONAL UNITS FLAG -- VALUES

1 - Inches/lbs

2 - Feet/lbs

3 - Mils/lbs

4 - Millimeters/gms

5 - Centimeters/kgs

6 - Meters/kgs

7 - User Defined

The records following the header repeat in groups of n, where n is the number of 80-byte records per master file record. The value of n is specified in the header as entry number 3. For the demo system the value of n is 3. That is to say, the master file records are 240 bytes long. There are three 80-byte input records per rester file record.

The first of the three 80-byte records in a group is fixed in the format prescribed by the header.

The second is free format, delimited by blanks, with a total of 20 entries. Unused entries should be set to zero.

The third record is a user-defined line, containing two entries of alphanumeric description. One *is* 30 *characters* long and the other is 40 characters.

The three-record group is then laid out as follcws:

RECORD 1 OF 3

FIELD	COLS	CONTENT	SAMPLE VALUE
1	1-8	spec/Mcc	Abbbbbbb
2	9-16	Schedule	.l09/2D
3	17-22	NPSi	4.000
4	23-28	Inlet Wall Thickness	.109
5	29-34	NPSO	4.000
6	35-40	Outlet Wall Thickness	.109
7	41-44	ESID	111
8	45-60	Mat'l Type (key)	MTI6420-200I1-91
9	61-79	stock Code No.	9999-DAO-999999

Abbreviations: .

b = blank

MCC = Material Classification Cede

NPSi = Nominal Pipe Size, inlet

NPSo = Nominal Pipe Size, outlet

ESID = Element Sub-type Identifier

- Text Must be left-justified and blank-padded.

- Numbers must be right-justified.

RECORD 2 OF 3

FIELD	COLS	CONTENT	SAMPLE VALUE
1	N/A	Fitting Length 1	
2		Fitting Length 2	
3		Fitting Length 3	
4		Fitting Length 4	
5		Fitting Length 5	
6		Connection Length	
7		Flange Outer Diam	
8		Fitting Weight	
9		Cross-sect Area	
10	FREE FORMAT	Surface Area	VARIABLE VALUES, DEPENDING UPON ESID NUMBER
11		Stress Intensification factor	
12		X-Section Modulus	
13		Y-Section Modulus	
14		Z-Section MODULUS	
15		Flex Factor	
16		Torsional Constant	
17		Shear Factor	
18		X-Moment of Inertia	
19		Y-Moment of Inertia	
20		Z-Moment of Inertia	

- Not all of these fields are used on every ESID number.

- Unused entries should be set to zero.

- If the free-format entries take up more than 80 columns, another record is required, and entry number 3 on the header card must be increased accordingly.

RECORD 3 of 3

FIELD	COLS	CONTENTS
1	1-32	Description, part 1
2	34-75	Description, part 2

- Both entries are actually free-format, enclosed in quotes, delimited by a blank, left-justified, and blank-padded to end-of-field.

These groups of 3 records (or in generally, n records) comprise the remainder of the input file.

The property file layouts are as follows:

- 80-BYTE INPUT FILE

Record 1 - Header Record

Record 2-
Record 3 - Three-record group defining a 240-byte master record.
Record 4,

Record 5
Record 6 - Three-record group defining a 240-byte master record.
Record 7

.
.
.
(and so on to end of file)

Remember this is the layout of the file which is input to the PLSORT program. Each 3-record group may occur in arbitrary order in the input file. The PLSORT function will reorder them per the sort methcd *selected* within PLSORT. The demo system is ordered by schedule, NPSi, ESID, and material type.

- 240-BYTE PIPING MASTER PROPERTY FILE

Record # 1 - Record count & header

Record # 2 - 240 bytes

Record # 3 - 240 bytes

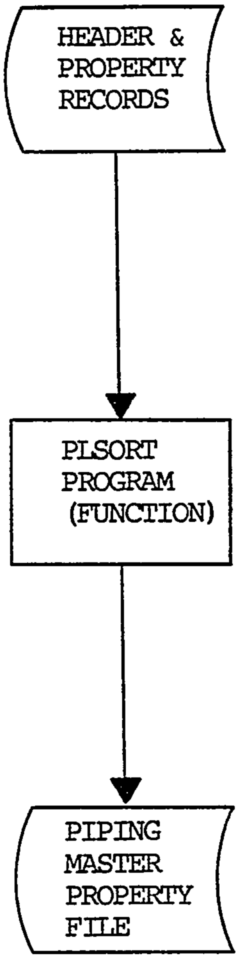
.
.
.

Record # n - 240 bytes

- n 2 - 1
- Record count includes the first record.

Figure A-1 shows graphically in summary the process of creating the MPR.

CREATION OF PMPF



HEADER & PROPERTY RECORDS

- SEQUENTIAL
- 80-BYTE RECORDS
- EDITABLE
- MAY BE CREATED BY MENU-DRIVEN USER-INTERFACE PROGRAM
- 3-RECORD GROUPS

PLSORT PROGRAM (FUNCTION)

- VENDOR-SUPPLIED
- PROPRIETARY
- CREATES ONE MASTER RECORD PER 3-RECORD GROUP
- SORTS BY USER SPECIFIED SEQUENCE

PIPING MASTER PROPERTY FILE

- DIRECT-ACCESS
- NOT EDITABLE
- RECORD LENGTH = 80X3 = 240 BYTES
- 16-CHARACTER MATERIAL KEY POINTING TO MASTER MATERIAL FILE
- 4-DIGIT ESID POINTING TO MASTER DESCRIPTION FILE

FIGURE A-1

APPENDIX B

CREATION OF THE PIPING MASTER MATERIAL FILE (PMMF)

Creation of the Master Material File is very similar to creation of the property file. However, the MMF is much smaller than the property file, being only several hundred records long. Major differences are listed here in Summary:

- There are 5 input 80-byte records per MMF record. All 5 are prescribed by the system The number 5 is fixed, not variable.

- MMF record length is 400 bytes.

- The proprietary vendor-supplied program which creates the MMF is AECMATSRT. Again, a functional equivalent of this program is needed by any yard wishing to create such a material file.

Figure B-1 graphically depicts the creation of the PMMF.

The header record for the MMF is laid out as follows:

PMMF Header Record Layout

FIELD	COLS	CONTENTS	VALUE
1	1	Flag specifying model units. Same values as those for PMPF.	1
2	2-79	Available	Blanks
3	80	Carriage return	Blanks

The 5-record group that comprises each MMF record is free-format except for the material name. The first five fields are character strings, the rest are numeric. All the numeric fields in the demo system are set to zero.

The five 80-byte records are laid out as follows:

RECORD 1 of 5

ENTRY	CONTENTS	SAMPLE VALUE
1	Material name, (Maximum 24 characters)	'MT16420-200I1-91'
2	Stock Cede Number (Maximum 12 characters)	'NONE'
3	2-D Symboll = (Maximum 24 characters)	' NONE'

RECORD 2 of 5

1	Material, short description (max 12 characters)	'CNA 90-10'
2	Material, long description (max 64 characters)	' 803-4384356, Class A, Type 1'

The remaining three records are included merely because they are prescribed by the system. The fields are not used at present at the contracting yard, neither for production nor for the demo system

RECORD 3 of 5

ENTRY	CONTENTS	SAMPLE VALUE
1	Modulus of Elasticity	NOT USED, ALL ZEROS
2	Shear Modulus	↓
3	Poisson's Ratio	↓
4	Mass Density	↓
5	Coeff. of Thermal Expansion	↓
6	Ref. Temp. for Thermal Expansion	↓

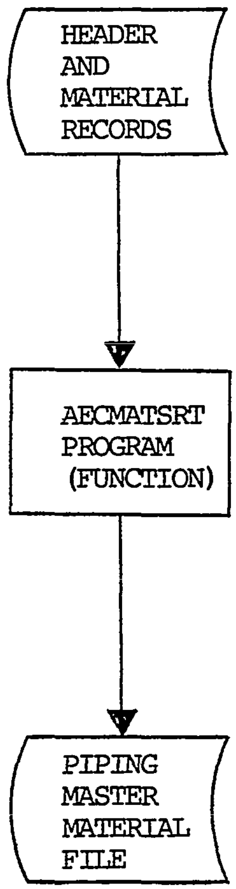
RECORD 4 0f 5

ENTRY	CONTENTS	SAMPLE VALUE
1	Pipeline Element Damping Coefficient	NOT USED — ALL ZEROS
2	Stress Limit - Tension	
3	Stress Limit - Compression	
4	Stress Limit - Shear	
5	Ultimate Strength - Tension	
6	Ultimate Strength - Compression	

RECORD 5 0f 5

ENTRY	CONTENTS	SAMPLE VALUE
1	Ultimate Strength - Shear	NOT USED, ALL ZERO
2	Yield Strength - Tension	↓
3	Yield Strength - Compression	↓
4	Yield Strength - Shear	↓
5	Available	↓
6	Available	↓
7	Available	↓
8	Available	↓
9	Available	↓
10	Available	↓

CREATION OF PMMF



- SEQUENTIAL
- 80-BYTE RECORDS
- EDITABLE
- MAY BE CREATED BY MENU-DRIVEN USER-INTERFACE

- VENDOR-SUPPLIED
- PROPRIETARY
- CREATES SINGLE MASTER RECORDS
- SORTS BY USER-SPECIFIED SEQUENCE

- DIRECT ACCESS
- NOT DIRECTLY EDITABLE
- RECORD LENGTH = 5x80=400 BYTES
- 16-CHARACTER KEY CONNECTS WITH PROPERTY FILE

FIGURE B-1

• 400-BYTE PMMF LAYOUT

RECORD#1 - Header and Record Count

RECORD#2 - 400-bytes

RECORD # 3 - 400-bytes

.

.

.

RECORD # n - 400-bytes

Each 400-byte record consists of the 5 component 80-byte records concatenated together, from left to right, in the same order as they occur in the 5-record group.

APPENDIX C

CREATION OF
THE PIPING MASTER DESCRIPTION FILE (PMDF)

Creation of the Piping Master Description File follcws the same general pattern as the other two master files. Again PLSORT is used to generate the master file records from 80-byte input records. Figure C-1 is the graphic depiction of the process.

There are two 80-byte input records per each 160-byte MDF record. They are laid out as follows:

RECORD 1 of 2

ENTRY	CONTENTS
1	ESID - Fixed in cols 1-4, right justified.
2	2-D symbol name, free format, maximum 24 characters.

ENTRY	CONTENTS
1	Short description, free format, maximum 24 characters
2	long description, free format, maximum, 79 characters.

160-byte PMDF layout

RECORD#l - total record count, right justified to co1 64.

RECORD #2 - 160-bytes

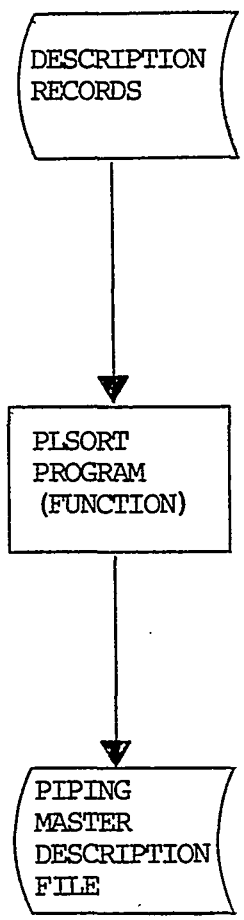
.

.

.

RECORD #n - 160-bytes

CREATION OF PMDF



DESCRIPTION RECORDS:

- SEQUENTIAL
- 80-BYTE RECORDS
- EDITABLE
- MAY BE CREATED BY MENU-DRIVEN USER-INTERFACE

PLSORT PROGRAM (FUNCTION):

- VENDOR-SUPPLIED
- PROPRIETARY
- CREATES SINGLE MASTER RECORDS
- SORTS BY ESID

PIPING MASTER DESCRIPTION FILE:

- DIRECT ACCESS
- NOT DIRECTLY EDITABLE
- RECORD LENGTH = 2x80=160 BYTES
- 4-DIGIT ESID CONNECTS WITH PROPERTY FILE

FIGURE C-1