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A Graphical Database for Hull Fracture Reports

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ABSTRACT

HFDB is the Hull Fracture Database system, implemented by AeroHydro, Inc. (AHI) for ARCO Marine, Inc. (AMI). The purpose of HFDB is the establishment, maintenance, and utilization of a graphics-oriented database of structural fracture data from the AMI fleet of crude oil tankships. HFDB takes its primary input from a graphics tablet, allowing fracture locations to be conveniently entered from fracture report sheets supplied as part of the system. Graphics tablet menus are used for auxiliary data input. Graphic screen displays are provided during input to visually verify the input data. The data is stored in a Paradox database suited to selective retrieval. Graphical output displays show locations, frequency of occurrence, and severity of fractures as a function of ship name, ship class, time interval, structural element, and severity. The overall purpose of HFDB is to enable a human operator to discern and explore patterns of fracture experience, which may lead to improved design, maintenance, and inspection procedures and to reduced risk of structural failures in the future operation of the fleet.

NOMENCLATURE

FRS - Fracture Report Sheet
FR - Fracture Report
HFDB - Hull Fracture Database

DESIGN GOALS

It is anticipated that HFDB will be used over a long period of time. Provisions are specifically included to allow handling of fractures through 2059. It is also anticipated that the program will be used by people such as summer interns who have never used the program before. For this reason the system has been designed to be as fool proof as possible. The complete user manual is accessible as a hypertext document by pressing a function key while using the program. In addition there is a complete tutorial, including sample input data and database, that a new user can follow to become familiar with the system without jeopardizing the actual fracture database.

A goal of the system is to make it easy to enter data. This is important because if it is not easy, it may very likely not be done.

SYSTEM IMPLEMENTATION

The core of HFDB is implemented as a Paradox Application Language (PAL) program. This program calls compiled programs written in Microsoft QuickBASIC to perform graphical functions not conducive to implementation with PAL. These auxiliary programs return to the PAL program when their functions are complete. Because the fracture database is a Paradox database, all of the analysis and reporting capabilities of Paradox are available in addition to the capabilities provided by HFDB. In addition, the data can be exported from Paradox for use by other analysis programs.

THE FRACTURE DATABASE

The *raison d'etre* of HFDB is the fracture database. The fracture database contains one record for each fracture.

The following information is recorded for each fracture:

FR serial number - Fracture Report serial number

Fracture number - within fracture report

FRS number - identifies the fracture report sheet from which the data was entered

Ship - *Independence, Spirit, Alaska, California, Anchorage, Fairbanks, Juneau, Texas, Prudhoe Bay, Sag River*

Class - 260MDWT, 190MDWT, 120MDWT, 90MDWT, 70MDWT

X - Feet, 0 at F.P., positive aft

Y - Feet, 0 at centerline, positive to starboard

Z - Feet, 0 at baseline, positive upwards

Severity - <3", 3"-6", 6"-12", 1'-2', >2', Thru

Member - Web Frame Plate, Web Stiffener, Bulkhead Plate, Bulkhead Stiffener, Longitudinal Girder Plate, Longitudinal Girder Stiffener, Shell Plate, F.B. Tie Bar, Longitudinal, Bracket, Strut, Face Plate, Horizontal Girder Plate

Disposition - Repair, Modify, Renew

Year repaired

Date entered

FRACTURE REPORT SHEETS AND FRACTURE REPORTS

Input to HFDB is initially entered by a shipyard surveyor on a paper form called a **Fracture Report Sheet** (FRS). An FRS is an 8.5" x 11" form with a drawing of a particular structure in a particular class of ship. When a shipyard surveyor finds a fracture, he or she chooses from the set of FRS's for the class of ship being surveyed the FRS whose main drawing shows the location of the fracture. An FRS also has boxes on which the surveyor must check off the ship name and date. Some FRS's also have a secondary drawing (described below). There are currently five FRS types:

(1) Bulkhead
(2) Web Frame
(3) Bulkhead/Web Frame
(4) Centerline Girder
(5) Longitudinal Girder (off-center)

A particular FRS may be "unique" or "generic." For instance, a bulkhead FRS for a bulkhead in the parallel midsection of a ship would be generic: the same FRS would be used for any of the several identical bulkheads in the parallel midsection. A bulkhead FRS for a bulkhead in the forward tapered section of the ship would be unique.

Generic FRS's have a secondary, schematic drawing (the "auxiliary view") which allows the FRS to be located in the ship. For a generic bulkhead, web frame, and bulkhead/web frame FRS, the auxiliary view is a schematic profile of the ship with the longitudinal locations of the structures illustrated. Generic longitudinal girder FRS's have a secondary drawing which is a schematic section. There are no generic centerline girder FRS's.

When using a generic FRS (any FRS with a auxiliary view), the surveyor must mark the auxiliary view to uniquely identify the structure within the ship.

The surveyor must mark the primary drawing of the FRS with both the location and the severity. The location should be marked with an "X". The severity, positioned adjacent to the "X", should indicate the size of the fracture in feet and inches, or "Thru" if the fracture is all the way through the structural member. An FRS may be marked with more than one fracture, as long as the fractures are for the same ship, year and, in the case of generic FRS's, structure.

When a blank FRS has been filled out, it becomes a **Fracture Report** (FR). When the FR is entered into the HFDB system (in a process described below), an FR serial number is assigned to it and written by the data entry operator into the space provided on the FRS.

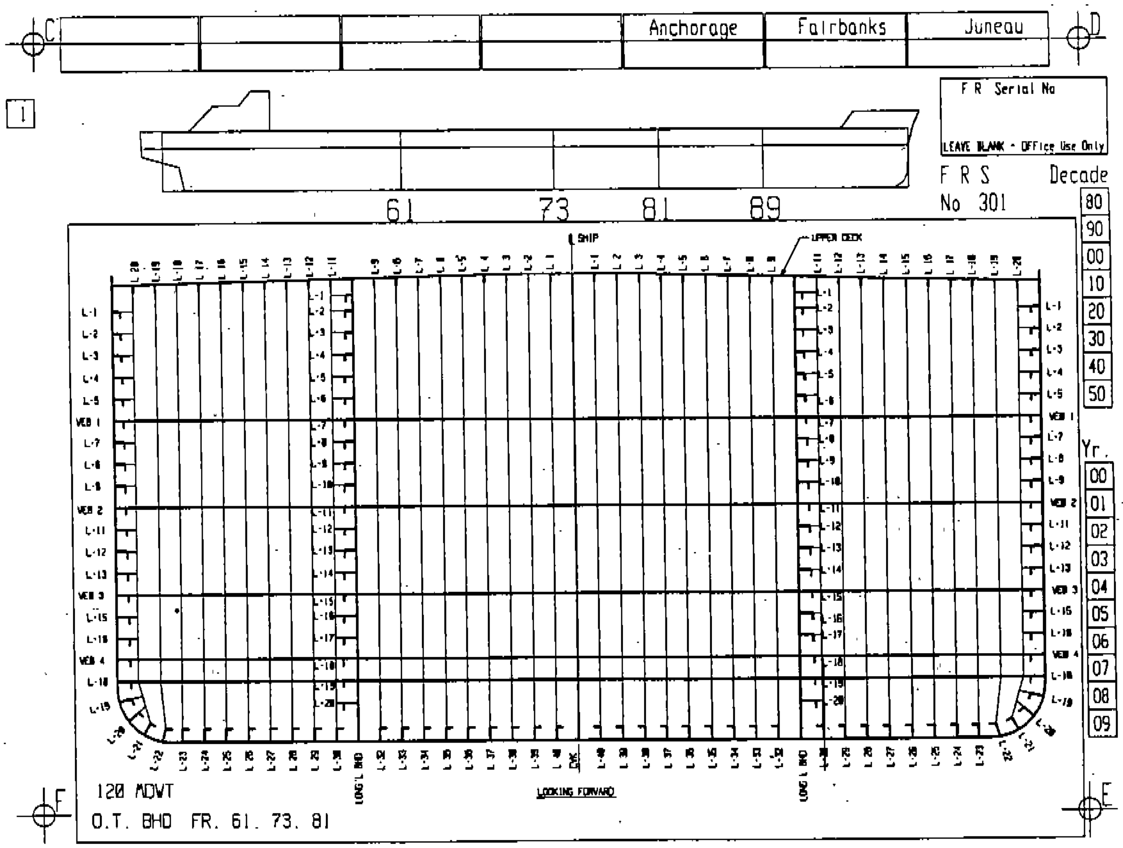


Fig. 1. A generic bulkhead fracture report sheet with a profile auxiliary view.

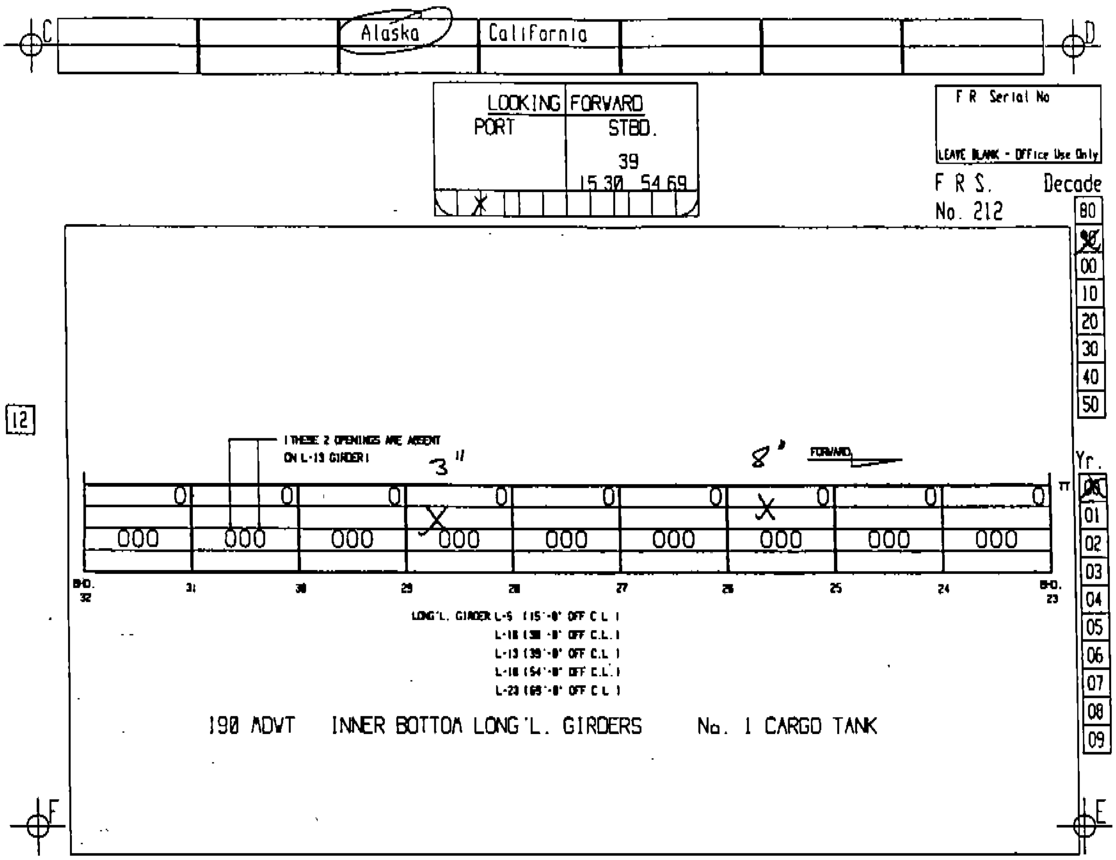


Fig. 2. A generic off-center longitudinal fracture report. Notice that the transverse auxiliary view has been marked.

THE HFDB PROGRAM

HFDB is a menu driven program. The main, top level menu provides access to the three principal functions of interest here:

- Data entry
- Data selection
- Display

The main menu also provides access to utility functions such as backing up and restoring the fracture database and deleting erroneous fracture records.

Tablet Data Entry

The data entry procedure is operated almost entirely through selections made on the graphics tablet. Screen prompts and displays are used to guide the process and to confirm selections before they are finally accepted.

Tablet selections are made by clicking the tablet stylus or tablet mouse (button 1) within labeled rectangular areas on the tablet forms which are referred to as "buttons."

The availability of various buttons is controlled by the program, so that only an appropriate set of buttons is active at any given time. If the user clicks an active button, the computer makes a short, high-pitched beep to confirm the selection is understood. If the user clicks an inactive button or an inactive area of the tablet, a longer, lower-pitched tone indicates that the click was not effective.

The first step of the data entry procedure is to register the Permanent Form containing the buttons that need to be permanently available during the tablet data entry procedure. Figure 3 shows the Permanent Form. The program needs the registration information in order to know the position of the Permanent Form on the tablet. The program prompts the user to click two bulls-eyes labeled A and B.

HFDB then prompts the user to mount a Fracture Report on the tablet and register it by clicking bulls-eyes labeled C, D, E, and F on the four corners of the form.

Following registration, HFDB prompts for identification of ship, decade, year, and FRS by clicking appropriate marked buttons on the FR. These can be entered in any order.

As noted above, an FRS may be unique or generic. On a generic FRS, the operator must click the stylus on the surveyor's mark on the auxiliary view which allows the proper structure to be uniquely identified. On a unique FRS, this step is not required.

Next, HFDB displays the fracture entry screen. Figure 4 shows an example. Most of the screen is taken up with the structural drawing. Below the drawing are several labeled lines containing blanks where fracture data will be filled in.

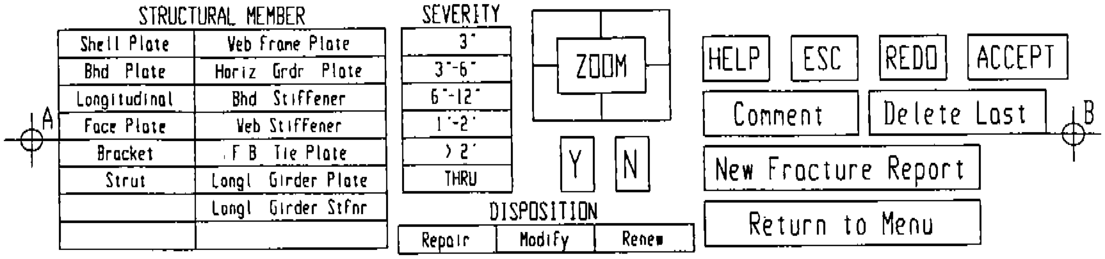


Fig. 3. The HFDB Permanent Form.

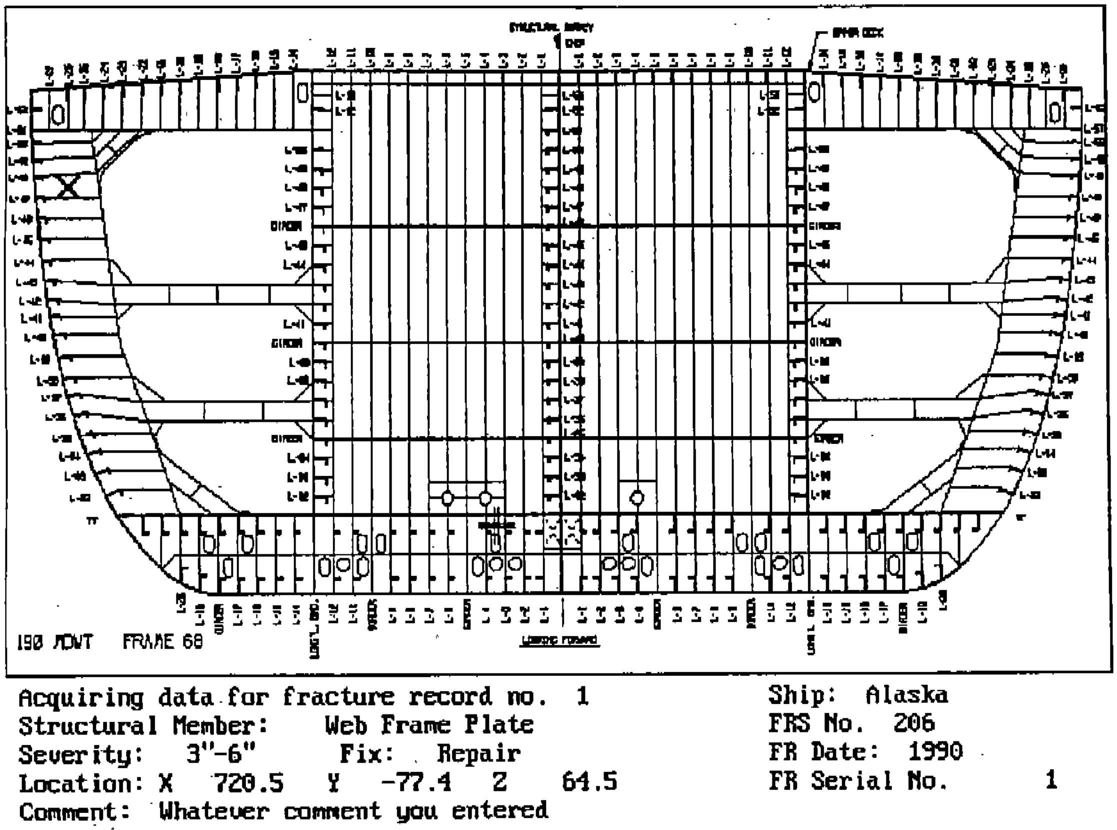


Fig. 4. HFDB fracture entry screen.

Logging a fracture always requires entry of at least the following information:

(1) A structural member selected from the permanent form
(2) A severity level selected from the permanent form
(3) A location on the structural drawing

The following items are optional:

(4) A Fix selected from the permanent form (Repair/Modify/Renew); the default is "Repair"
(5) A text comment

All these items may be entered in any order and can be re-clicked as many times as necessary. As each is entered, it is displayed in the appropriate location on the screen, for confirmation.

A graphics cursor in the drawing area of the screen will track the tablet stylus when the stylus is in the drawing box. Clicking the stylus leaves a bright green X on the screen at the cursor location. The selected coordinates are echoed in the text area of the screen. This is the tentative location of the fracture; it can be corrected by re-clicking. When the user accepts the fracture record, the green X changes to red.

The user clicks the <ACCEPT> button to confirm that the fracture has been entered correctly. HFDB is then ready to accept another fracture from the same FR. If all the fractures have been entered, the user can click the <New Fracture Report> button or the <Return to Menu> button to end the data entry session.

Data Selection

Data analysis with HFDB involves first selecting a subset of the data and then displaying that subset in any one of three forms.

HFDB provides a selection screen on which the user may make selections based on ship, class, structure fractured, severity, and date. The selections are made by using the cursor control keys to move to the desired item and then highlighting the item by pressing the space bar. In this manner it is easy to make a selection such as "All fractures on *Alaska* or *California* which were discovered in 1989 or 1990."

It is also possible to select a single FR by its FR serial number or to select all fractures which have been entered on a particular FRS by using the three digit FRS number.

For experienced Paradox users, there is a provision to enter Paradox, make a selection using all the capabilities of the Paradox query mechanism, return to HFDB, and display the selected subset.

Graphic Display

The user can now display the selected subset. The simplest display is the "Time Plot" which displays a histogram of the selected fracture records vs. time. The bars of the histogram are color coded for severity.

The second display is the profile display. This shows a schematic profile of a ship below a stacked bar chart representing the longitudinal distribution of the selected fractures. Each bar is color coded to represent the occurrence of each severity. There is also a description of the current selection criteria.

While the profile is displayed, the user can use the cursor control keys to choose one or more subsets of the longitudinal bars and then display those selected fractures in section view, with a color coded dot for each fracture and two stacked bar charts showing the athwartship and vertical distributions of the selected fractures.

While viewing each of these three displays, the user may press a function key which will cause a presentation quality version of the display to be printed by an attached PostScript laser printer. Several of these displays are included below in the section on preliminary results.

Also available is a display of a single fracture report. This display is similar to the data entry display and can be used to confirm that a fracture report has been entered correctly.

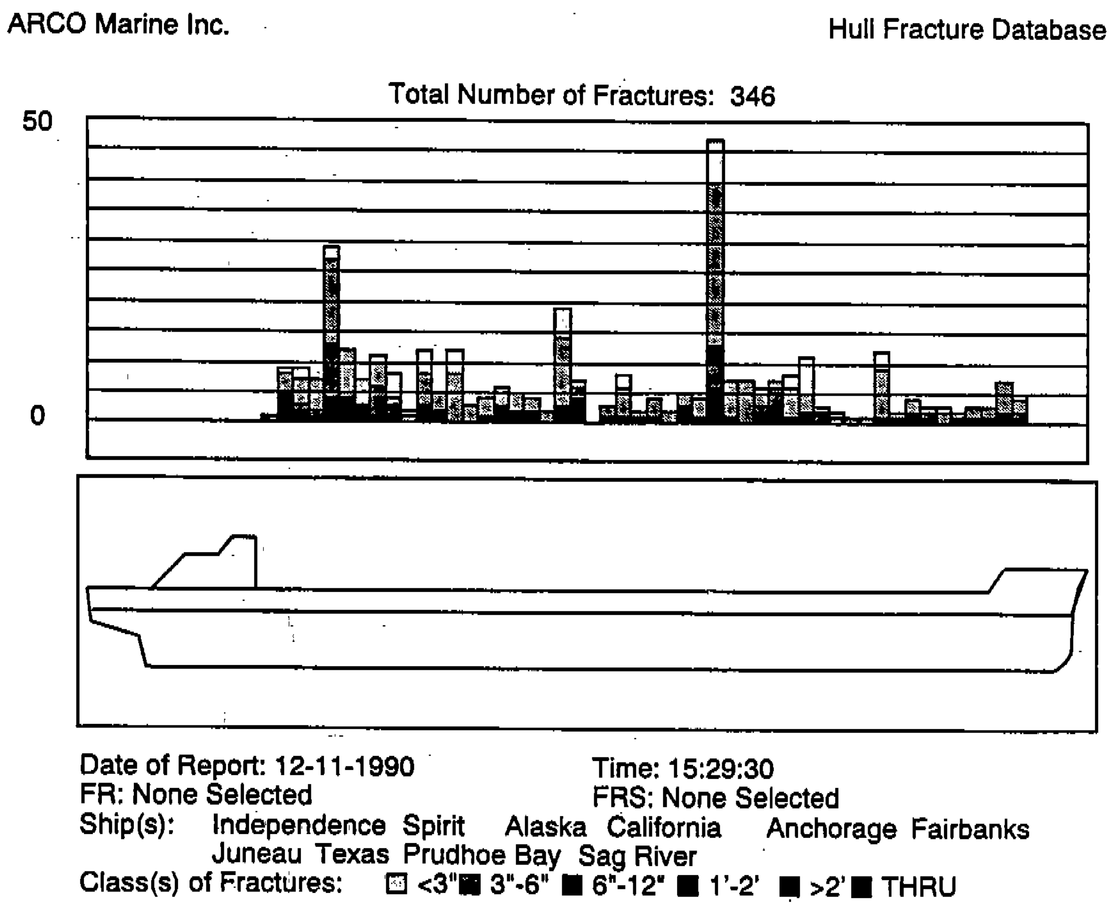


Fig. 5. Longitudinal distribution of fractures of Alaska Class ships.

PRELIMINARY RESULTS

ARCO Marine Inc. is using HFDB to monitor and assess hull fractures in its fleet of ten crude oil tankers in the Alaska to West Coast trade. Use of the database focuses ARCO's fracture control efforts which include inspections, analyses, and modifications. Better focus ensures better use of available resources for these tasks, which in turn reduces the risks of undetected fractures and of failure to understand the cause and to effect successful remedies.

Figures 5 and 6 show the longitudinal and transverse distributions of fractures in the two ships of the ARCO Alaska Class (190,000 dwt). These plots are based on 346 fractures detected since 1984.

The longitudinal distribution shows the concentration of fractures at the transverse bulkheads and especially the wing ballast tank bulkheads. The transverse distribution shows that the fractures are concentrated at the ship's side in the lower half of the ship's depth. This distribution is contrary to anecdotal information which suggests that fracturing is more common in the upper part of the ship. Although a slightly greater incidence of fracturing is recorded for the starboard side, the difference with respect to the port side is not at great as anecdotal information suggests.

Based on anecdotal information, ARCO had postulated that the cause of the fractures was wave loads in the loaded voyage on the weather side. The focused, more complete view of the fracture record, as shown in Figure 6, suggests other possibilities. The need for analysis of the structure near the ship's sides between the 7th and 14th longitudinal above the baseline is evident.

Figure 6 also shows the concentration of fractures at the vertical level of the transverse bulkhead horizontal girders. It is evident that these fractures are most prevalent at the intersections of the horizontal girders and the ship's sides and longitudinal bulkheads. Analysis of the structure in these locations could lead to a better repair which would prevent the reoccurrence of the common fractures.

Figure 7 shows how HFDB can be used to identify the type of structure which is failing. Figure 7 is the same transverse view shown in Figure 6, but shows only fractures in flatbar tie plates. Similar plots can be made for each structural type, and a comparison of these plots with Figure 6 can be used to identify the type or types of structures which fracture as well as their locations. The success of modifications over time can also be determined by accessing only fractures in modified structures. These techniques give ARCO an increasingly better understanding of the fractures in its ships and improve the probability of successful remedies.

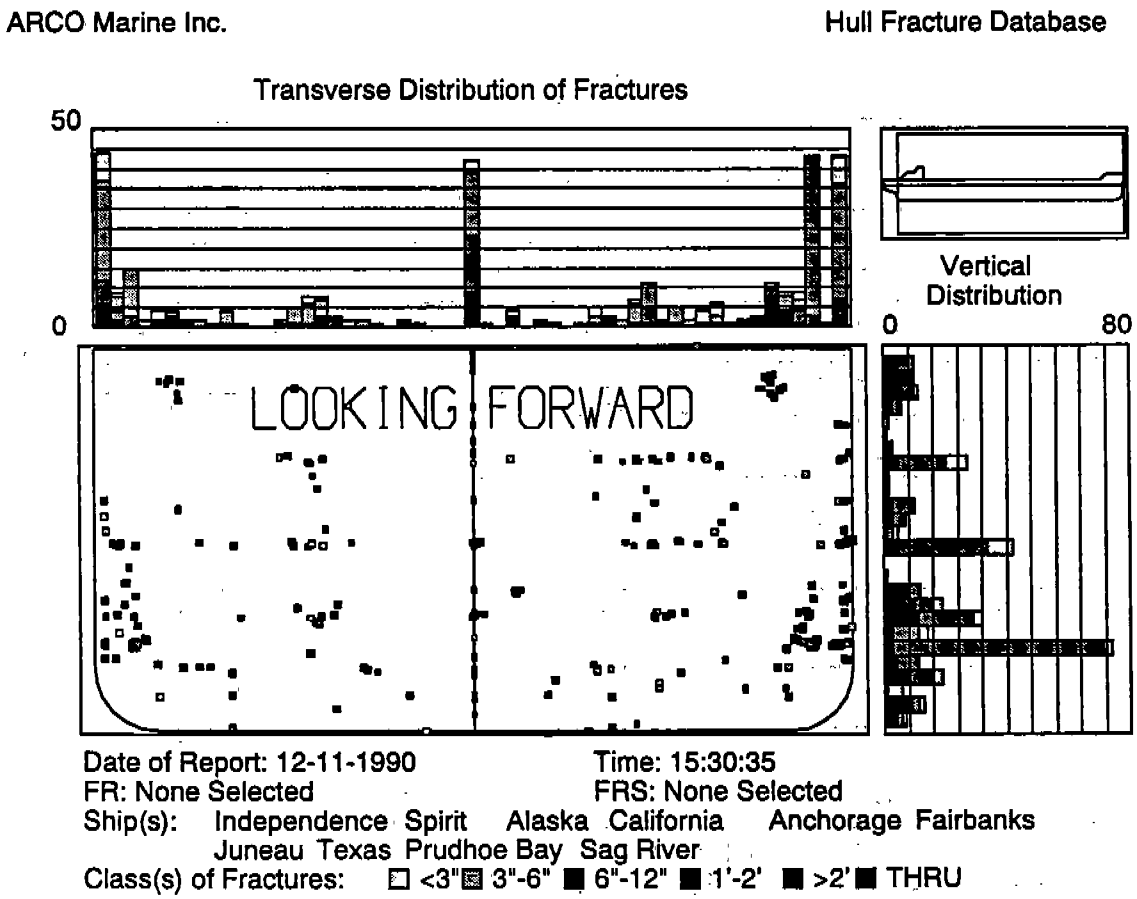
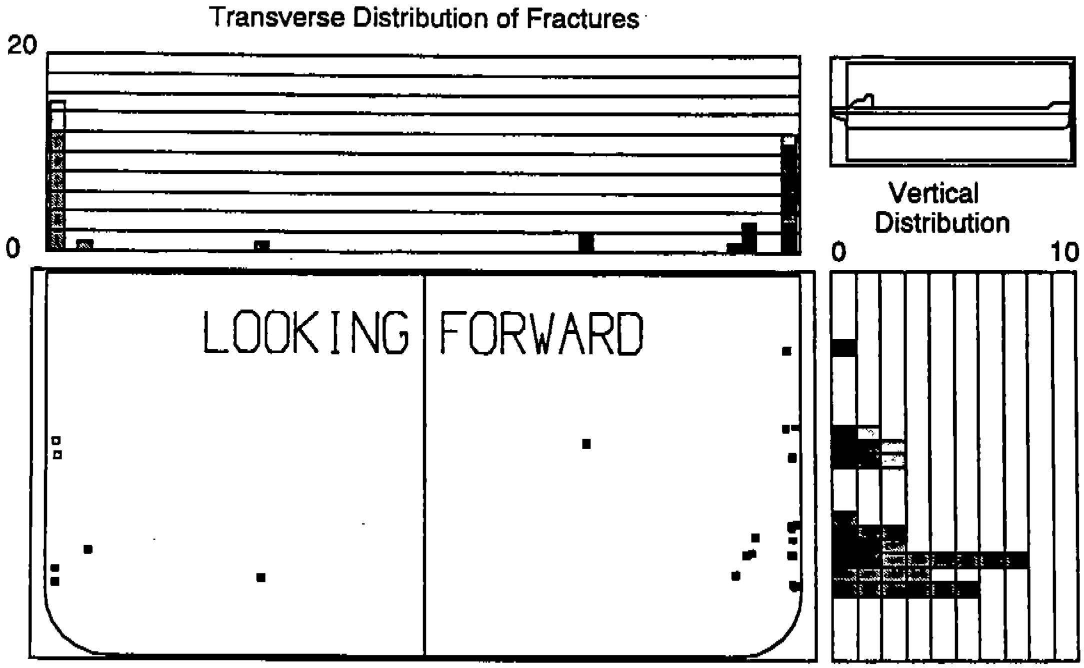


Fig. 6. Transverse distribution of fractures of Alaska Class ships.



Date of Report: 12-11-1990 Time: 16:10:50
FR: None Selected FRS: None Selected
Ship(s): Independence Spirit Alaska California Anchorage Fairbanks Juneau Texas Prudhoe Bay Sag River
Class(s) of Fractures: □ <3" ▩ 3"-6" ■ 6"-12" ■ 1'-2' ■ >2' ■ THRU

Fig. 7. Transverse distribution of fractures in flatbar tie plates of Alaska Class ships.