1. Introduction

Working Stress Design (WSD) loads are evaluated throughout the entire length of the casing from the Well Head to the Casing Shoe. True Vertical Depth (TVD) is now fully linked to Vertical Well Geometry or Directional Well Geometry. Accurate TVD’s are used for precise Burst, Collapse and Tensile load calculations. User defined Custom Casing Specifications can also be incorporated into the design. The program is designed to take the user through a logical sequence to achieve the optimum casing design.

2. Operation

A. Menu
On the Menu page, selecting **About This Program** and the **WSD Parameters** buttons explain the program parameters. Selecting **Enter Design Survey** shows the Directional/Survey page. Selecting **Utilities** shows the contact details of drillingsoftware. Selecting **Exit** closes the program.

### B. Set-up

To set-up the design program select **Enter Design Survey**, The Directional/Survey page is shown.

![Directional/Survey Page Buttons](image)

Fig.2 Directional/Survey Page Buttons

On the top of the Directional/Survey page are four buttons (Ref. Fig. 2A). These buttons are:

- **Set View size** selecting this shows an option to increase or decrease the magnification
- **Well Profile** selecting this shows the Well Profile data form (Ref. Fig. 3)
- **Design** selecting this shows the Design page (Ref. Fig. 4)
- **Printout** prints the Survey page.
(1) Well Data

Before proceeding with the casing design, the Well Profile must be established. On the Directional/Survey page, select Well Profile. The Well Profile data form is shown (Ref. Fig. 3).

On the Well Profile data form, these parameters are selected:
- Units (Feet or Meters)
- Well Bore (Vertical or Directional)
- Casing Design (Onshore Well, Shallow Offshore or Deep Water Offshore).

Before entering new data, old data is cleared by using the Clear Old Survey button.

After the Well Profile data is entered, selecting Close shows the Directional/Survey page. On the Directional/Survey page the selected well data is entered.
(a) Vertical Well (Ref. Fig. 3A)

A Vertical Well requires these inputs:
- The Measured Depth (MD)
- The Inclination (0°)
- The Azimuth (0°).

External data can also be imported.
(b) Directional Well (Fig. 3B)

A Directional Well requires these inputs:
- The Survey Depth
- The MD
- The Inclination
- The Azimuth.

When this data is entered, the following is automatically calculated:
- TVD
- Sub Sea TVD (TVD SS)
- N/-S
- E/-W
- DLS
- Closure.

External data can also be imported.
C. Casing Design

The Directional/Survey page is the entry point for the design stage. To start the casing design, on the Directional/Survey page, select Design. The Design page is shown (Ref. Fig. 4) with the Menu Bar overlay.

Fig.4 Design Page

NOTE: For the Menu Bar button functions and the Casing Design flow chart, refer to Appendix A.

Any existing anomalies in the design will cause a red message to be shown on the Menu Bar. The warning message shown informs the design engineer of the specific design fault.

(1) Casing and Liner Data

(a) Casing Data

On the Menu Bar, select Select Casing. The Casing Data form is shown.
(Ref. Fig. 5). On the Casing Data form, up to 4 different weights and grades of casing can be selected. If a tapered string design is required, different sizes of casing can be selected. The casing database contains over 4000 different joints. Customized casing data can be appended to the database.

Fig. 5 Casing Data Form

To select a casing, highlight the required casing section. Select and if the design requires only 1, 2, or 3 sections. The program automatically returns to the Design page after 4 sections are selected. The selected Casing Data is shown at the top of the Design page (Ref. Fig. 6) is then shown.
Select **OK** on the prompt. The Menu Bar is shown.

On the Menu Bar select **Enter Casing Depths**. The Section Depths data form is shown (Ref. Fig. 7).
Select **Clear Depths** to clear any existing data. After entering the depths of each casing section in the section panels, select **Continue**. The Update Charts prompt is shown (Ref. Fig 8).

![Update Charts](image)

**Fig.8 Update Charts**

Selecting **NO** returns the program to the Design page (Ref. Fig. 4). If **YES** is selected, refer to Para. 2. C. (14).

(b) Liner Data

On the Design Page (Ref. Fig. 4), select **Select Liner Design**. A Design for a Liner panel is shown (Ref Fig. 9).

![Design for a Liner](image)

**Fig.9 Design for a Liner**

Use the existing upper section of the casing and enter the TOL as the bottom of section 1. Enter up to 3 liner sections below the existing cemented casing.
On the panel, select \( \text{Yes} \). The liner(s) can now be selected in the same manner as selecting casing data [Ref. Para. 2. C.(1) (a)]. After selection, the design page is shown with the selected liner data shown at the top of the design page (Ref. Fig. 10).

![Fig.10 Liner Data](image)

If the sections for a liner have been selected, and was selected on the Design for a Liner panel (Ref. Fig. 9), the prompt is shown. Select \( \text{Yes} \) on the Liner Design Dialogue. The Liner Data is now shown at the top of the Design page (Ref. Fig. 10).

(2) Design Safety Factors (Fig. 11)

On the Design page, select \( \text{Design Menu} \). The Menu Bar is shown. On the Menu Bar, select \( \text{Design Setup} \). The Design Factors data form is shown (Ref. Fig. 11).

![Fig.11 Design Factors](image)
On the Design Factors data form, the following are selected:
- Burst
- Collapse
- Tension.
An option to enter Custom Safety Factors is also available.
Make the required selections and select **OK**. The Casing Design Condition Setup data form is shown (Ref. Fig. 12).

(3) Casing Design Condition Setup (Fig. 12)

![Casing Design Condition Setup](image)

On the Casing Design Condition Setup data form, the following are selected:
- Design Conditions:
  - Salt Water Gradient (Offshore)
  - Onshore or Offshore
  - Drilling or Producing Case
  - Axial Tension.

Note: The updated version of the Casing Design program includes Bi-axial and Tri-axial calculations.

- String Selection:
  - Structural
  - Jetted
  - Driven
  - Conductor
  - Surface 1 Csg
  - Surface 2 Csg
  - Scab Liner
  - Intermediate Csg
  - Intermediate Liner/Drlg Liner
  - Production Csg
  - Production Liner
  - Tieback String.
Make the required selections and select continue. The Gas/Oil Gradient data form is shown (Ref. Fig. 13).

(4) Gas/Oil Gradient (Fig.13)

![Gas/Oil Gradient](Fig.13 Gas/Oil Gradient)

Enter the gas or oil gradient and select continue. The Mud Weight – Leakoff data form is shown (Ref Fig. 14).

(5) Mud Weight – Leakoff (Fig 14)

![Mud Weight – Leakoff](Fig.14 Mud Weight – Leakoff)

Enter:
- The Present Mud Weight
- Leakoff @ present shoe
- Old Mud Weight.

Select continue. The Add in any Mud Weight Overbalance data form is shown (Ref. Fig. 15).
(6) Mud Weight Overbalance Option (Fig. 15)

![Fig.15 Mud Weight Overbalance](image)

This data form gives an option to enter any overbalance. This is deducted from the mud weight to give a more accurate pore pressure.

Select **Clear** if not required for the design.

Select **OK**. The Section Depths data form is shown (Ref. Fig. 16).

(7) Section Depths (Fig. 16)

![Fig.16 Section Depths](image)
At the top of the Section Depths data form there is a reference to the selected type of well and all the datum depths. Enter the depths at the bottom of each casing section.

Note: A warning will indicate any errors in the design.

Select **Clear Depths** and enter the new depths. Select **Continue**. The estimated BHT data form is shown (Ref. Fig. 13)

(8) Temperatures and Estimated BHT (Fig. 17)

Select **Clear all Temperature inputs** before entering new temperatures.
Enter the known ambient temperature.
Select the Linear Interpolation or Custom Input for the bottom of each casing section.
Select the Temperature units (°C or °F).
A reference to all the datum depths, TVD, MD and the linear and/or custom temperatures is shown in the Design Temperature panel.

Select. The Select Well Head Rating data form is shown (Ref. Fig. 18).

(9) Select Well Head Rating (Fig. 18)

Select the well head rating design (from 1000psi to 20000psi).

Note: If a rating below the calculated surface pressure is selected, a red warning will be shown.

The maximum design burst pressure and the safety factors have all been calculated in the background.

Select. The Mud Evacuation Selection data form is shown (Ref. Fig. 19).
(10) **Mud Evacuation (Fig. 19)**

![Mud Evacuation Selection](image)

**Fig. 19 Mud Evacuation**

Select the percentage of mud evacuation for the design. 0% to 100% or a custom percentage can be entered.

Note: If a producing well design was previously selected, the program automatically selects 100% mud evacuation.

Select **OK**. The Update Charts data form is shown (Ref. Fig. 20)

(11) **Update Charts (Fig. 20)**

![Update Charts](image)

**Fig. 20 Update Charts**

Select **YES** to update all the Design Report/ Design Charts (Ref. Figs. 24 and 25).

If **YES** is selected, the Printout Header Data page is shown. Go to Para. 2. C. (14).

Selecting **NO** shows the Design Progress page (Ref. Fig. 21)
Accessing the Design page at this stage gives a quick, visual check as to how the design is progressing. Any design failures are shown as red cells.

At the top section of the design page selected casing sections parameters are shown. The parameters shown are:
- The Outside Diameter (in.)
- The Nominal Weight (ppf)
- The Grade
- The Joint Connection
- Collapse Strength (psi)
- Joint Strength (psi)
- Body Yield Strength (lbs)
- Wall Thickness (in.)
- Option to select Drift or ID
- Box Diameter (in.).

The light blue section shows all the present and previous mud data and the next setting depths.

Immediately below the light blue section all the design safety factors are shown. Any failed safety factors will show in red.

The Mud Gas Interface (MGI) depth is shown in the light blue section of the survey data.
Note: Any section of the design set-up can be accessed via the Menu Bar. Quick changes to any of the design parameters can be accomplished without going through the complete sequential design set-up.

The Menu Bar is shown when Setup Design Criteria is selected on the Design page.

On the Menu Bar, select Design Criteria. The Design Criteria page is shown (Ref. Fig. 22).

(13) Design Criteria (Fig. 22)

From the Design Criteria Page the following are reviewed:
- Temperature De-rating Factors
- De-rating Factors due to Axial Loading
- Cementing Safety Factors.

Select View Temperature Derating Factors to access the Temperature De-rating Effect page (Ref. Fig. 22A).
(a) Temperature De-rating Effect (Fig. 22A)

Use the scroll bar to review all data.

Select to return to the Design Criteria page.

Select to access the Collapse Strength De-rating Factors (Ref. Fig. 22B).
(b) De-rating Collapse Curve Factors (Fig. 22B)

Fig. 22B De-rating Collapse Curve Factors

Use the scroll bar to review the data.

Select [Close] to return to the Design Criteria page.

Select [Cementing Safety Factors and Loads] to access the Cementing Collapse Load page (Ref. Fig. 22C).
(c) Cementing Collapse Load (Fig 22C)

After reviewing the data, select OK to return to the Design Criteria page. Select OK to return to the Design Page. Select Close on the Menu Bar.
(14) Printout Header (Fig. 23)

The Printout Header is accessed from either the [Update Design] button on the Design page (Ref. Fig. 4) or the [YES] button on the Update Charts prompts (Fig. 8 and Fig. 20).

The Printout Header is used to input the well particulars. These are:
- Well Name/No.
- Location
- Rig
- RKB Elev
- RKB-WH
- AFE
- Coordinates (Lat/Long)
- Design Prepared By
- For Operating Company
- Date
- Risk Classification.

Enter the data. Select [Continue]. The Design Report is shown (Ref. Fig. 24).
The Design Report is a full and comprehensive report, broken down into four sections.

The Design Report can be exported or e-mailed to the operator. When a copy of the report is selected, a copy of the report is also exported to the local well file.
Section 1 of the Design Report shows:

- The Report Header
- Well Particulars
- Casing Design Report:
  - Well Classification (Onshore/Offshore)
  - Casing String
  - Well Classification (Drilling/Production)
  - SW Grad
  - Mud Evacuation (%)
  - Well Classification (Vertical/Directional)
  - Water Depth
  - Gas/Oil Grad.
  - Risk Class
  - Well Head Rating.

- Casing Section:
  - MD
  - Size
  - Weight
  - Grade
  - Connection
  - Collapse (psi)
  - Burst (psi)
  - Joint (lbs)
  - Body (lbs)
  - Wall
  - ID
  - Drift ID
  - Box OD.
- Survey Data:
  - MD
  - Inclination (˚)
  - Azimuth (˚)
  - TVD
  - TVD SS
  - N/S
  - E/W
  - DLS
  - Closure

- Mud Gas Interface (MGI).

Note: The MGI is linked to the % of mud evacuation and is indicated in all four sections of the Design Report.

(b) Design Report: Section 2 (Fig. 24B)

Section 2 of the Design Report shows:
- MD at the top of each section
- MD at the bottom of each section
- TVD at the top of each section
- TVD at the bottom of each section
- All calculated design safety factors.

(c) Design Report: Section 3 (Fig. 20C)

Section 3 of the Design Report shows:
- All Rated Strengths
- All De-rated Strengths due to temperature effect.
(d) Design Report: Section 4 (Fig. 24D)

Section 4 of the Design Report shows:
- All De-rated strengths due to axial loading
- Cementing safety factors.

When **Update Design** is selected in the Design Report, all the design parameters and safety factors are linked and updated. These include:
- De-rated Loads
  - Burst
  - Collapse
  - De-rated Tension
  - Pressure ratings
  - Temperature De-rated Yields.

In addition, all Design Charts are constructed (Ref. Fig. 25).
(17) Typical Design Charts (Fig. 25)

When [View Charts] is selected in the Design Report, the design charts are displayed to give an instant visual indication for easy analysis.

- **Fig. 25A Design Chart (DLS)**
- **Fig. 25B Design Chart** (De-rated Burst and Collapse vs Rated Burst and Collapse)
- **Fig. 25C Design Chart (Departure)**
- **Fig. 25D Design Chart (Vertical Section View)**
- **Fig. 25E Design Chart** (De-rated Tensile Strength vs Tensile Load)
- **Fig. 25F Design Chart** (Yield Strength De-rating Factors vs Temp)
Appendix A

1. Menu Bar Button Functions and Casing Design Flow Chart

- Casing Data (Figs. 5 and 6)
- Liner Data (Figs. 5 and 10)
- Section Depths (Fig. 7)
- Design Factors (Fig. 11)
- Casing Design (Fig. 12)
- Gas/Oil Gradient (Fig. 13)
- Mud Weight-Leakoff (Fig. 14)
- Mud Weight Overbalance (Fig. 15)
- Section Depths (Fig. 7 and 16)
- Temperatures (Fig. 17)
- Well Head Rating (Fig. 18)
- % Mud Evacuation (Fig. 19)
- Update Charts (Fig. 20)
- Design Progress (Fig. 21)
- Printout Header (Fig. 23)
- Design Report (Fig. 24)
- Design Charts (Fig. 25)

- Temperature De-rating Effect (Fig. 22A)
- De-rating Collapse Curve Factors (Fig. 22B)
- Cementing Collapse Load (Fig. 22C)
- Design Criteria (Fig. 22)
- Survey
- View Report
- View Charts
- Close
- Yes
- NO
- Print/Export
- Print/Export
Appendix B

1. Glossary

BHT ----------------------------- Bottom Hole Temperature
˚C ----------------------------- Degrees Centigrade
Csg ----------------------------- Casing
DLS ----------------------------- Dog Leg Severity
Drlg ----------------------------- Drilling
E/-W ----------------------------- East/West
˚F ----------------------------- Degrees Fahrenheit
ID ----------------------------- Inside Diameter
in ----------------------------- inches
lbs ----------------------------- pounds
MD ----------------------------- Measured Depth
MGI ----------------------------- Mud Gas Interface
N/-S ----------------------------- North/South
OD ----------------------------- Outside Diameter
ppf ----------------------------- pounds per foot
psi ----------------------------- pounds per square inch
TVD ----------------------------- True Vertical Depth
TVD SS --------------------------- True Vertical Depth Sub Sea
WSD ----------------------------- Working Stress Design