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User Guide

Software for Well and Downhole Equipment Modeling

Contents

1. General Information

The **New Vision** solution is designed for comprehensive selection of optimal equipment and performing calculations required for well operation. It provides engineers and specialists with a user-friendly interface for entering and analyzing data related to well parameters, fluid flow, equipment design, and engineering calculations.

1.1. Solution Features

The solution provides the following features:

- Selection of equipment suitable for operating conditions.
- Multiphase flow calculation for natural flow and artificial lift systems.
- Calculation of fluid PVT properties.
- Well profile modeling and visualization in various projections.
- Adjustment of correlations used in calculations.
- Surface equipment calculation.
- Engineering calculations (choke selection, complication analysis, strength margin calculation).

1.2. Supported Business Processes

The solution provides functionality for the following business processes:

- Selection of downhole pumping equipment.
- Adding equipment to the database.
- Modeling of current well operating conditions with artificial lift equipment.
- Performing engineering calculations related to the well model.

1.3. F.A.Q.

1. At what frequency are pump parameters recorded in the database?

Pump data are stored at 3 500 RPM. During equipment selection, recalculation is performed based on the frequency selected by the user. For details, see Pump.

2. When selecting a pump that achieves the required flow rate, the resulting head is very high. Why is that?

A high head may be caused by a high WHP or frictional losses. Additionally, the total dynamic head is calculated using the fluid's PVT properties and current operating parameters. This value differs from the nominal head which is typically determined using water.

3. How to work with correlations and select the right one?

All correlations are described in the corresponding section of this guide. For details, see Appendix A: PVT Correlations.

4. At what frequency is the pump power consumption calculated?

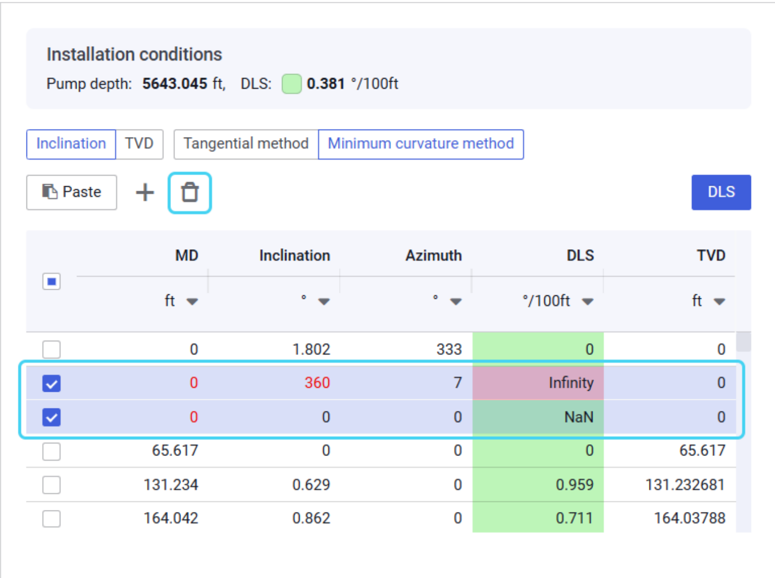
At the operating frequency.

5. Why are the gas separator parameters not calculated when I select equipment for a new well?

Most likely, the pump has not been added. If this is the case, it is impossible to determine the pressure/temperature conditions at the intake, which means it is impossible to assess gas separation parameters in a non-flowing well before running the equipment. For details, see Pump.

6. How to add deviation survey data?

In the **Wellbore** section, on the **Deviation survey** tab, click **Add (+)** to add a new row or click **Paste ( )** (or press Ctrl+V) to paste data from another table.
The inserted data must contain numerical values only. If the data includes a row with zero values or NaN (not a number) values, delete them after insertion.
For details, see Deviation survey.



7. The temperature distribution graph is not generated, and it's not possible to change the length of the submersible cable.

The temperature gradient calculation is only possible after selecting the cable, as it depends on the properties of its conductors and insulation.

The length of the power cable is set automatically based on the pump setting depth. The lengths of the high temperature cable and motor lead extension (MLE) must be set

manually. They are subtracted from the power cable length.
For details, see Cable.

8. In the 'Transformer and Controller' section, no parameter values are displayed in the diagrams.

Ensure that the cable is selected, as the data for calculating the surface electrical equipment is taken from this section. It is also necessary to verify that all equipment components—from the pump to the cable—are selected and the corresponding sections are filled out. For details, see Cable.

9. How do friction factor and hold-up factor affect calculations?

Both the friction and hold-up factors are taken into account when calculating the total pressure loss in the wellbore. The following formula is used:

$\boldsymbol{\Delta P}$=friction factor $\boldsymbol{\Delta P_f}$+ hold up factor $\boldsymbol{\Delta P_a}$ + $\boldsymbol{\Delta P_g}$

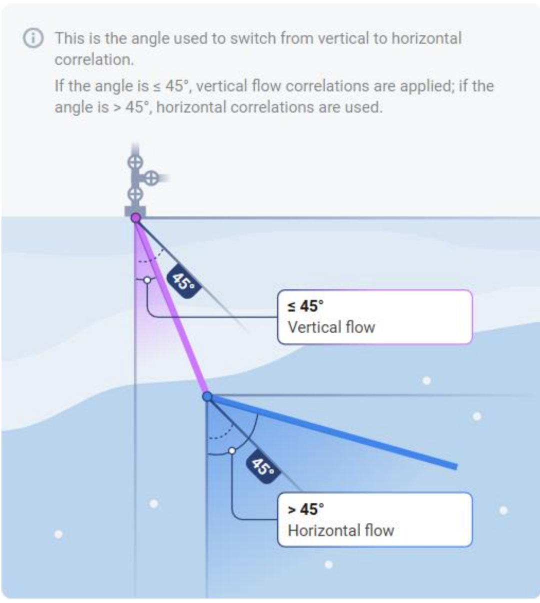
where:

- ΔPf – frictional losses
- ΔPa – hydrostatic gradient
- ΔPg – losses due to phase acceleration

The default value of the friction and hold-up factors is 1. Values entered manually can be used for the purpose of testing or empirical data matching.

10. How is the swap angle value used in calculations?

The swap angle defines the threshold at which vertical correlations are applied instead of horizontal ones. If the inclination angle is less than or equal to 45°, horizontal correlations are used. If the angle is greater than 45°, vertical correlations are applied.



13. What is IFT and how does it influence calculations?

IFT stands for interfacial tension. In multiphase flow calculations, it is used for the following purposes:

- Flow regime determination: IFT affects the shape of bubbles and droplets, influencing whether the flow is classified as bubbly, slug, or annular.
- Interfacial interaction calculations: IFT affects friction and phase distribution, which, in turn, affect pressure losses.
- Gas holdup estimation: IFT is used in empirical correlations (e.g., Duns & Ros, Hasan & Kabir) to estimate the fraction of gas retained in the liquid phase.

14. What data is on the 'Heat transfer' tab and how does it influence calculations?

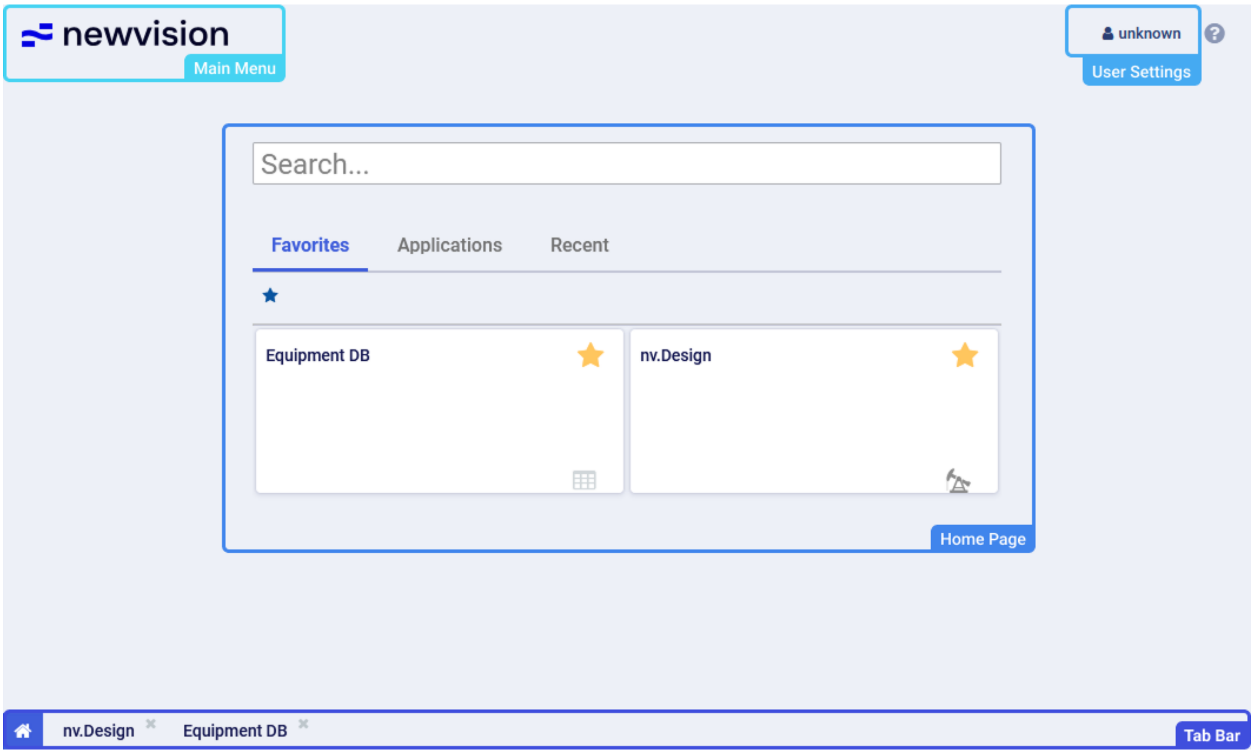
The **Heat Transfer** tab is designed to calculate the temperature distribution along the wellbore. To start, you need to specify input data such as surface and reservoir temperatures. Then, select a calculation method that will determine the required input parameters. For details, see Heat transfer.

15. When should Hasan-Kabir and Rough Approximation methods be used?

The **Hasan-Kabir** method provides higher accuracy as it considers individual heat transfer coefficients for casing, tubing, cement, and the surrounding earth, as well as the thermal conductivity of the rock.

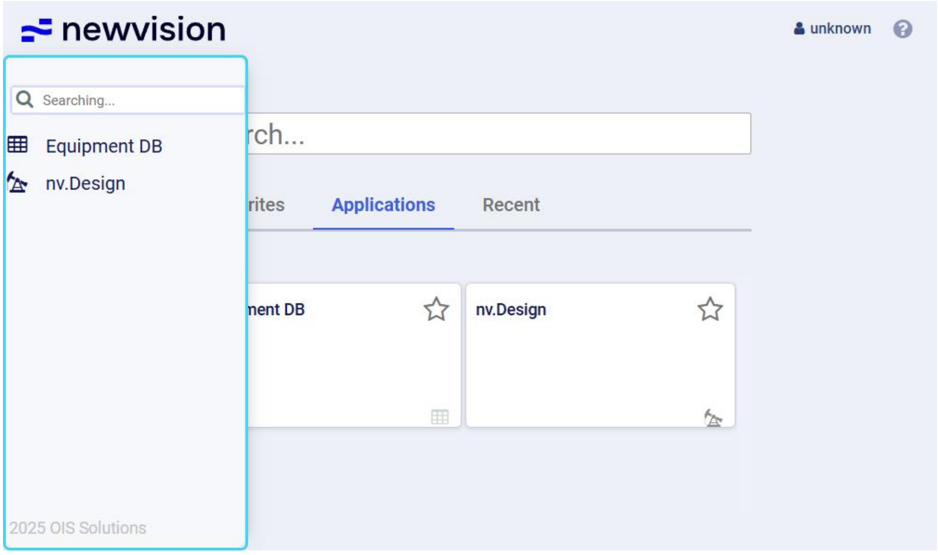
The **Rough Approximation** method uses a generalized heat transfer coefficient to estimate the temperature profile, making it simpler but less precise.

2. System Interface



The system interface consists of the following parts:

- **Main menu**: Opens the menu with a list of all system modules.

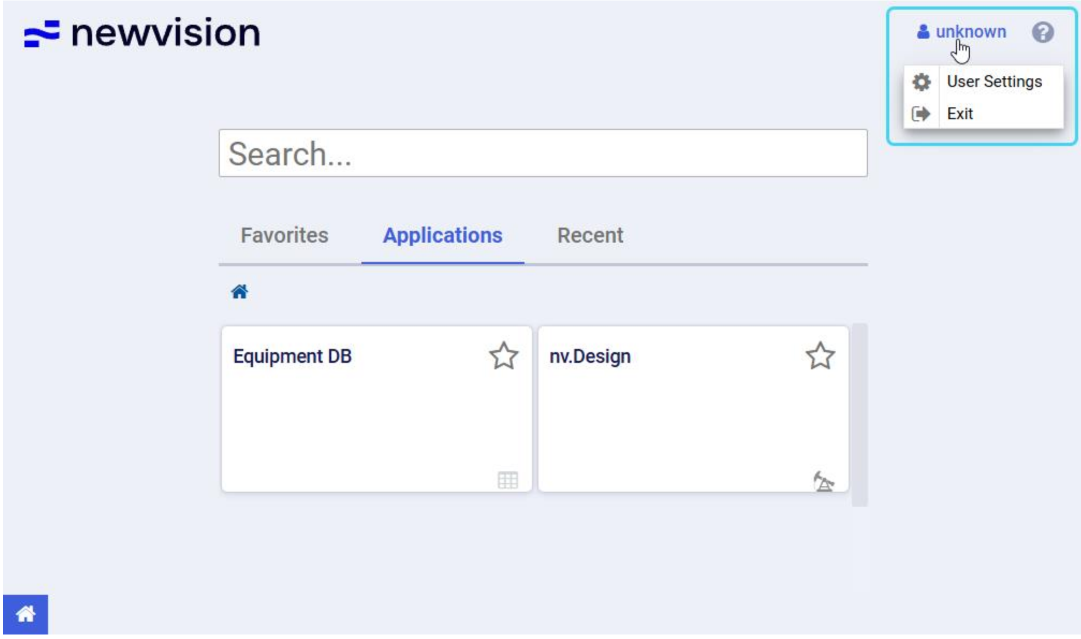


- **User settings**: Opens the menu from which you can change user settings and log out of the system. For details, see User Settings.
- **Home page**: Provides a list of all system modules displayed as tiles with the ability to set up quick access and view recently opened modules. For details, see Home Page.
- **Tab bar**: Provides a list of all currently opened modules displayed as tabs.

2.1. User Settings

The **User Settings** menu provides the ability to configure user system settings and log out of the system.

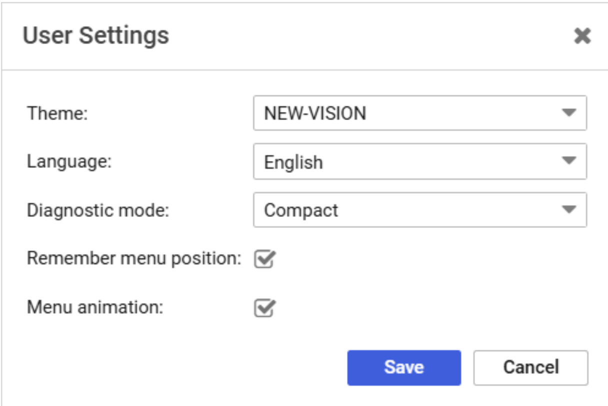
To open the menu, in the upper-right corner of the system window, click the name of the current user.



The **User Settings** menu contains two options:

- **User Settings**: Opens a window with general interface settings that are individual for each user.
- **Exit**: Ends your current session in the system.

The **User Settings** window provides the ability to configure general system parameters, such as interface language and menu behavior.



In the **User Settings** window, you can configure the following parameters:

- **Theme**: Color theme of the system interface.
- **Language**: System interface language.

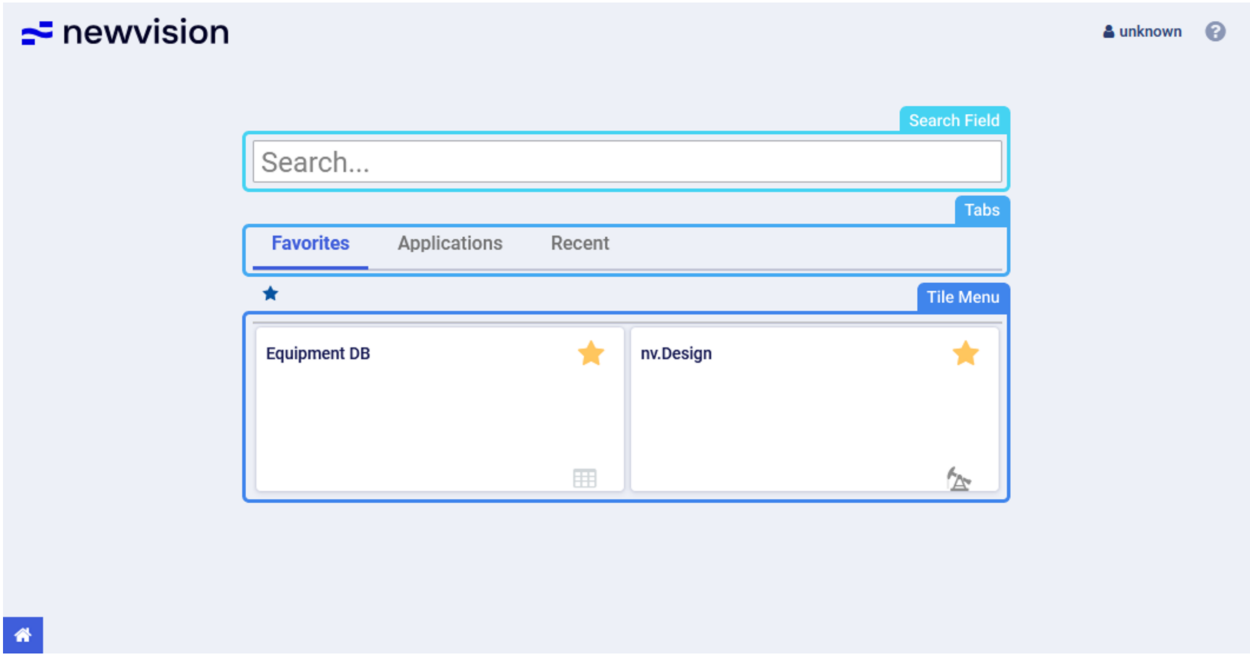
- **Diagnostic mode**: Level of detail in system error notifications.
  By default, the **Compact** mode is selected, and error notifications are displayed in pop-up windows that appear in the lower-right corner of the window and disappear automatically in a few seconds.
  If the **Full** mode is selected, error notifications are displayed in a separate dialog window.
- **Remember menu position**: If selected, every time you open the main menu during the current session, it opens at the position where you left off.
  If cleared, the menu always opens at its default state with all lists of modules collapsed.
- **Menu animation**: If selected, navigation through the main menu is smoothed with animation effects.

To apply the settings, click **Save**. If you change the theme or interface language, the system reloads automatically. Other settings are applied without reloading.

2.2. Home Page

Home page is the first page that opens after you log in to the system.

You can open it at any time while working with the system by clicking **Home (🏠)** in the lower-left corner of the system window.



Home page contains the following components:

- **Search field:** Text field for searching for the required module.
- **Tabs:** Tabs for grouping and navigation among system modules:
  - **Modules**: All system modules available to you.
  - **Favorites**: Modules that you added to favorites.
    To add a module to favorites, click the star icon in the upper-right corner of its tile. To remove it from favorites, click the star icon again.
  - **Recent**: Modules that you opened recently.
- **Tile menu:** Modules represented as tiles for quick access to the system modules.

To open a module, click the corresponding tile in the tile menu or use the main menu instead.

To close a module, click the cross icon (✖) in the right part of the corresponding tab in the tab bar.

For details, see System Interface.

3. Getting Started

To start working with the **nv.design** module, you need to log in to the system. For details, see Logging In.

After logging in, you can create, import, or open a project (well design). For details, see Creating Projects, Importing Projects, and Opening Projects.

For each project, you can select a default or configure a custom unit measurement system. For details, see Unit Selection.

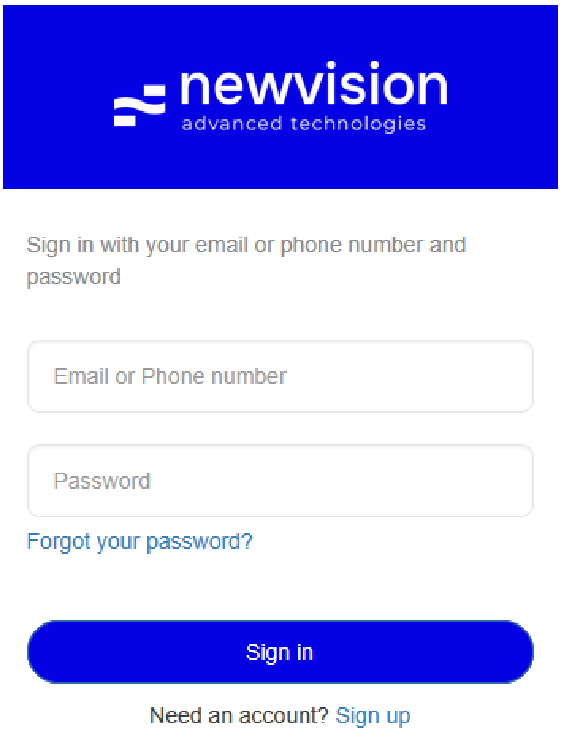
All projects comprise multiple sections with the well and equipment parameters. For details, see Well Design Parameters.

When the project configuration is completed, you can generate a summary and detailed reports. For details, see Reports.

3.1. Logging In

To access **newvision**, perform the following actions:

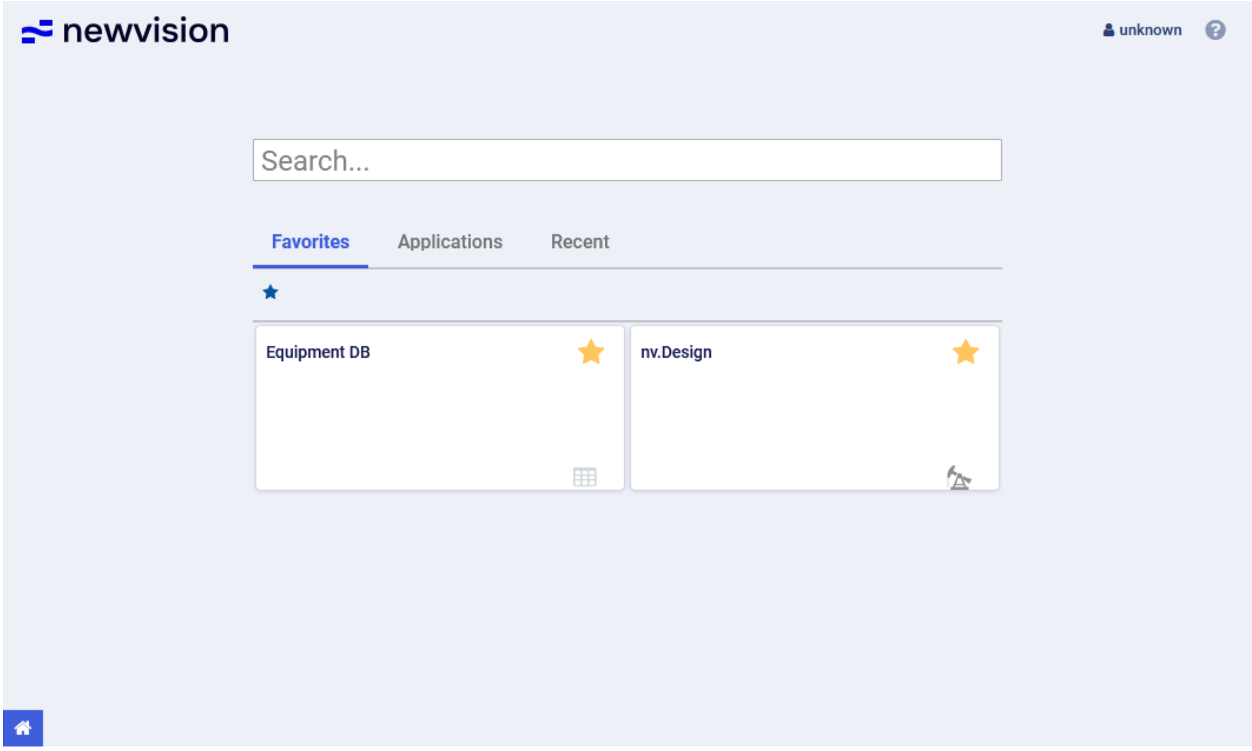
1. In your web browser, enter the system URL.
   The login window appears.



2. In the login window, enter your email or phone number and password.

   Note
   If you were not provided with the account credentials, contact your system administrator.

3. Click **Sign in**.
   If the entered credentials are valid, the system home page opens. For details, see Home Page.



3.2. Creating Projects

In the **nv.design** module, you can create a new project in several ways, depending on your current stage in the module workflow:

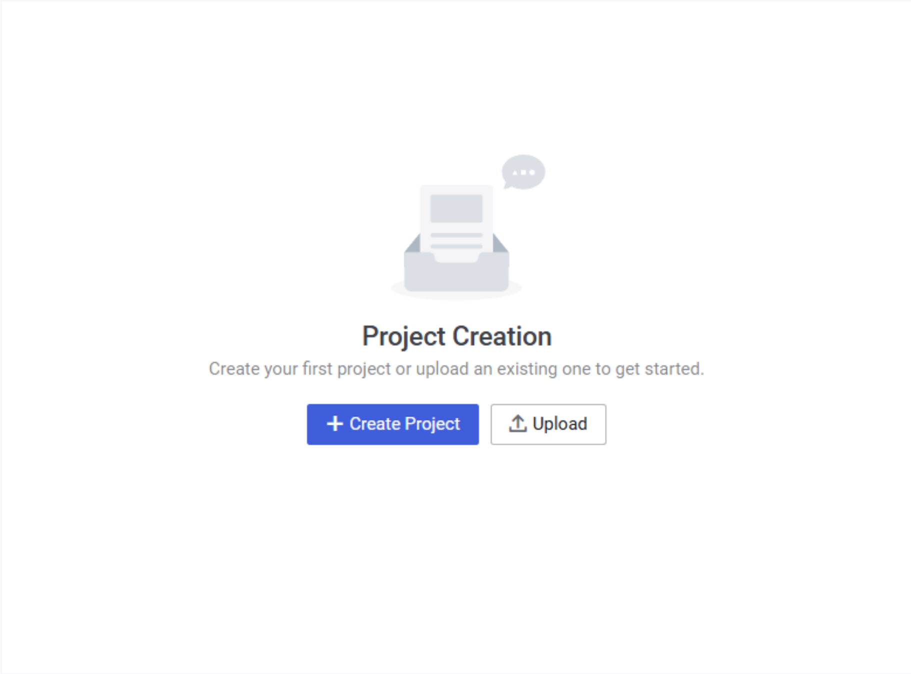
- Upon opening the module
- While working on an existing project

The created project opens with a default case (well design scenario) created automatically.
For details on creating cases, see Adding Cases.

3.2.1. Creating New Project Upon Opening nv.design

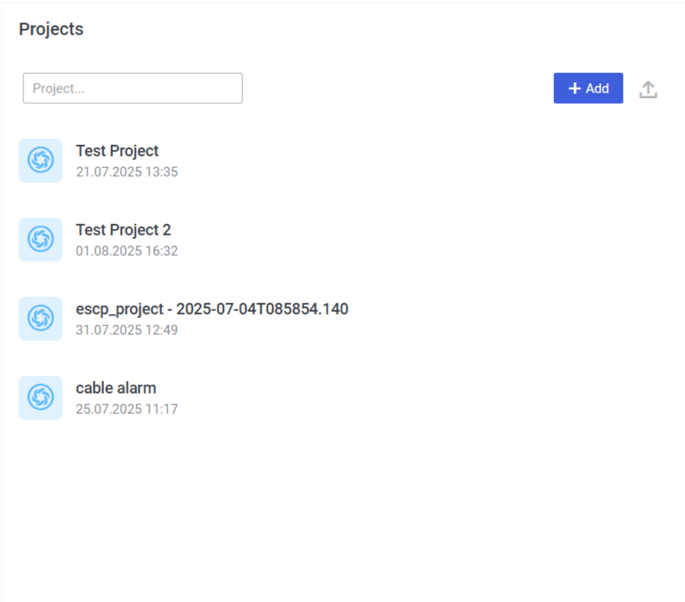
To create a project upon opening the **nv.design** module, perform the following actions:

1. Open the **nv.design** module.
   For details on navigation in the system, see System Interface.
2. Depending on whether there are any projects in the system, perform one of the following actions:
   - If there are no projects, in the **Project Creation** window, click **Create Project (+)**.

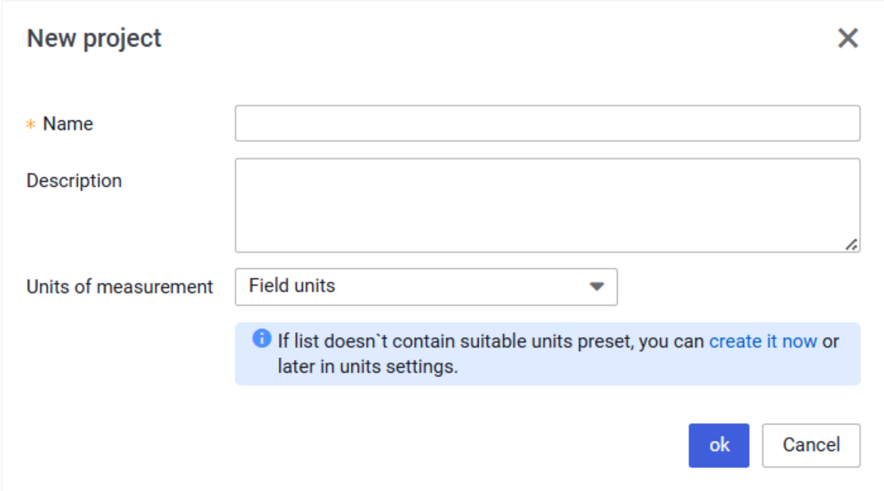


- If there already are some projects, in the upper-right corner of the **Projects** window, click **Add (+)**.

  Important
  This method is relevant only if you open the module for the first time or after clearing the browser cache. Otherwise, when you open the module, the last project you worked on will open automatically. In this case, see Creating New Project While Working on an Existing Project.



The **New project** window opens.



3. In the **New project** window, perform the following actions:
   a. In the **Name** field, enter the new project name.
   b. *(Optional)* In the **Description** field, enter a description for the new project.
   c. From the **Units of measurement** list, select the desired measurement system: **Field units** (US oilfield units) or **SI units** (metric units).

      Note

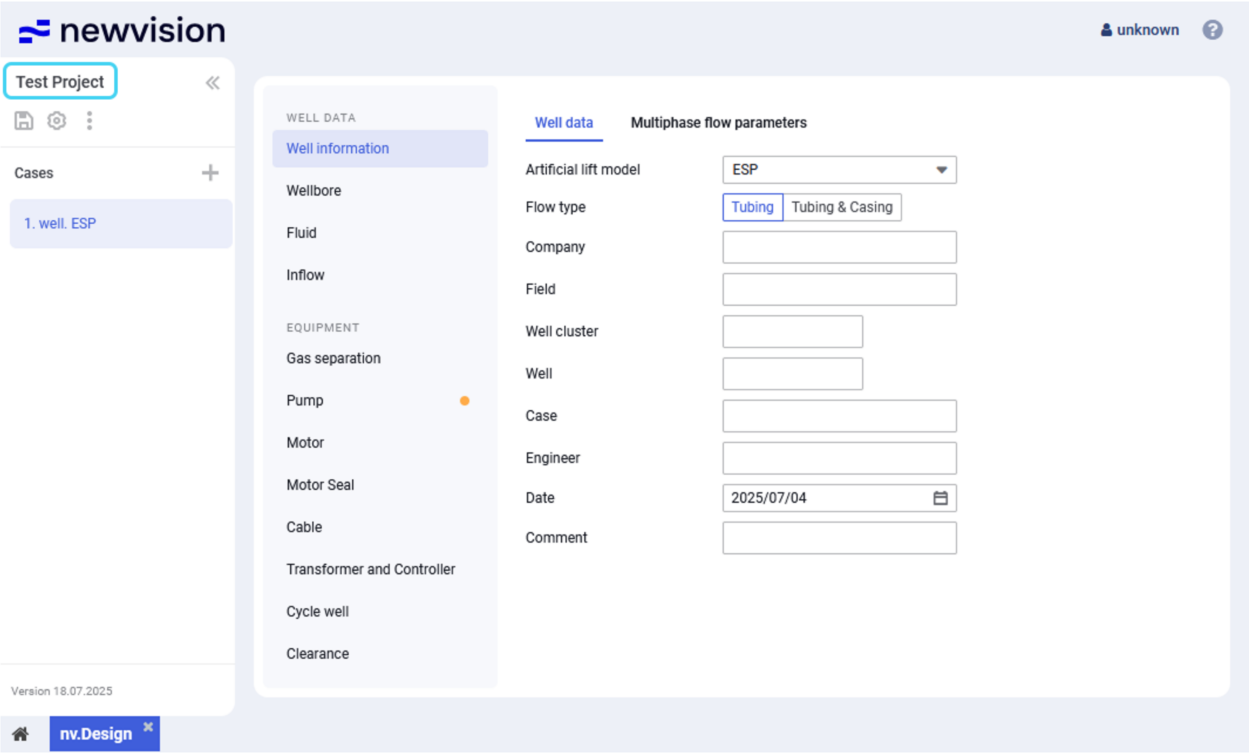
      You can also create a custom set of measurement units. To do this, in the area below the list, click **create it now**. You can do this after the project is created as well. For details, see Configuring Custom Set of Units.

   d. In the lower part of the window, click **ok**.

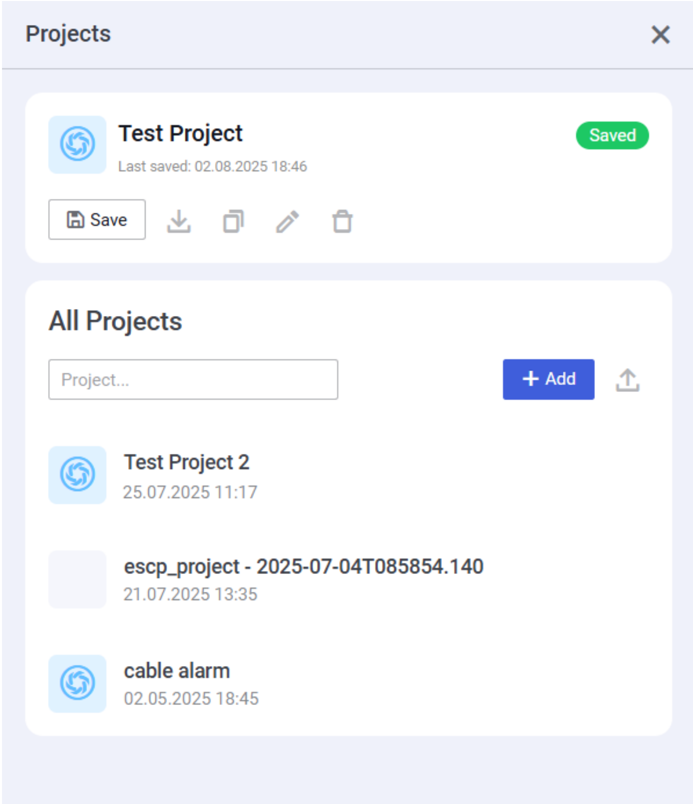
3.2.2. Creating New Project While Working on an Existing Project

To create a project while working on an existing **nv.design** project, perform the following actions:

1. In the upper-left corner of the module, click the name of the currently open project.

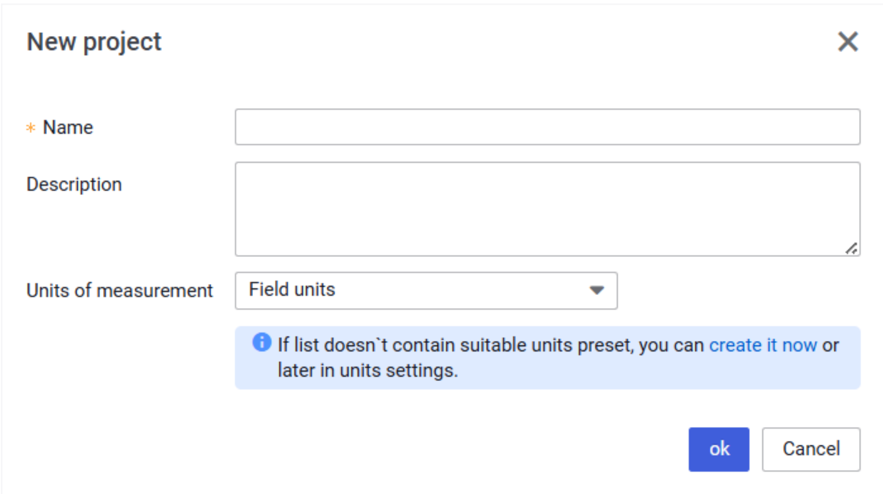


The **Projects** window opens.



2. In the **Projects** window, under the **All Projects** heading, click **Add (+)**.

   The **New project** window opens.



3. In the **New project** window, perform the following actions:
   a. In the **Name** field, enter the new project name.
   b. *(Optional)* In the **Description** field, enter a description for the new project.
   c. From the **Units of measurement** list, select the desired measurement system: **Field units** (US oilfield units) or **SI units** (metric units).

      Note

      You can also create a custom set of measurement units. To do this, in the area below the list, click **create it now**. You can do this after the project is created as well. For details, see Configuring Custom Set of Units.

d. In the lower part of the window, click **ok**.

3.3. Importing Projects

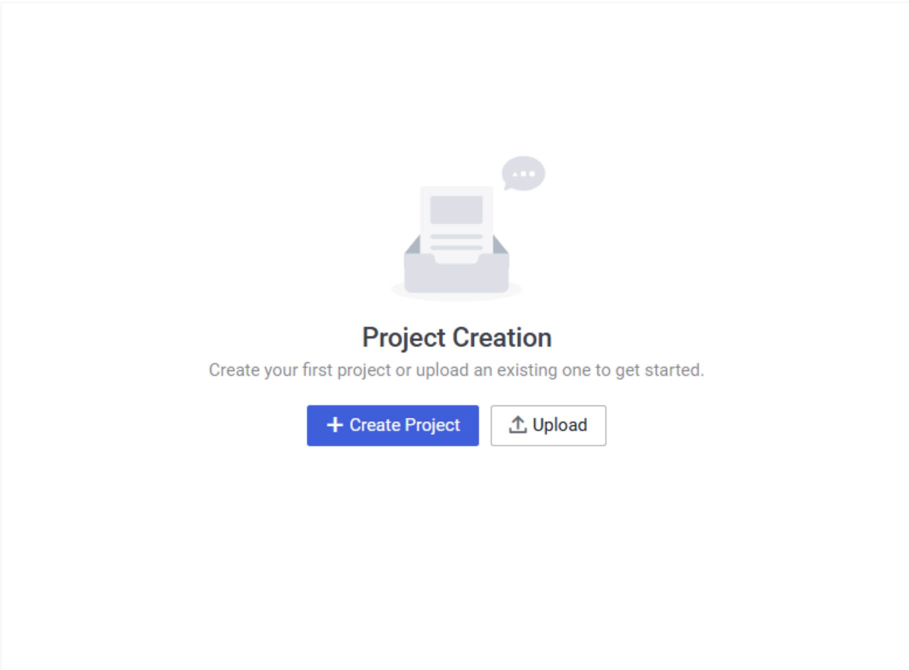
In the **nv.design** module, you can import an existing project in the JSON format in several ways, depending on your current stage in the module workflow:

- Upon opening the module
- While working on an existing project

3.3.1. Importing New Project Upon Opening nv.design

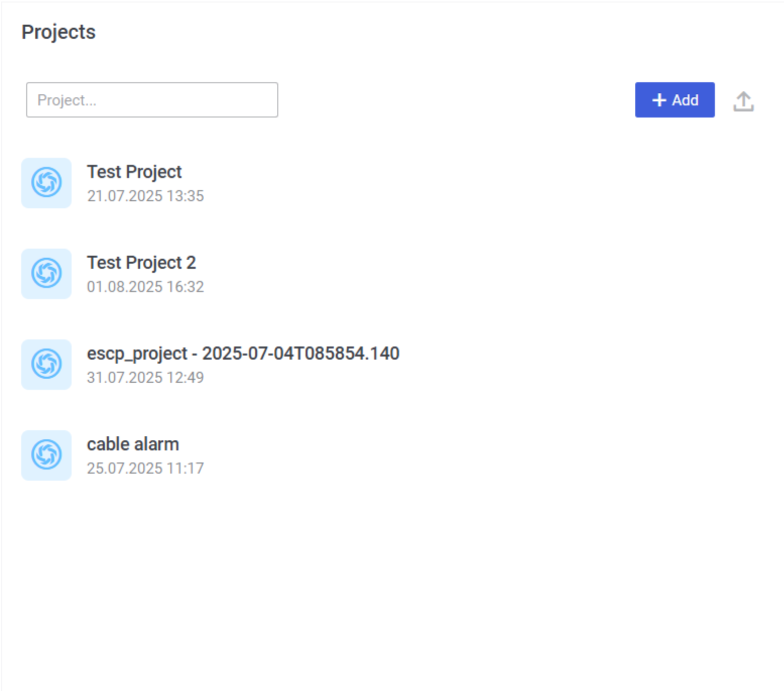
To import a project upon opening the **nv.design** module, perform the following actions:

1. Open the **nv.design** module.
   For details on navigation in the system, see System Interface.
2. Depending on whether there are any projects in the system, perform one of the following actions:
   - If there are no projects, in the **Project Creation** window, click **Upload ( )**.

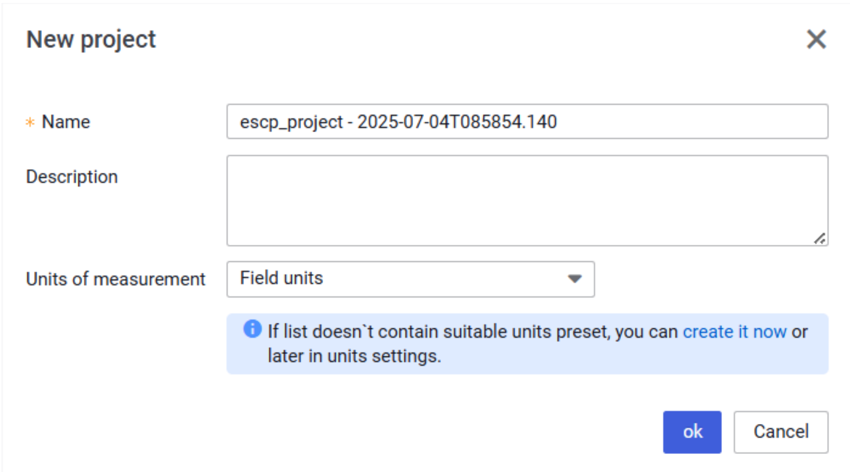


- If there already are some projects, in the upper-right corner of the **Projects** window, click **Upload (⭱)**.

  Important
  This method is relevant only if you open the module for the first time or after clearing the browser cache. Otherwise, when you open the module, the last project you worked on will open automatically. In this case, see [Importing New Project While Working on an Existing Project].



3. In the file explorer window, select the JSON file with the project you want to import.
   The **New project** window opens.



4. In the **New project** window, perform the following actions:
   a. *(Optional)* In the **Name** and **Description** fields, edit the project name and description.

b. From the **Units of measurement** list, select the desired measurement system: **Field units** (US oilfield units) or **SI units** (metric units).

Note

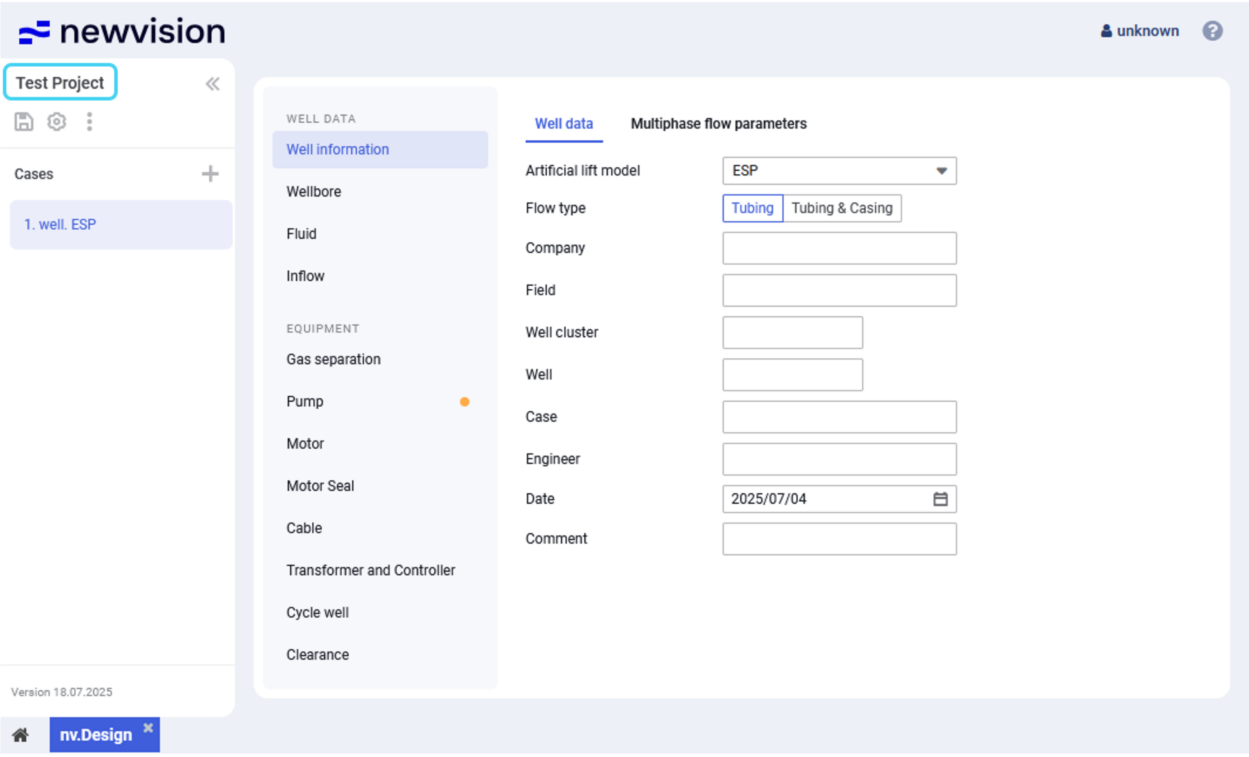
You can also create a custom set of measurement units. To do this, in the area below the list, click **create it now**. You can do this after the project is created as well. For details, see Configuring Custom Set of Units.

c. In the lower part of the window, click **ok**.

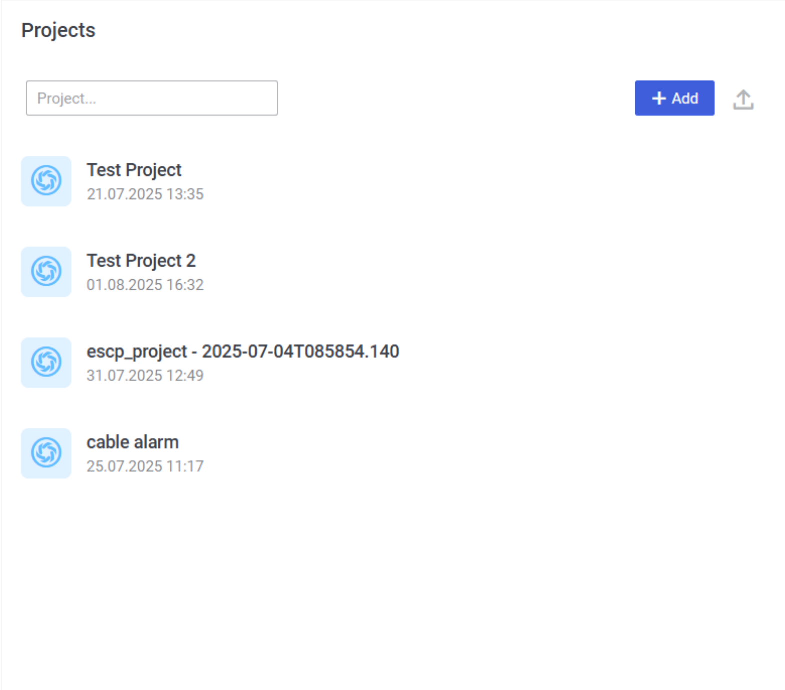
3.3.2. Importing New Project While Working on an Existing Project

To import a project while working on an existing **nv.design** project, perform the following actions:

1. In the upper-left corner of the module, click the name of the currently open project.

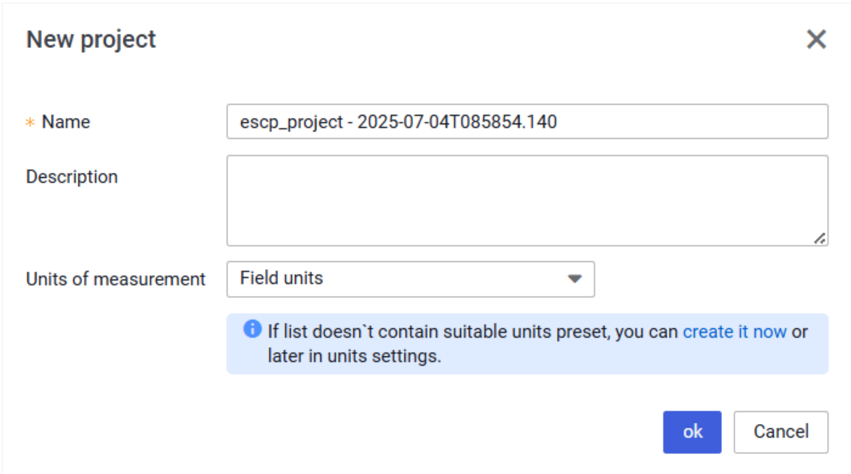


The **Projects** window opens.



2. In the **Projects** window, to the right of the **Add (+)** button, click **Upload (⭱)**.
3. In the file explorer window, select the JSON file with the project you want to import.

   The **New project** window opens.



4. In the **New project** window, perform the following actions:
   a. *(Optional)* In the **Name** and **Description** fields, edit the project name and description.
   b. From the **Units of measurement** list, select the desired measurement system: **Field units** (US oilfield units) or **SI units** (metric units).

   Note

   You can also create a custom set of measurement units. To do this, in the area below the list, click **create it now**. You can do this after the project is created as well. For details, see Configuring Custom Set of Units.

c. In the lower part of the window, click **ok**.

3.4. Opening Projects

In the **nv.design** module, you can open an existing project from the project catalog in several ways, depending on your current stage in the module workflow:

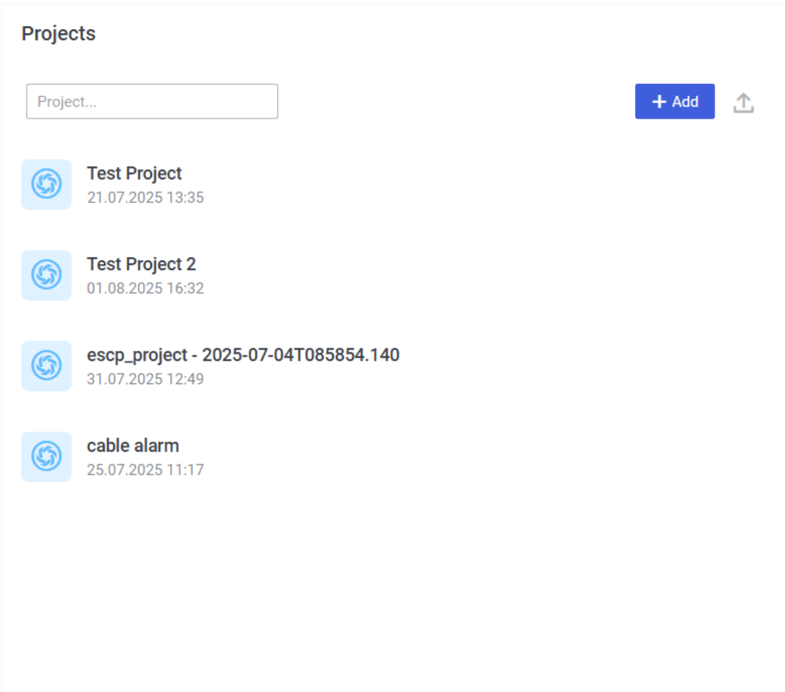
- Upon opening the module
- While working on an existing project

3.4.1. Opening Existing Project Upon Opening nv.design

Important
This method is relevant only when you open the module for the first time or after clearing the browser cache. Otherwise, when you open the module, the last project you worked on will open automatically. In this case, see Opening Existing Project While Working on Another Project.

To open a project upon opening the **nv.design** module, perform the following actions:

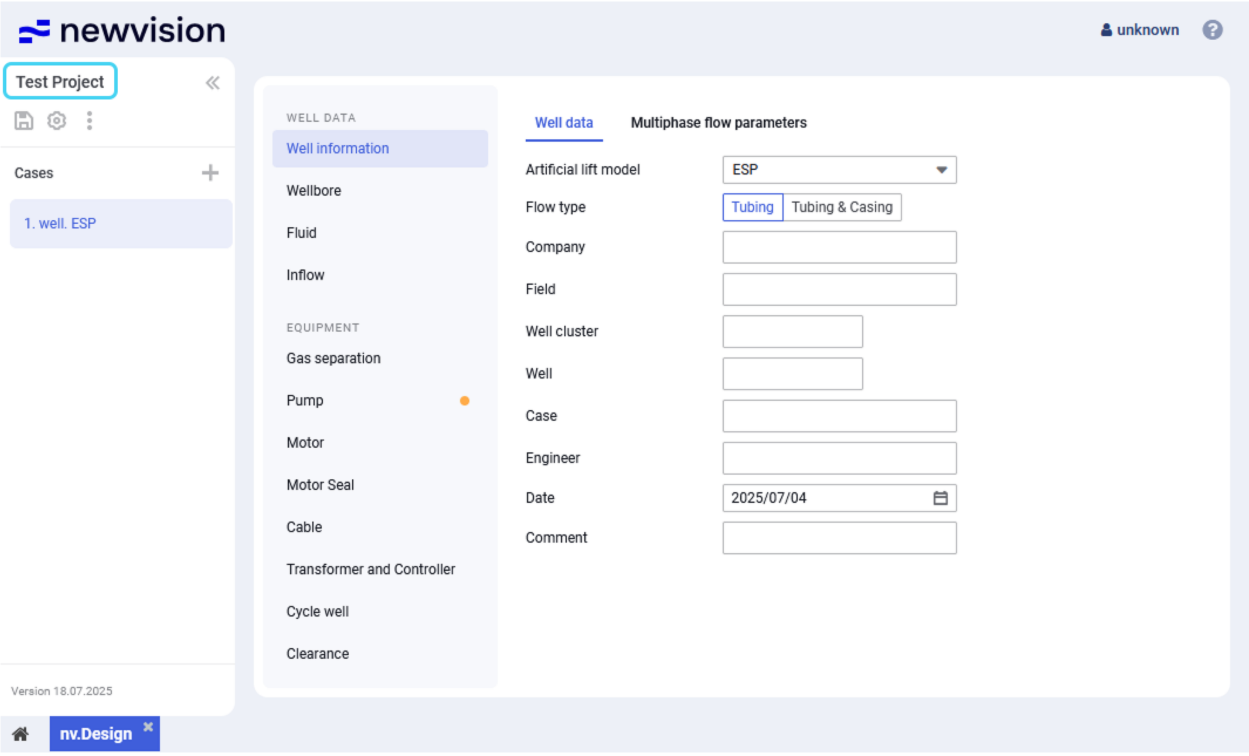
1. Open the **nv.design** module.
   For details on navigation in the system, see System Interface.
2. In the **Projects** window that appears, click the name of the desired project.



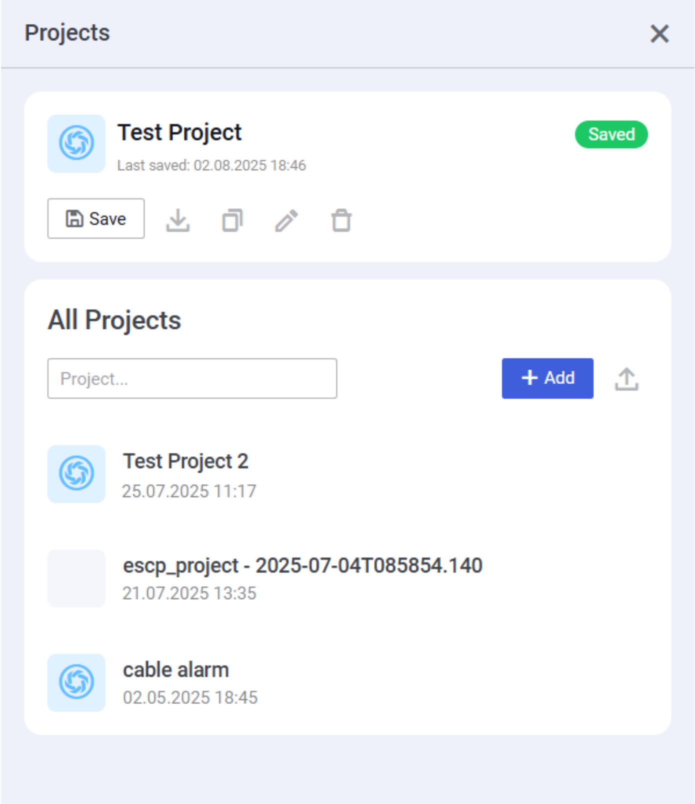
3.4.2. Opening Existing Project While Working on Another Project

To open a project while working on another **nv.design** project, perform the following actions:

1. In the upper-left corner of the module, click the name of the currently open project.



The **Projects** window opens. For details, see Project Catalog.



2. In the **Projects** window, under the **All Projects** heading, click the name of the desired project.

   Note
   You can also search for projects using the search field under the **All Projects** heading.

3.5. Adding Cases

After a project is created, imported, or opened, you can create well design cases (versions) within it.

By default, all new projects contain a default case pre-filled with well, fluid and reservoir data. You can modify it to match your conditions and select the appropriate equipment.

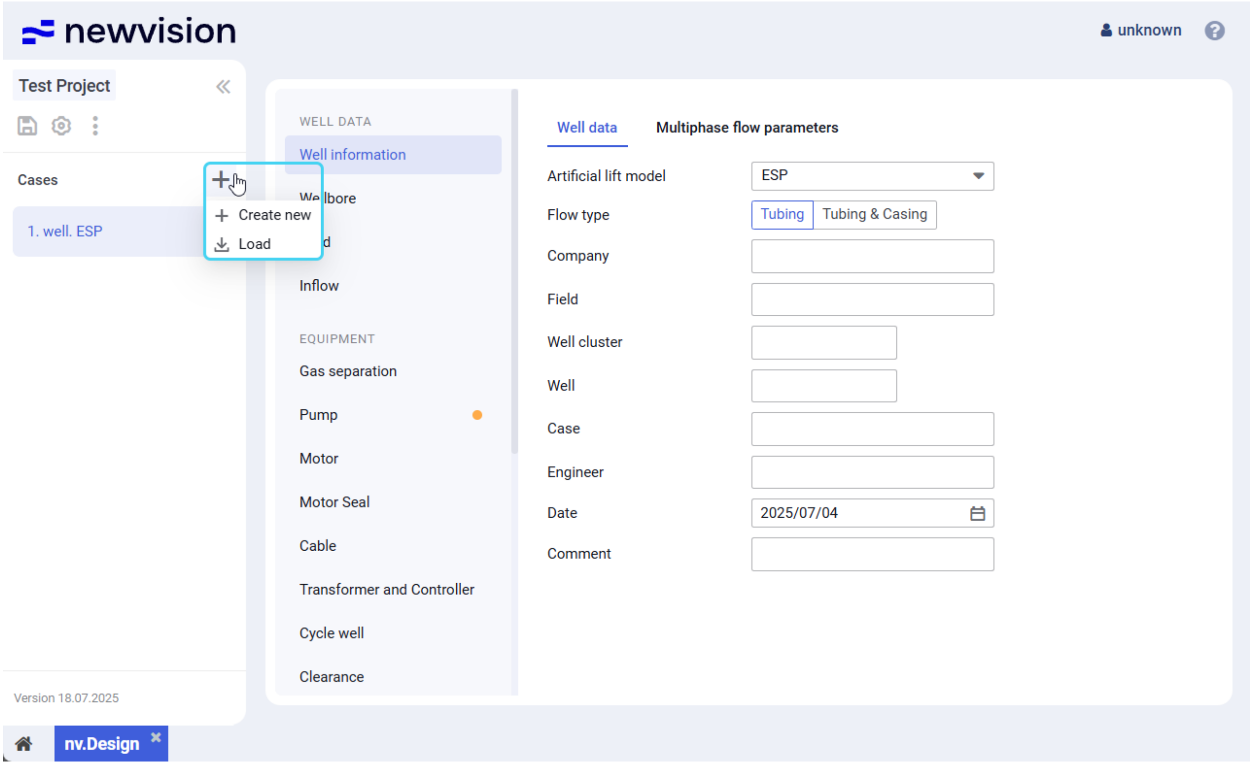
You can add more cases by creating them, copying existing ones, or importing from JSON files stored locally.

3.5.1. Creating New Cases

To create a new case from scratch, perform the following actions:

1. Open the **nv.design** module.
   For details on navigation in the system, see System Interface.

2. In the pane located in the left part of the module, in the **Cases** area, click **Add (+)**, and then select **Create new (+)** from the drop-down menu.



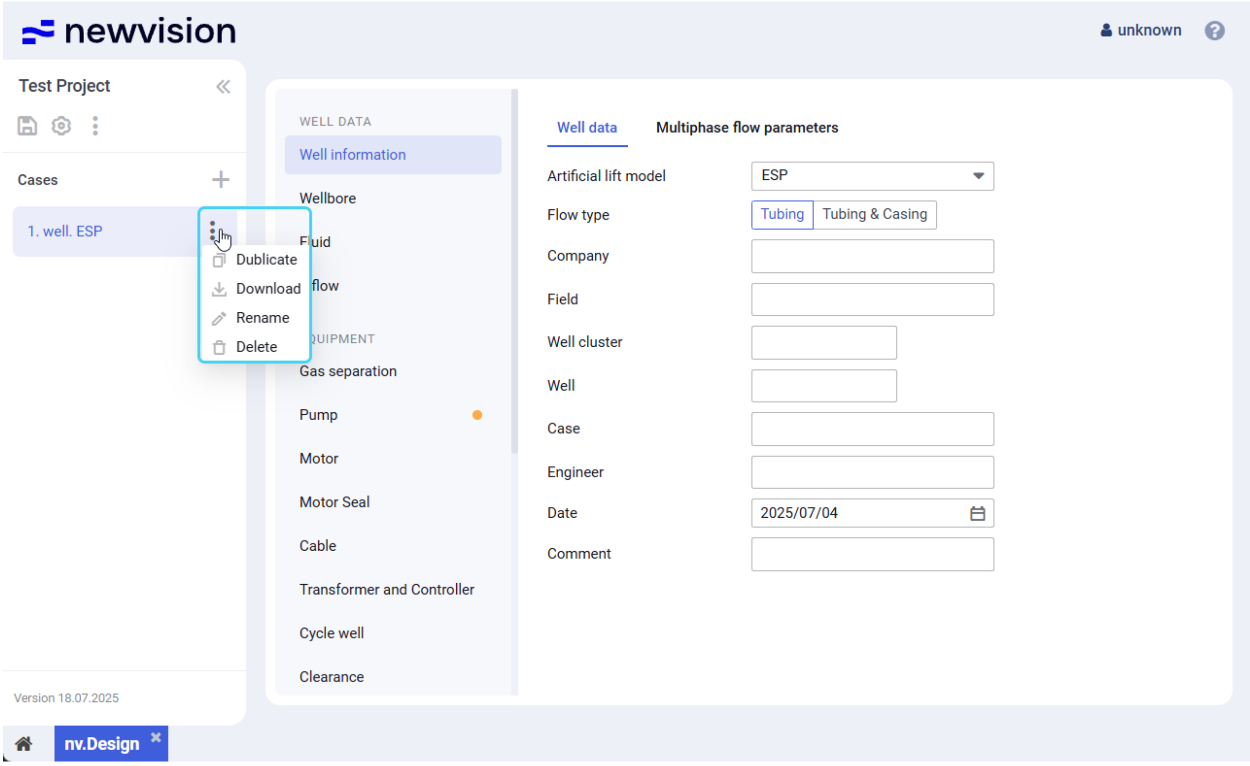
3. In the window that appears, enter a name for the new case.
4. Proceed to configuring the well design parameters in the module sections. For details, see Well Design Parameters.
5. After the configuration is completed, in the left part of the module, click **Save (🖫)** under the name of the current project.

3.5.2. Copying Existing Cases

To create a new case by copying an existing one, perform the following actions:

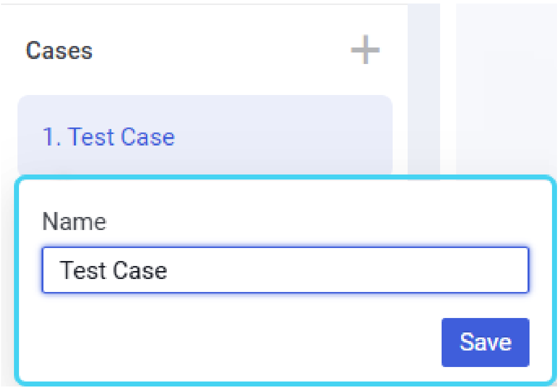
1. Open the **nv.design** module.
   For details on navigation in the system, see System Interface.
2. In the pane located in the left part of the module, in the **Cases** area, hover over the name of the case that you want to copy, and then, in the right part of the

row, click the three dots icon **(⋮)** and select **Duplicate ( )** from the drop-down menu.



A copy of the selected case appears in the list.

3. (*Optional)* To rename the copied case, perform the following actions:
   a. Hover over the created case and click the three dots icon **(⋮)**.
   b. From the drop-down menu, select **Rename ( )**.



   c. In the window that appears, enter a new name for the case and click **Save**.

Note

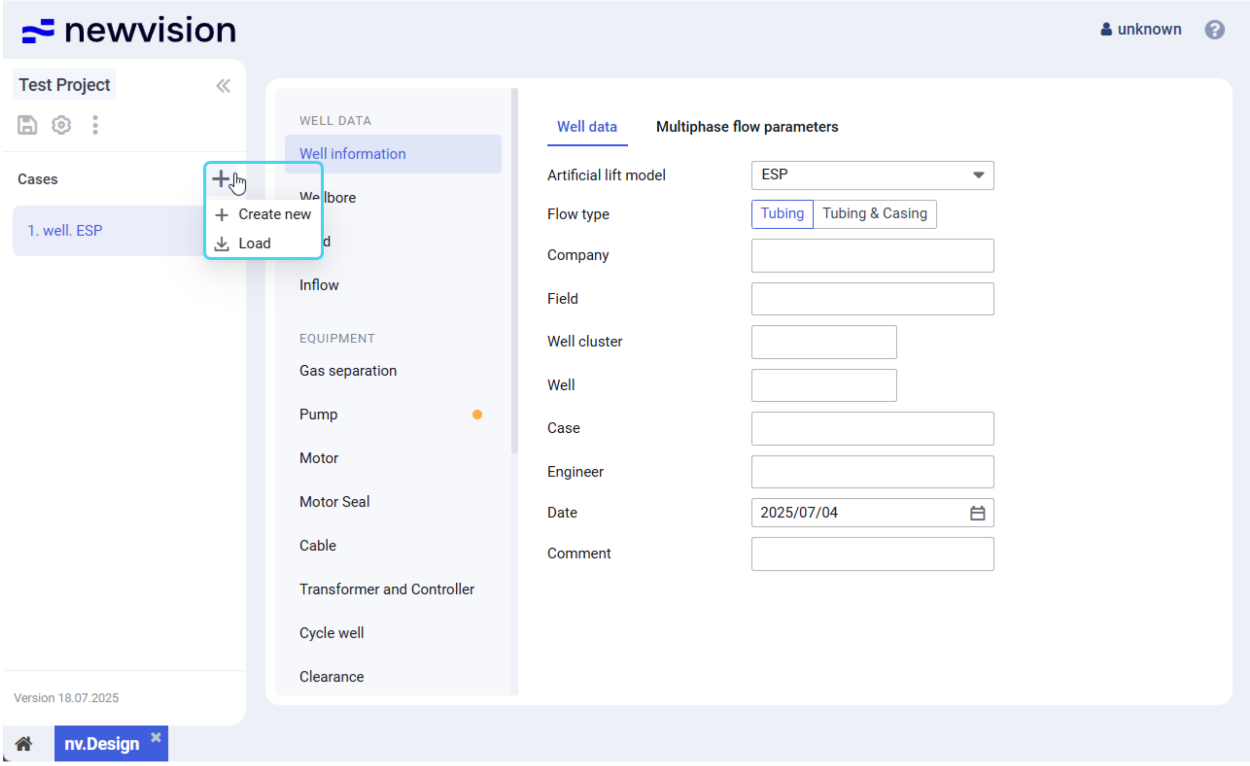
Alternatively, you can change the case name in the **Well information** section, on the **Well data** tab. For details, see Well Data.

4. Proceed to configuring the well design parameters in the module sections. For details, see Well Design Parameters.
5. After the configuration is completed, in the left part of the module, click **Save ( )** under the name of the current project.

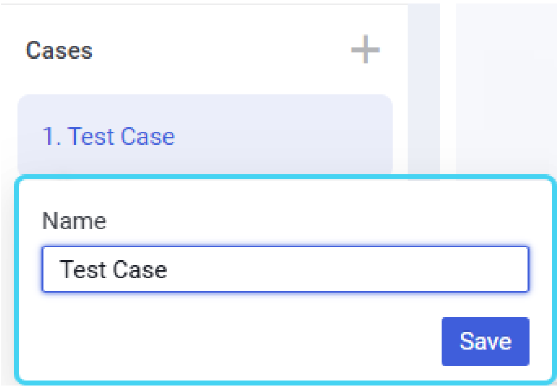
3.5.3.Importing Cases

To import a case from a file in the JSON format stored locally, perform the following actions:

1. Open the **nv.design** module.
   For details on navigation in the system, see System Interface.
2. In the pane located in the left part of the module, in the **Cases** area, click **Add (+)**, and then select **Load (+)** from the drop-down menu.



3. In the file explorer window, select the JSON file with the project you want to import.
   The imported case appears in the list.
4. (*Optional)* To rename the copied case, perform the following actions:
   a. Hover over the created case and click the three dots icon **(⋮)**.
   b. From the drop-down menu, select **Rename (** ✎ **)**.



c. In the window that appears, enter a new name for the case and click **Save**.

Note

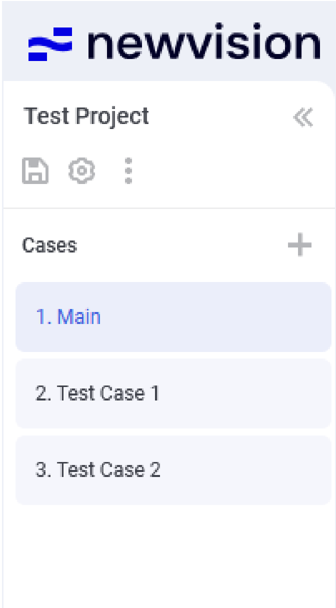
Alternatively, you can change the case name in the **Well information** section, on the **Well data** tab. For details, see Well Data.

5. Proceed to configuring the well design parameters in the module sections. For details, see Well Design Parameters.
6. After the configuration is completed, in the left part of the module, click **Save ( )** under the name of the current project.

4. nv.design Interface

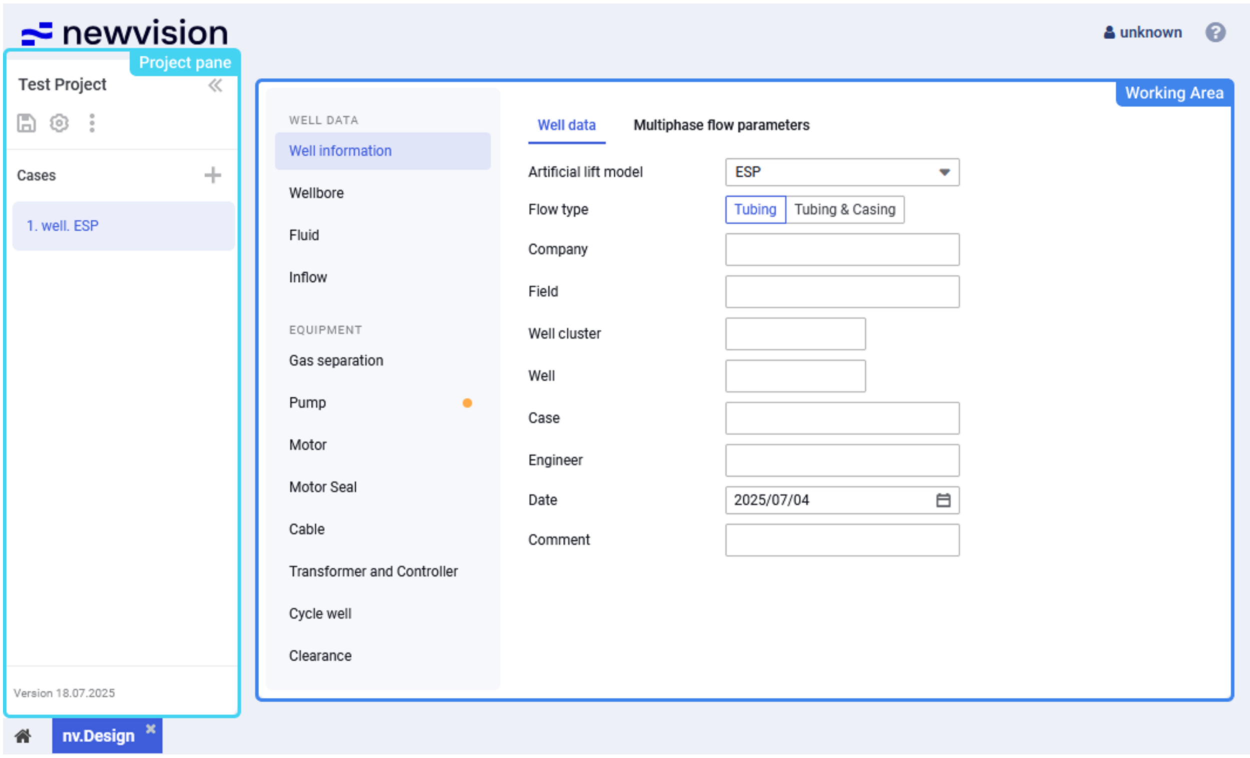
In the **nv.design** module, well design entities are called projects and cases.

A project acts as a folder containing multiple cases, with each case representing a single design version (scenario). A project can consist of up to 10 cases.



The **nv.design** module interface consists of the following parts:

- Project pane in the left part of the module.
  For details on creating, importing, and opening projects, see Getting Started.
- Working area in the central part of the module.



4.1. Project Pane

The project pane in the left part of the module provides controls for managing projects and cases. It consists of the following parts:

- Project controls at the top.
- **Cases** area in the center.
- Module version at the bottom.

You can collapse the pane to a smaller size by clicking the double arrow icon («) in its upper-right corner.

Project Controls

At the top of the project pane, the name of the currently open project is displayed. By clicking it, the **Projects** window opens. In this window, you can see the status of the current project, and manage all projects that were added to the module. For details, see Project Catalog.

Below the current project name, the following controls for managing the project are located:

Save ( )

Saves changes made to the current project.

Important

If the project is not saved, changes to its parameters and all the cases within it will be lost on closing the module, switching to another project, or refreshing the webpage.

Units ( )

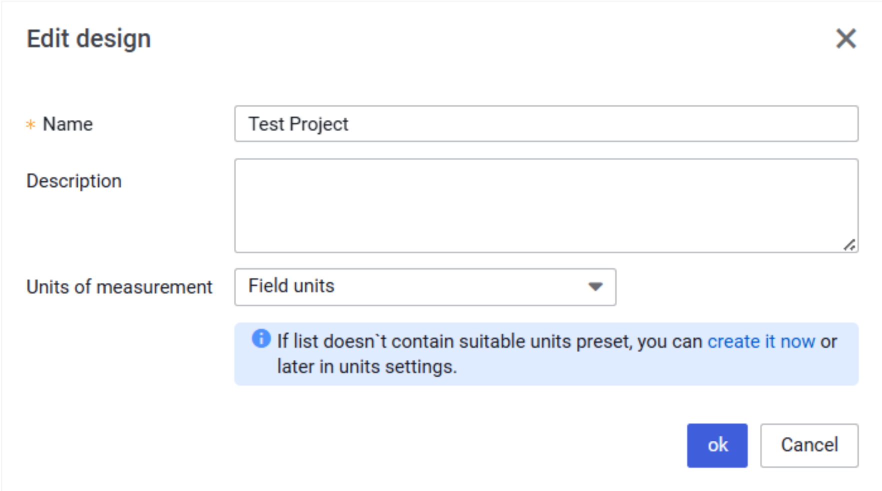
Opens the window for configuring measurement units for the project. For details, see Unit Selection.

Action menu ( )

Provides access to the following project controls:

- **Duplicate ( )**: Creates a copy of the current project.
  The created copy appears in the project catalog. For details, see Project Catalog.
- **Download ( )**: Exports the project to a file in the JSON format.

- **Update (✎)**: Provides the ability to edit the name, description, and/or measurement unit system of the project in the window that appears.



- **Delete (🗑)**: Deletes the project.

Cases

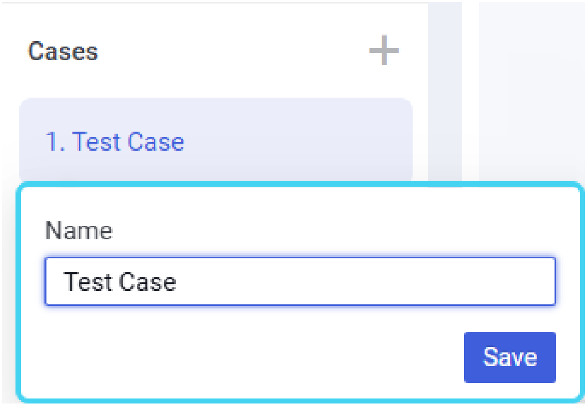
The pane contains a list of the cases created in the project and controls for managing them.

To open a case, click its name in the list.

To add a case, in the upper-right corner of the pane, click **Add (+)** and select the desired option: **Create (+)** or **Load ( )**. For details, see Creating Cases.

On hovering over a case in the list, in the right part of the corresponding row, the three dots icon (⋮) appears. It provides access to the action menu with the following options:

- **Duplicate ( )**: Creates a copy of the current case.
  The created copy appears in the list.
- **Download ( )**: Exports the case to a file in the JSON format.
- **Rename ( )**: Provides the ability to edit the name of the case in the window that appears.



- **Delete ( )**: Deletes the case.

Important
To save changes made to the cases, at the top of the window, click **Save ( )**.

Module Version

The current module version is displayed at the bottom of the project pane.

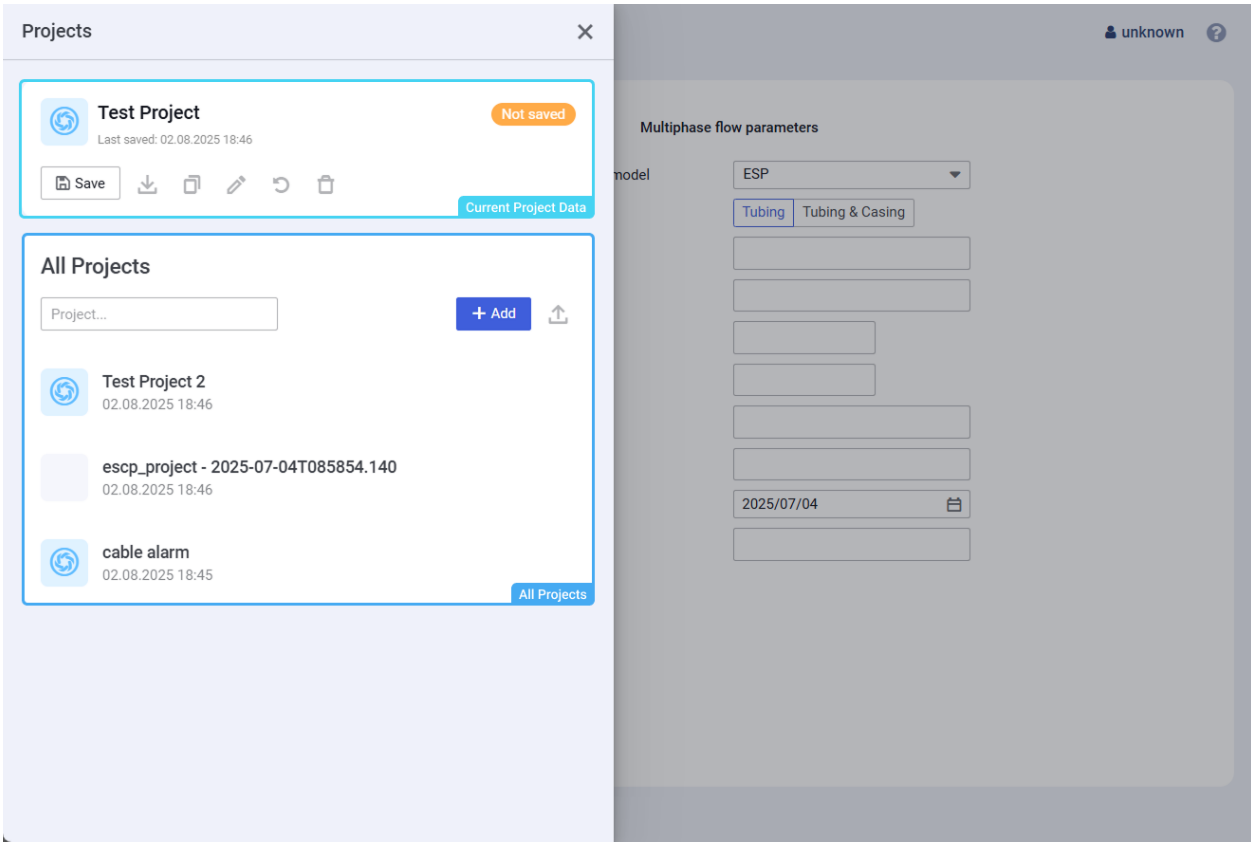
By clicking it, you can open the **Release Notes** window with information about the past and future releases. For details, see Release Notes.

4.2. Project Catalog

The **Projects** window provides access to all projects existing in the **nv.design** module.

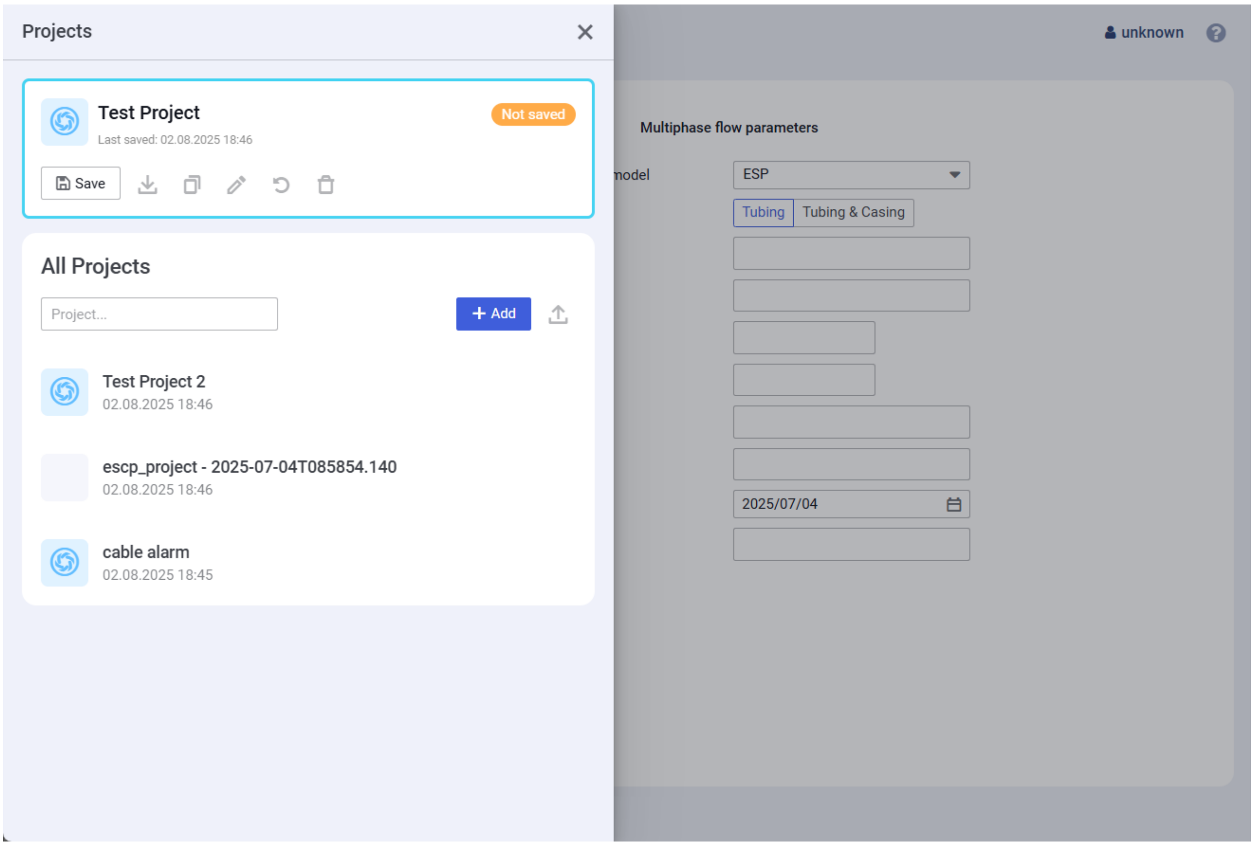
The window is divided in two parts:

- Current project data in the upper part of the window.
- **All Projects** area in the central part of the window.



Current Project Data

The area provides information and controls for managing the project that is opened at the moment.



At the top of the area, the name of the current project is displayed, along with the date and time of the last project save. On the right, the status of project changes is shown: **Saved** or **Not saved**.

Below, the following controls are available:

Save ( )

Saves the changes made to the project.
After saving, the project status changes to **Saved**.

Download ( )

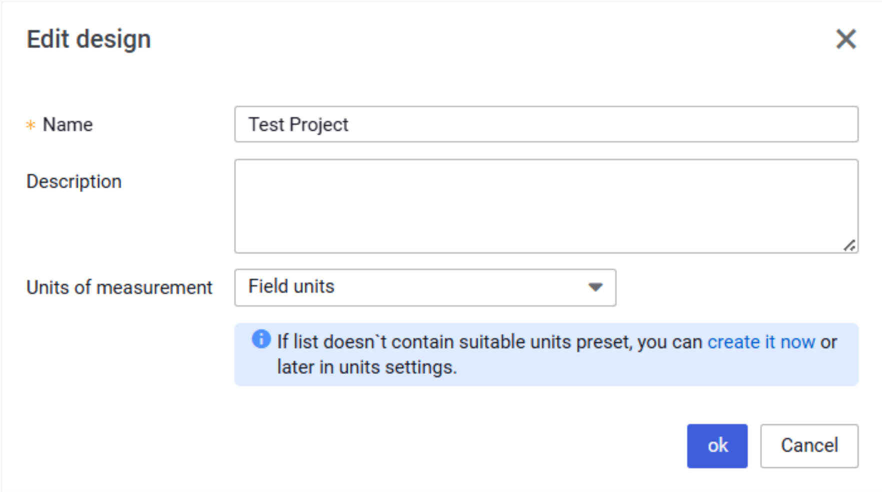
Provides the ability to export the project to a file in the JSON format.
For details on importing projects, see [Importing Projects].

Duplicate ( )

Creates a copy of the current project.
The created copy appears in the list in the **All projects** pane.

Update ( )

Provides the ability to edit the name, description, and/or measurement unit system of the project in the window that appears.



Reset unsaved changes ( )

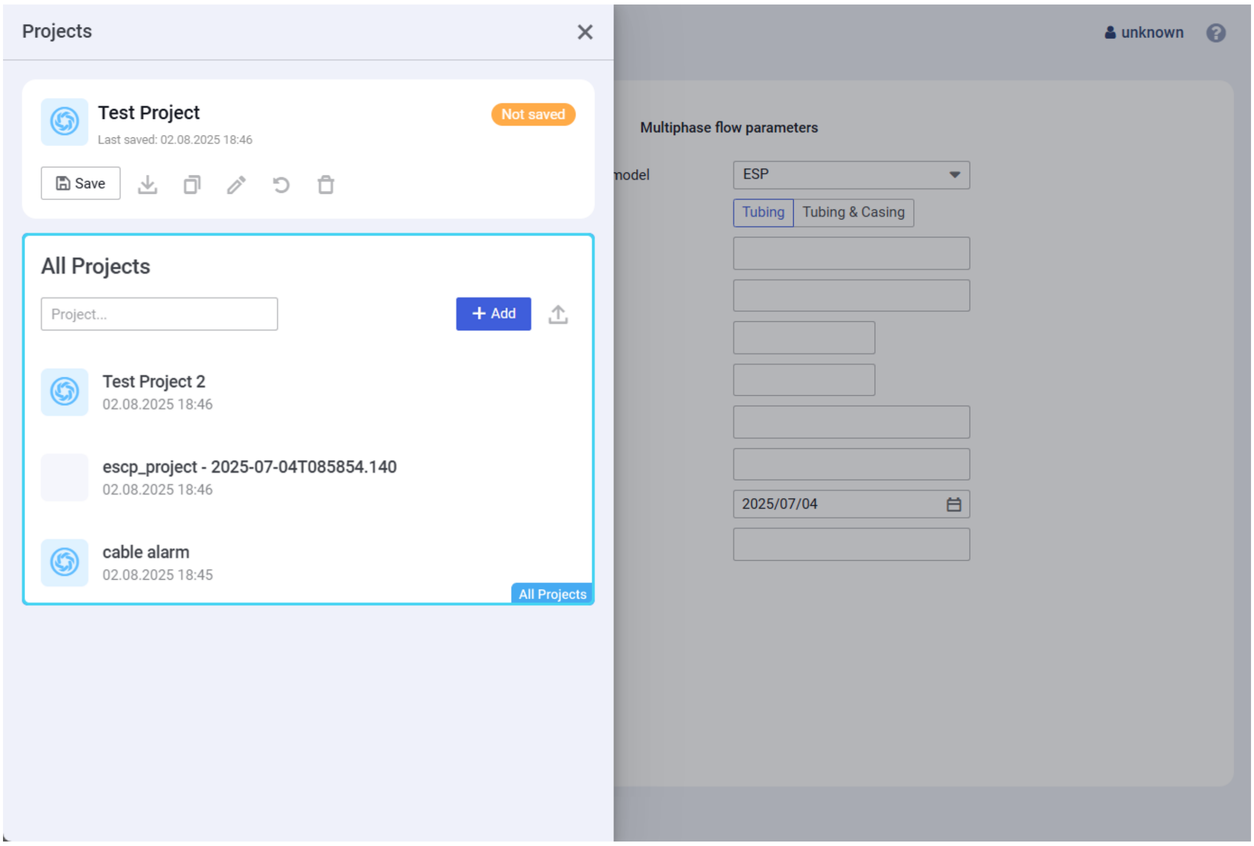
Reverts the project to its state at the time of the last save. All unsaved changes are discarded.

Delete ( )

Deletes the project and all cases within it.

All Projects

The area contains a list of all projects existing in the module and provides controls for their managing.



To open a project, click its name in the list.

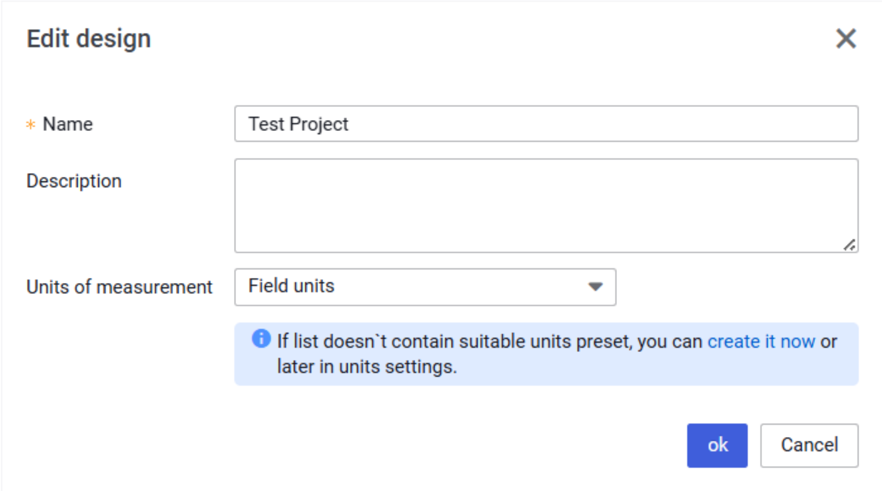
You can search for a project by typing its name or a part of it in the search field at the top of the area.

In the upper-right corner of the area, the **Add (** + **)** and **Upload (** ⇪ **)** buttons are available. Using them, you can create a new or import an existing project in the JSON format. For details, see Creating Projects and Importing Projects.

On hovering over a project in the list, in the right part of the corresponding row, the three dots icon (⋮) appears. It provides access to the action menu with the following options:

- **Duplicate (** ⧉ **)**: Creates a copy of the current project.
  The created copy appears in the list.

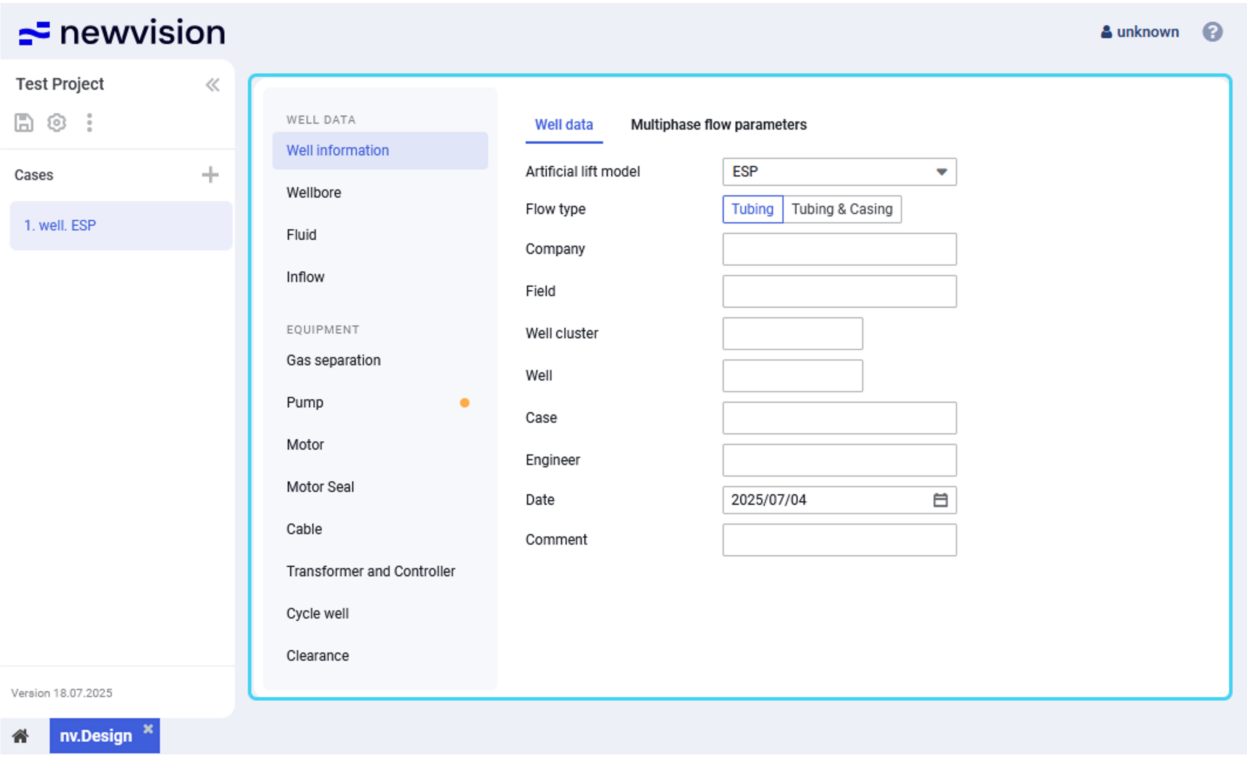
- **Update (✎)**: Provides the ability to edit the name, description, and/or measurement unit system of the project in the window that appears.



- **Delete (🗑)**: Deletes the project and all cases within it.

4.3. Working Area

The working area content depends on the section selected in its left part. For details on each of the sections, see Well Design Parameters.



4.4. Unit Selection

By default, in the **nv.design** module, two systems of measurement units are available:

- **Field units** (US oilfield units)
- **SI units** (metric units)

Measurement system is selected at the stage of project creation. For details, see Creating Projects and Importing Projects.

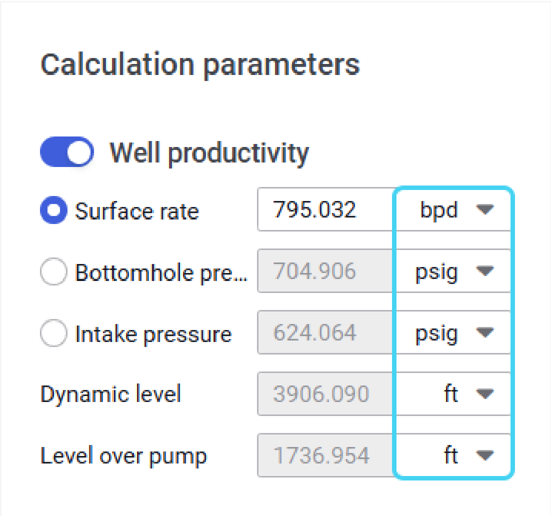
However, you can change the measurement system after a project is created in one of the following ways:

- Change other measurement units for specific parameters
- Select another measurement system for the entire project
- Configure a custom set of units

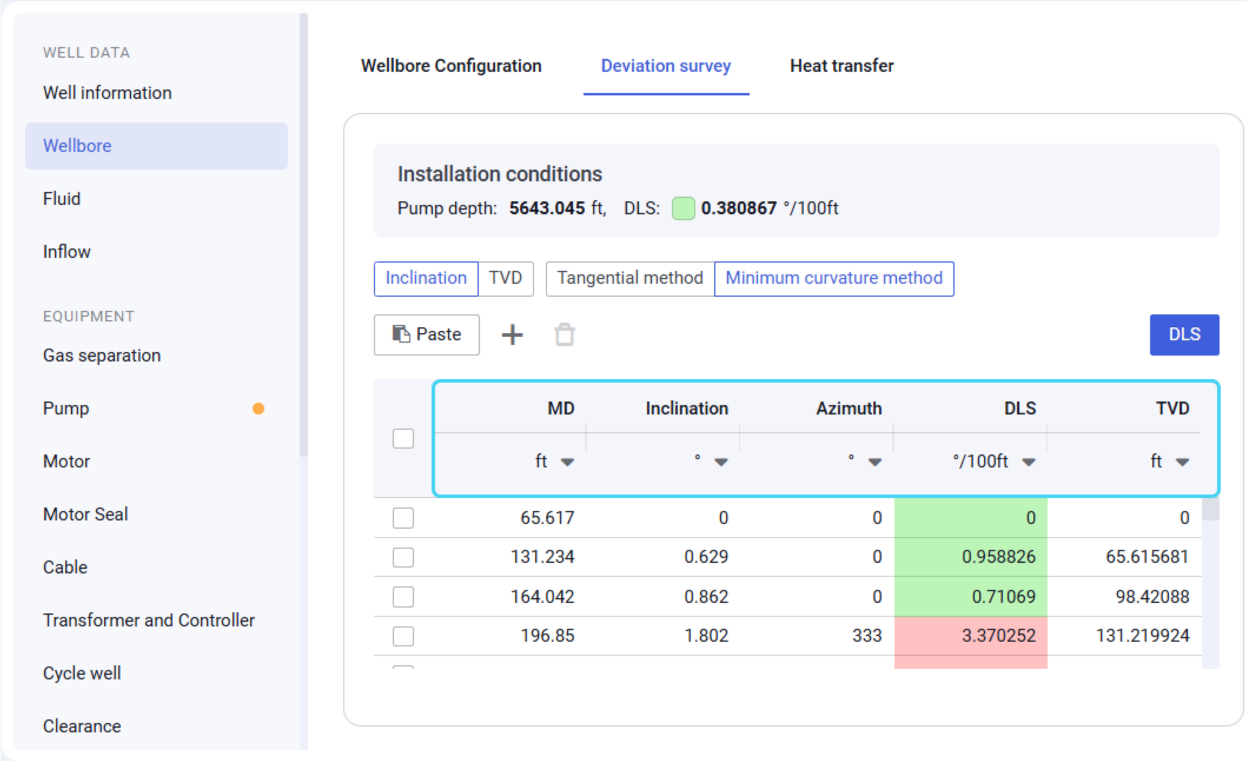
4.4.1.Changing Measurement Units for Specific Parameters

Most **nv.design** sections provide the ability to select another unit of measurement for specific parameters. For details on the module sections, see Well Design Parameters.

To change the measurement unit for a specific parameter, to the right of the field with the parameter value, click the current unit of measurement and select the desired option from the list.



In some tables, units can be changed from the column header.



After you change units for at least one parameter, a red marker (●) appears on the **Units (⚙)** button in the upper-left corner of the module. It indicates that there are changes made to the measurement units.

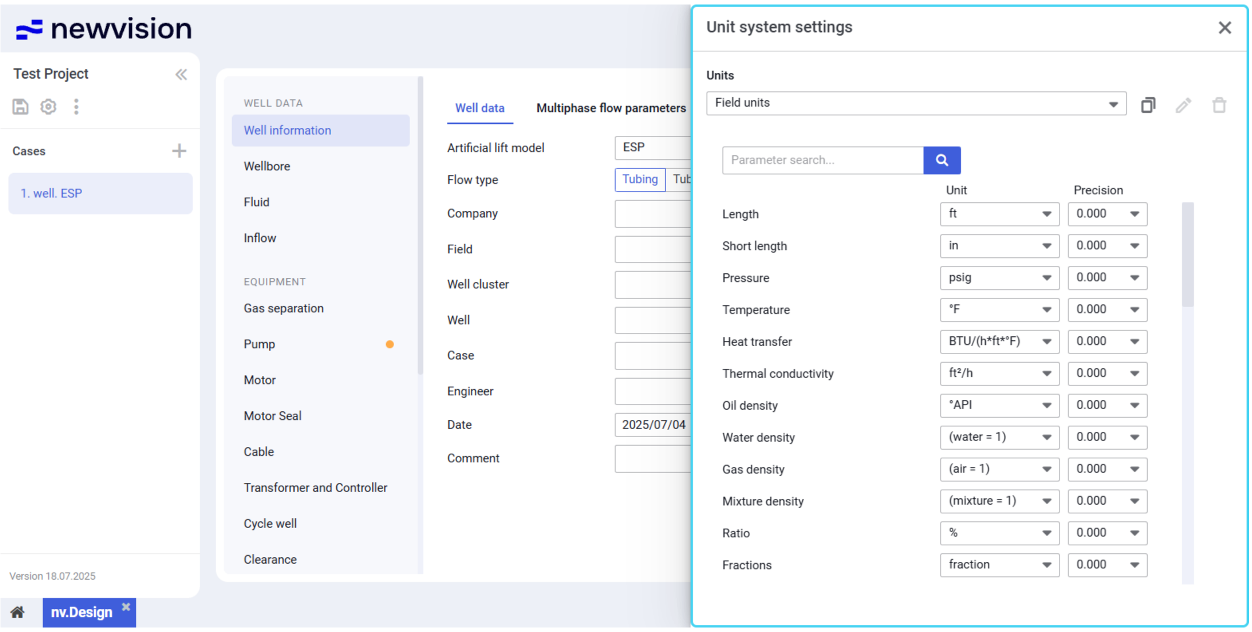
If the unit change is permanent, it is recommended to save the modified measurement system as a custom set. For details, see Configuring Custom Set of Units.

4.4.2.Selecting Another Measurement System for Entire Project

After the project is created, you can change the measurement system selected at the creation stage.

To do this, open the desired project and perform the following actions:

1. In the upper-left corner of the **nv.design** module, click **Units (** ⚙ **)**.
   The **Unit system settings** window opens in the right part of the module.



2. At the top of the window, under the **Units** heading, select the desired measurement system from the list.
3. Close the window by clicking the cross icon (✕) in its upper-right corner.

4.4.3.Configuring Custom Set of Units

nv.design provides the ability to configure custom sets of measurement units. This feature is helpful when the well design requires using units from different measurement systems with different precision for various parameters.

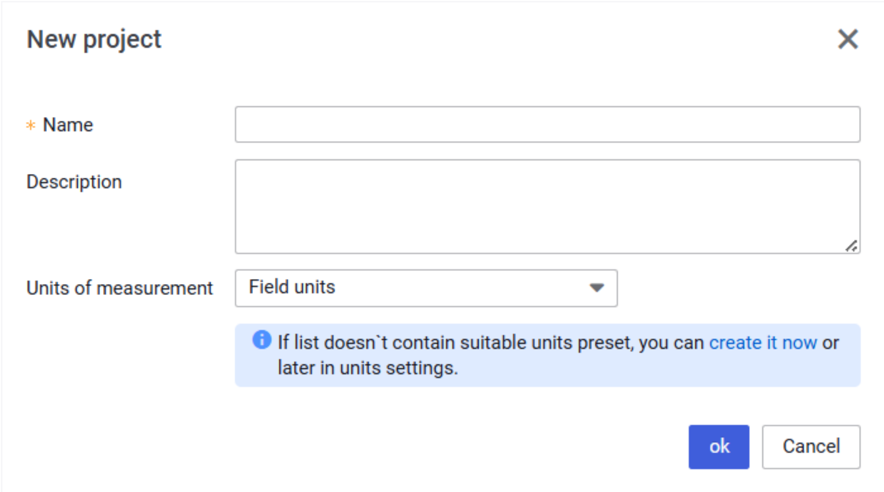
You can create a custom set of units:

- Upon creating or importing a project
- While working on an existing project

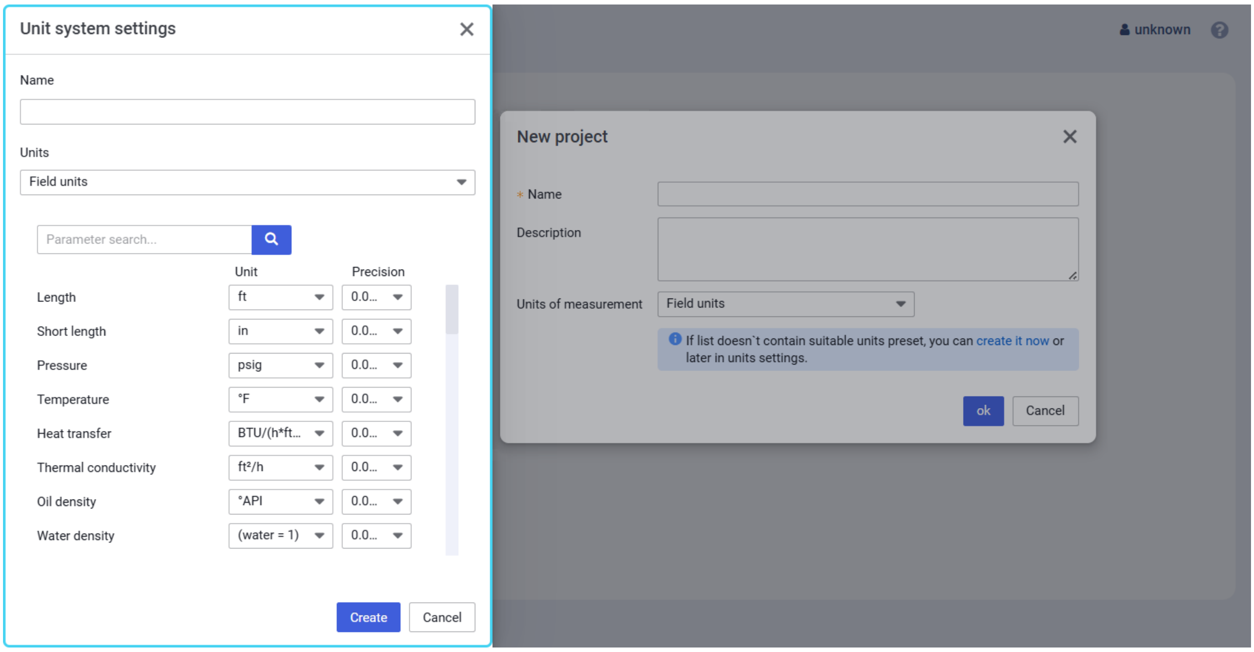
4.4.3.1. Configuring Custom Set of Units on Project Creation or Import

To configure a custom set of units on creating or importing a new project, perform the following actions:

1. In the **New project** window, click **create it now** under the list of available unit systems.



The **Unit system settings** window opens in the left part of the module.



2. In the **Unit system settings** window, perform the following actions:
   a. At the top of the window, in the **Name** field, enter the name for the new set of units.
   b. *(Optional)* From the **Units** list, select an existing unit system based on which you want to create a new one.
   c. *(Optional)* Search for the parameter for which you want to select another measurement unit or its precision level by entering the parameter name or its part in the **Parameter search** field.

d. To the right of the desired parameter name, select the desired unit from the list in the **Unit** column.

e. To specify precision with which the parameter value will be displayed, in the **Precision** column, select the desired number of decimal places from the list.

> **Note**
>
> After you modify the measurement unit or precision level for at least one parameter, to the right of the corresponding lists, the **Reset ( )** button appears. Using it, you can reset values in both columns to their initial state.

f. At the bottom of the window, click **Create**.

The created set is automatically selected from the **Units** list.

> **Note**
>
> You can modify the created set or create a new one later, while working on an existing project. For details, see Configuring Custom Set of Units for Existing Project.

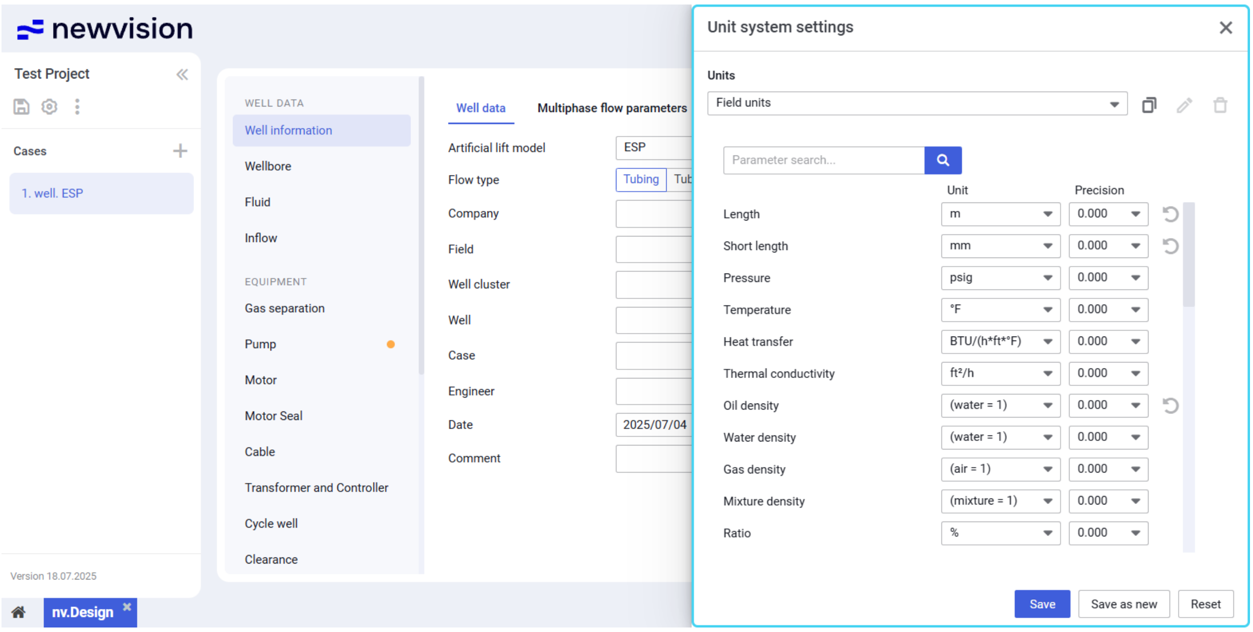
4.4.3.2. Configuring Custom Set of Units for Existing Project

To configure a custom set of units while working on a project, perform the following actions:

1. In the upper-left corner of the **nv.design** module, click **Units ( )**.

   The **Unit system settings** window opens in the right part of the module.

> **Note**
>
> If you have already altered measurement units for the desired parameters while working with the module sections, skip to **Step 6** of this procedure.



2. *(Optional)* From the **Units** list, select an existing unit system based on which you want to create a new one.

   Note

   You can also create a copy of an existing default or custom set of units by clicking **Clone ( )** to the right of the **Units** list.

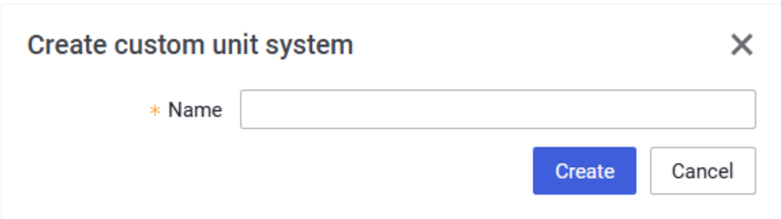
3. *(Optional)* Search for the parameter for which you want to select another measurement unit or its precision level by entering the parameter name or its part in the **Parameter search** field.
4. To the right of the desired parameter name, select a unit from the list in the **Unit** column.
5. To specify precision with which the parameter value will be displayed, in the **Precision** column, select the desired number of decimal places from the list.

Note

After you modify the measurement unit or precision level for at least one parameter, to the right of the corresponding lists, the **Reset ( )** button appears. Using it, you can reset values in both columns to their initial state.

6. Depending on the measurement system selected at **Step 2**, at the bottom of the **Unit system settings** window, perform one of the following actions:

   - *(For default systems)* Click **Save as new**, and then, in the window that appears, enter the name for the new set of units and click **Create**.

   - *(For custom sets)*
     - To save changes made to the set, click **Save**.
     - To save changes as a new set, click **Save as new**, and then, in the window that appears, enter the name for the new set of units and click **Create**.

   The configured set is automatically selected from the **Units** list and can be further used in other projects.

7. *(Optional)*

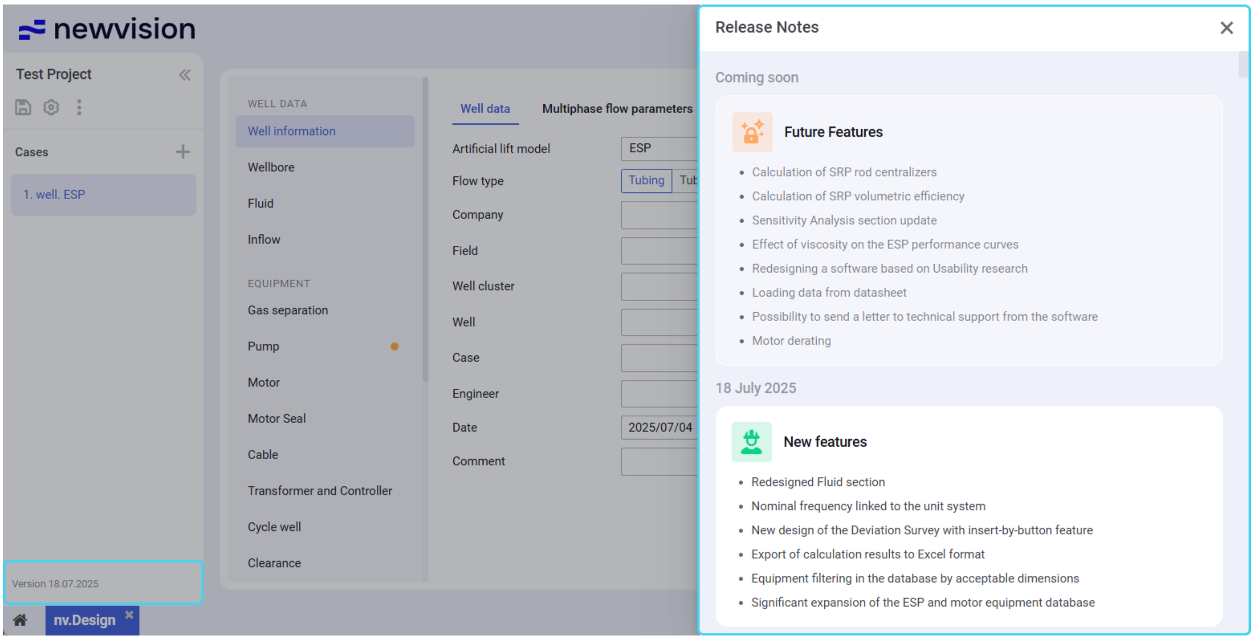
   - To rename a custom set, to the right of the **Units** list, click **Edit (✎)**.

   - To delete a custom set, to the right of the **Units** list, click **Delete (🗑)**.

4.5. Release Notes

In the **nv.design** module, you can view release notes that provide insight into the latest updates and features expected in upcoming releases.

To open the **Release Notes** window, click the name of the current version in the lower-left corner of the module.



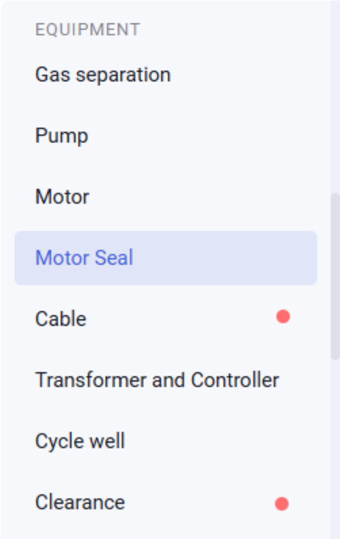
5. Well Design Parameters

Well design parameters in the **nv.design** module are distributed in sections that are organized in the following groups:

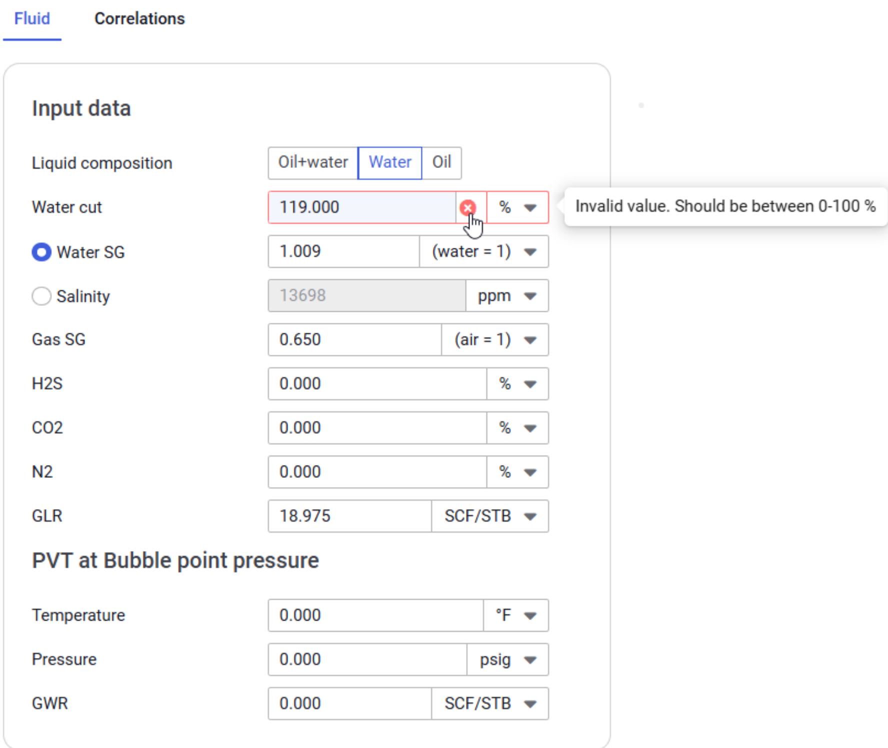
- Well Data
- Equipment
- Engineering Tools
- Reports

All the sections provide an error notification mechanism:

- A red marker (●) next to a section name or tab indicates that one or more values in the corresponding section or tab are incorrect. These are critical errors that must be resolved before proper well model operation is possible.

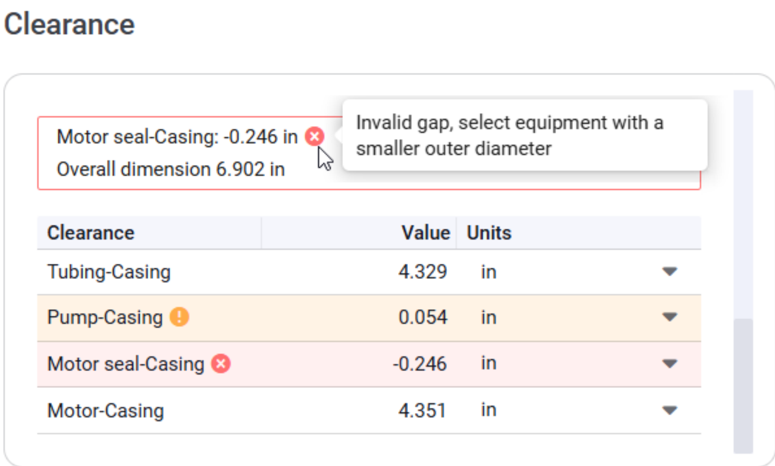


- Within the section, fields containing incorrect values are highlighted with a red border and an error icon (⊗). Hovering the cursor over the field displays an error message with details and recommendations for correction.



- An orange marker (●) next to a section name or tab indicates non-critical errors that should still be resolved to ensure calculation accuracy.

- In tables with calculated values, instead of a border, a cell fill of the corresponding color is used.



In some tables, the text color changes instead.

5.1. Well Data

The group consists of the following sections:

- Well Information
- Wellbore
- Fluid
- Inflow

Parameters in these sections do not depend on the well lift type and are essential for accurate calculations.

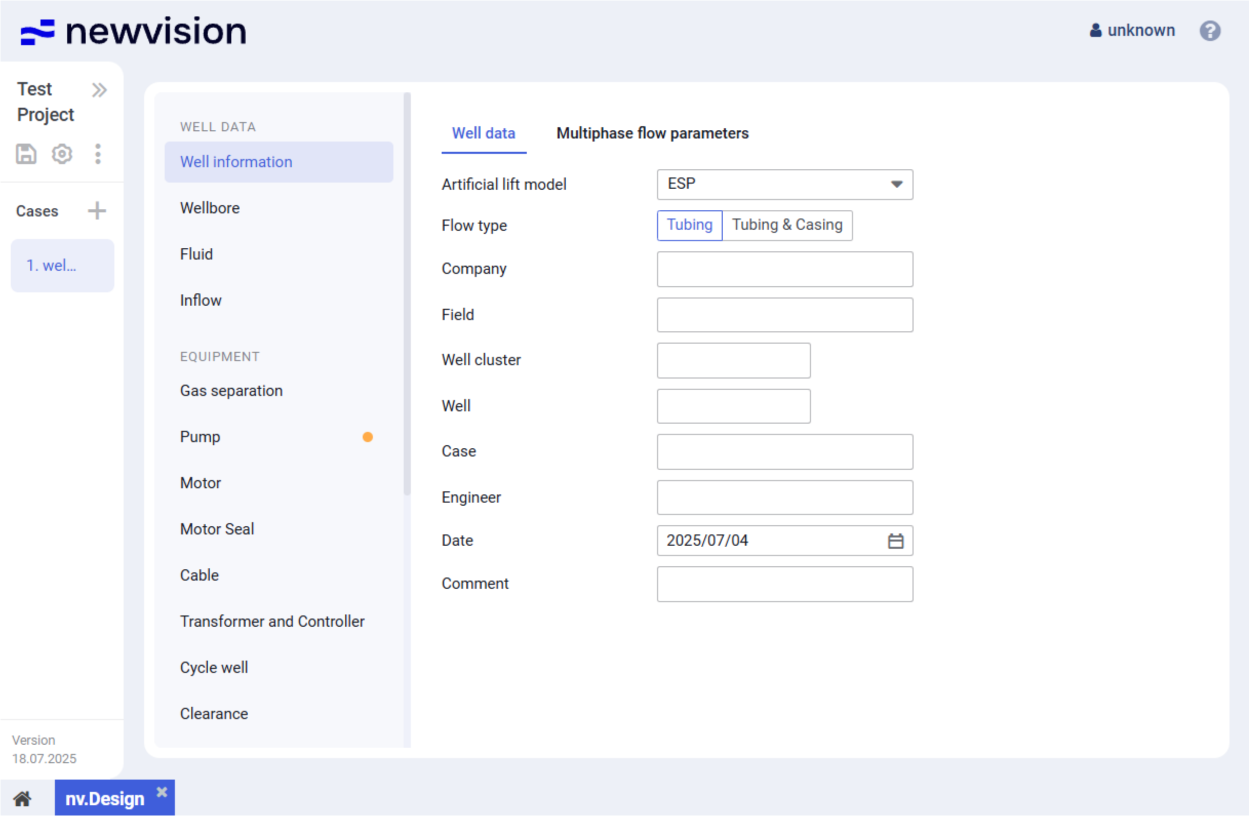
5.1.1. Well Information

The **Well information** section provides general information about the well. It consists of two tabs:

- Well data
- Multiphase flow parameters

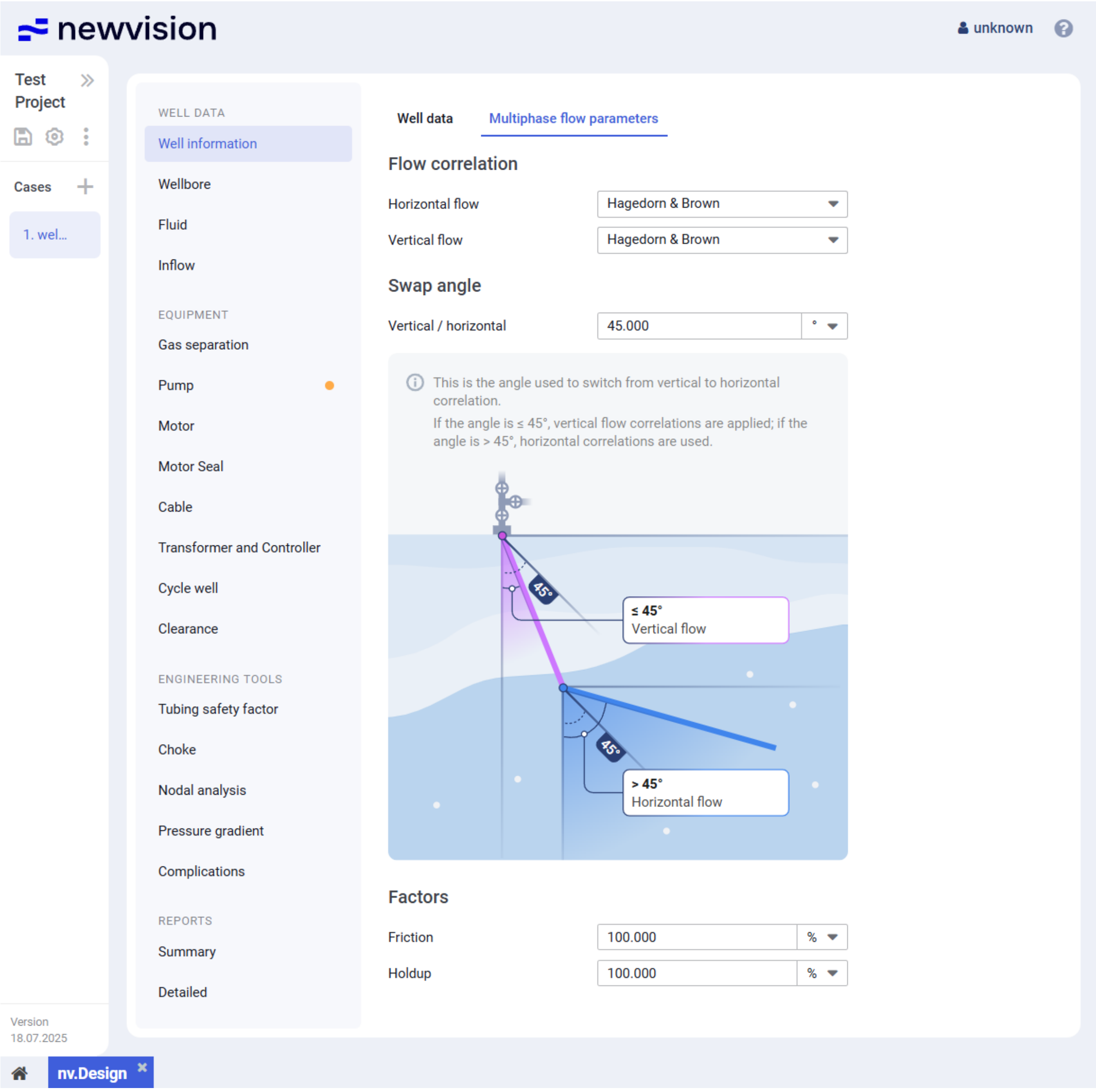
5.1.1.1. Well Data

On the **Well data** tab, you can select the well lift type and enter general information about the well, such as company name, field name, well number, etc.



5.1.1.2. Multiphase Flow Parameters

On the **Multiphase flow parameters** tab, you can select correlations used for the tubing multiphase flow and configure their application conditions.



The tab contains the following parameter groups:

- **Flow correlation**
- **Angle of transition between flows**
- **Factors**

Flow Correlation

In this group, you can select correlations that will be used for the horizontal and vertical flow calculations. For details on the available correlations, see Multiphase Flow Correlations.

Angle of Transition Between Flows

In this group, you can set the threshold inclination angle at which the system switches between horizontal and vertical flow correlations.

Below the field with the angle value, a simplified flow scheme is displayed. It visualizes horizontal and vertical flows and the selected transition angle.

> **Note**
> Switching between correlations is important because different flow regimes and pressure loss behaviors are observed depending on the pipe inclination. This automatic switch provides more accurate modeling of pressure losses and flow behavior in deviated and directional wells.

Factors

In this group, you can specify the friction and hold-up factors. They can be used to adjust pressure loss calculations in the wellbore:

- Friction factor affects frictional losses (ΔPf).
- Hold-up factor affects the hydrostatic gradient (ΔPa).

The total pressure loss is calculated using the following formula:

$$\Delta P = (\text{friction factor } \Delta Pf) + (\text{hold-up factor} \cdot \Delta Pa) + \Delta Pg$$

$$\Delta P = (\text{friction factor} \cdot \Delta Pf) + (\text{hold-up factor } \Delta Pa) + \Delta Pg$$

> **Note**
> This is a generalized formula. The exact formula for each component depends on the selected flow correlation.

The default value for both friction and hold-up factors is 100%. You can modify it in calibration and testing purposes.

5.1.1.2.1. Multiphase Flow Correlations

On the **Multiphase flow parameters** tab of the **Well information** section, the following multiphase flow correlations can be selected:

Moody

The Moody correlation is used to calculate friction factors and pressure losses in single-phase flows of gas or liquid, based on Reynolds number and relative pipe roughness. While it was originally developed for single-phase conditions, it is often

incorporated into multiphase models to estimate friction factors in each phase separately.
Typical data ranges:

- Temperature: 4°C – 177°C
- Pressure: 0.1 bar – 689 bar

Gray

The Gray correlation accounts for the influence of gas-liquid interaction in multiphase flow, specifically designed for pressure drop estimation in gas-lift operations and vertical wellbores. It is well suited for calculating bottomhole pressure and tubing performance where the gas-liquid ratio significantly affects flow behavior.
Typical data ranges:

- Temperature: 4°C – 150°C
- Pressure: 6.89 bar – 345 bar
- Gas-liquid ratio: Broad range typical for gas-lift systems

Poettmann-Carpenter

The Poettmann-Carpenter method was one of the first empirical models to incorporate the effects of two-phase flows in vertical wells. It estimates pressure losses in tubing based on flow rates and pipe dimensions, enabling basic evaluation of artificial lift performance and production behavior.
Typical data ranges:

- Temperature: 4°C – 177°C
- Pressure: 0.1 bar – 689 bar

Orkiszewski

The Orkiszewski correlation is widely applied in vertical multiphase flow modeling. It accounts for flow regime transitions (bubbly, slug, annular, segregated) and includes corrections for different flow patterns. This makes it valuable for pressure drop predictions in well design and production optimization.
Typical data ranges:

- Temperature: 4°C – 177°C
- Pressure: 0.1 bar – 689 bar

Griffith

The Griffith correlation is applied to vertical two-phase flows, particularly in wellbores. It considers gas-liquid interaction and offers a simplified method to calculate pressure losses based on mixture properties and flow regime assumptions.

Typical data ranges:

- Temperature: 4°C – 177°C
- Pressure: 0.1 bar – 689 bar

Duns & Ros

The Duns & Ros correlation evaluates pressure losses in vertical and inclined multiphase flow, accommodating various flow regimes including bubbly, slug, and annular. It provides accurate results for high gas-liquid ratio conditions that are often encountered in oil wells.

Typical data ranges:

- Temperature: 4°C – 177°C
- Pressure: 0.1 bar – 689 bar

Beggs & Brill

The Beggs & Brill correlation was developed for multiphase flows in pipelines with different inclination angles. It offers regime-specific calculations for pressure losses in horizontal, vertical, and inclined sections. This correlation is widely adopted due to its flexibility and applicability to field-scale models.

Typical data ranges:

- Temperature: 4°C – 177°C
- Pressure: 0.1 bar – 689 bar

Aziz

The Aziz model is designed for predicting multiphase pressure gradients in inclined and horizontal pipes. It captures complex gas-liquid interactions and adjusts for pipe angle, making it effective in pipelines and horizontal wellbores.

Typical data ranges:

- Temperature: 4°C – 177°C
- Pressure: 0.1 bar – 689 bar

Ansari

The Ansari correlation offers a mechanistic approach for predicting pressure drop, velocity, and flow distribution in vertical and inclined wells. It integrates flow regime transitions and detailed physical modeling to make it suitable for high-accuracy production system simulations.

Typical data ranges:

- Temperature: 4°C – 177°C
- Pressure: 0.1 bar – 689 bar

Hagedorn-Brown

The Hagedorn-Brown correlation is one of the earliest and most widely used models for vertical two-phase flows in oil wells. It enables reliable calculation of pressure losses based on well depth, fluid rates, and tubing diameter, serving as a benchmark for many commercial software implementations.

Typical data ranges:

- Temperature: 4°C – 177°C
- Pressure: 0.1 bar – 689 bar

5.1.2. Wellbore

The **Wellbore** section provides information about the downhole equipment, well profile, and heat transfer. It consists of three tabs:

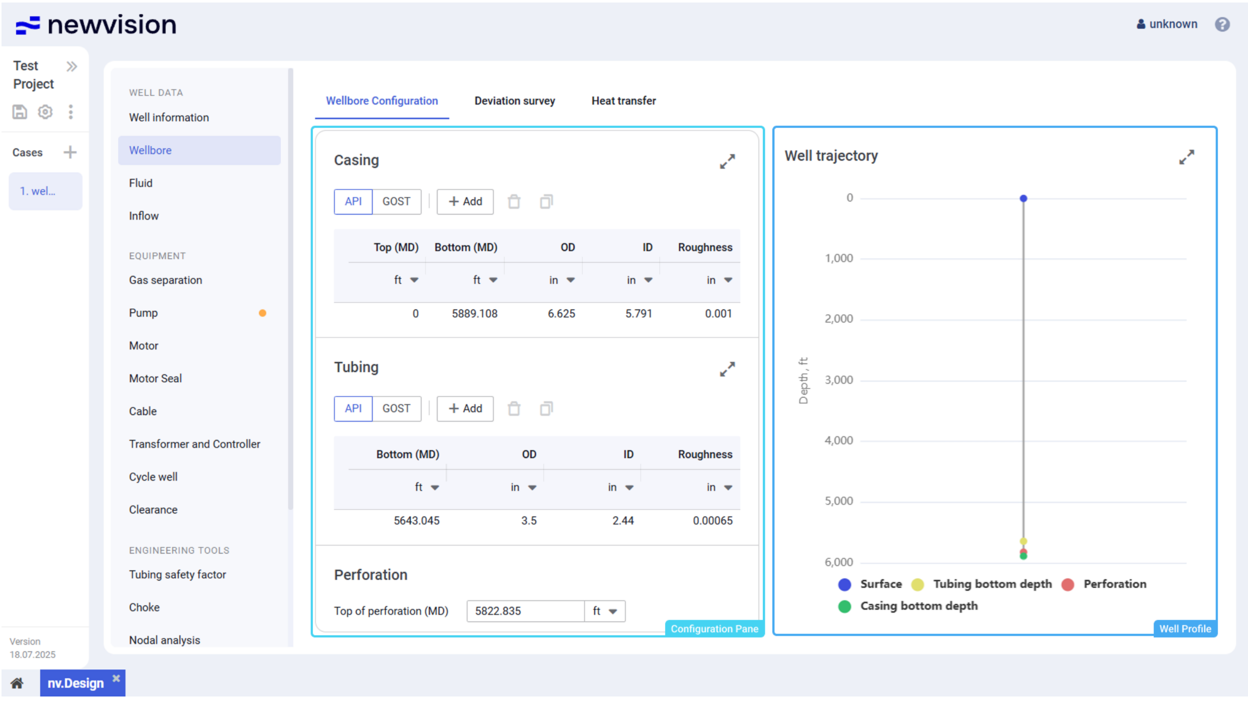
- Wellbore configuration
- Deviation survey
- Heat transfer

5.1.2.1. Wellbore configuration

On the **Wellbore Configuration** tab, you can configure tubing and casing parameters, such as their top and bottom depths (MD), number of stages, and diameters.

The tab consists of two panes:

- Configuration pane in the left part of the tab.
- Well profile in the right part of the tab.



Configuration Pane

The pane contains three groups of parameters: **Casing**, **Tubing**, and **Perforation**.

The **Casing** and **Tubing** groups contain tables with corresponding parameters. Each row in the table corresponds to one casing or tubing stage.

Both tables provide the following controls:

API/GOST

Provides the ability to select the set of standard pipe sizes, **API** (American Petroleum Institute standard) or **GOST** (Russian national standard), that prescribes the tubing and casing outer and inner diameters.

Add (+)

Adds a new row to the table for entering the casing or tubing stage parameters at the specified depth. For details, see Configuring Casing and Tubing Data.

You can enter data to the tables manually or paste it to a new row from another source using the Ctrl+V shortcut. The source table must have the same column configuration as the target one. The pasted entries are automatically sorted by depth. For example, you can try copying the data from the following table:

Top (MD)	Bottom (MD)	OD	ID
0	8690	7	6.276
8400	11320	4.5	3.92
0	7150	2.875	2.441

Note

The header row must not be copied from the source table.

Delete ( )

Deletes the selected row from the table.

Clone ( )

Creates a copy of the selected row.

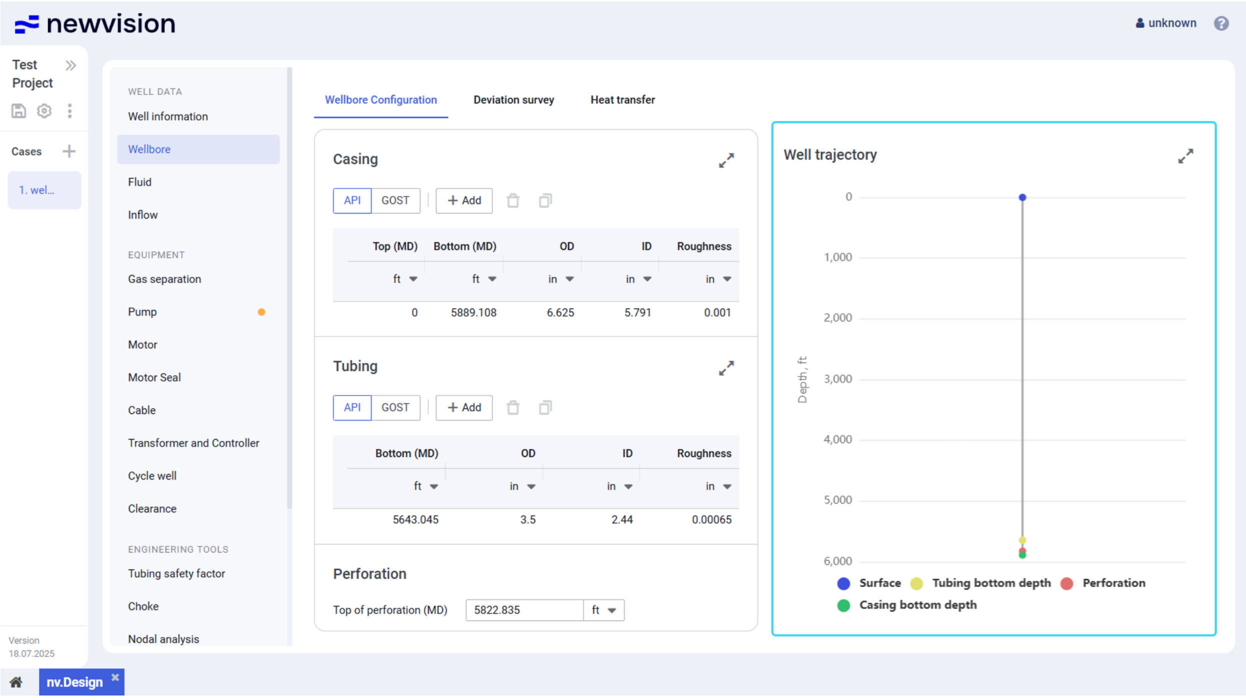
Expand ( ) / Collapse ( )

Expands the parameter group to full screen or collapses it back to the original size.

The **Perforation** group contains only one parameter, **Top of perforation (MD)**.

Well Profile

The pane contains the well profile that is built based on the data entered in the left part of the section (see description above).



On the profile, depths are displayed as markers of different color.

To show or hide a marker, click its name under the profile.

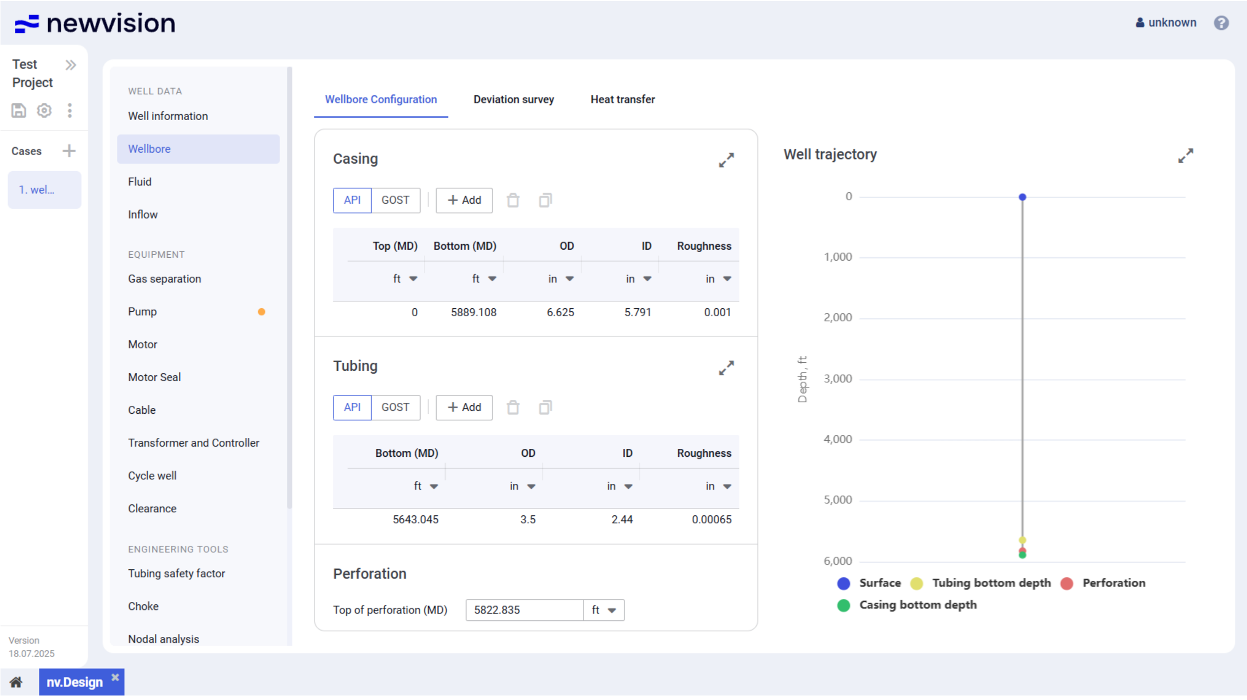
You can also expand the pane to full screen or collapse it back to the original size using the **Expand (** **)** / **Collapse (** **)** buttons located in the upper-right corner of the pane.

5.1.2.1.1. Configuring Casing and Tubing Data

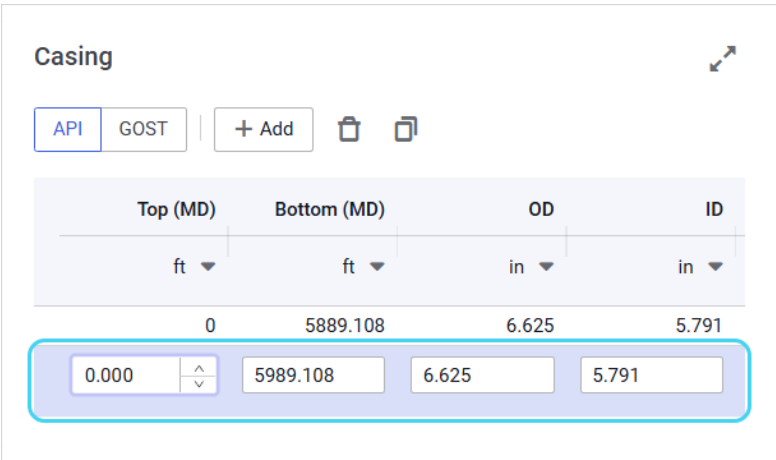
To configure the well tubing and casing parameters, perform the following actions:

1. Open the **nv.design** module.
   For details on navigation in the system, see System Interface.

2. In the left part of the working area, in the list of the module sections, click **Wellbore**.
   To the right of the list, the **Well Configuration** tab opens.



3. In the **Casing** parameter group, select the standard for outer and inner diameters of the casing: **API** or **GOST**.
4. Add new entries to the table. You can do it in the following ways:
   - To add a new entry, perform the following actions:
     a. Above the table, click **Add (+)**.
        A new row appears in the table.
     b. In the new row, double-click values in the **Top (MD)** and **Bottom (MD)** columns and enter the desired values.



     c. Double-click values in the **OD** and **ID** columns and select the desired outer and inner diameters from the lists.

- To create a copy of an existing entry, select the entry that you want to copy in the table, and then, above the table, click **Duplicate ( )**.
  The copied entry appears in the table.
- To paste a row with data from another table, copy it to the clipboard, select any entry in the table, and then press Ctrl+V.
  The copied entry appears in the table.

  Note
  The inserted data must contain numerical values only. If the data includes a row with NaN (not a number) values, delete them after insertion.

   Entries in the table are automatically sorted by the **Bottom (MD)** value.

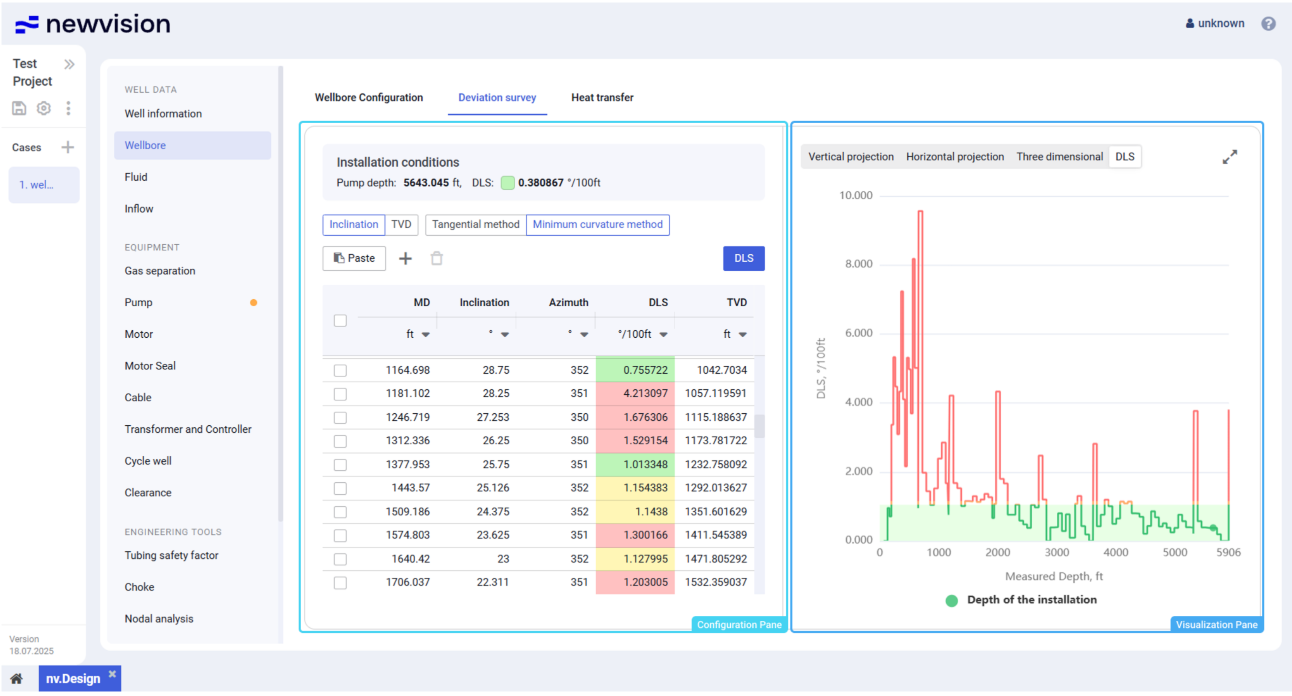
5. Repeat Steps 3–4 for the **Tubing** parameter group.
   In the right part of the **Well Configuration** tab, the well profile is displayed.
6. *(Optional)*
   - To edit an entry, double-click the desired value and make necessary changes.
   - To delete an entry, select it in the table, and then, above the table, click **Delete ( )**.
7. To save changes, in the left part of the module, click **Save ( )** under the name of the current project.

5.1.2.2. Deviation survey

On the **Deviation survey** tab, you can build vertical, horizontal, dogleg severity (DLS), and 3D projections of the well.

The tab consists of two panes:

- Configuration pane in the left part of the tab.
- Visualization pane in the right part of the tab.



Configuration Pane

The pane contains a table with the well directional survey data required for calculation. For details on how to enter the data and run a calculation, see <u>Running Deviation Survey Calculation</u>.

At the top of the pane, the installation conditions are displayed:

- **Pump depth** value equals the tubing bottom measured depth taken from the <u>Wellbore configuration</u> tab.
- **DLS** value corresponds to the dog leg severity at the pump setting depth. If there is no data for this very depth, the next available value is taken.
  The color of the square to the left of the DLS value indicates if it is feasible to install the pump at this depth: a green square means that the maximum **DLS** value is withing the allowable range, a red one means that the maximum allowable value is exceeded. This value can be configured in the **ESP depth setting determination** window. For details, see <u>Configuring DLS</u>.

Below the **Installation conditions** area, the following controls are available:

Inclination / TVD

Provides the ability to select the parameter based on which the calculation will be performed.
In the table, values of the selected parameter are entered manually. Values of the other parameter are calculated automatically.

Tangential method / Minimum curvature method

Provides the ability to select the calculation method:

- The **Tangential method** assumes constant inclination and azimuth between survey points. Is simpler but less accurate.
- The **Minimum curvature method** models the well as a smooth arc and provides higher accuracy, especially over longer intervals.

By default, the **Minimum curvature method** is used as it offers the most reliable results for most wellbore profiles.

Paste ( )

Pastes data from the clipboard to a new row in the table.
Alternatively, to paste data, you can use the Ctrl+V shortcut.

> **Note**
> The inserted data must contain numerical values only. If the data includes a row with NaN (not a number) values, delete them after insertion.

Add (+)

Adds a new row to the table for entering the deviation survey data. For details, see Running Deviation Survey Calculation.

Delete ( )

Deletes the selected rows from the table.
To select a row, select the corresponding check box in the leftmost column of the table.

DLS

Opens the **ESP depth setting determination** window where you can calculate the maximum allowable DLS values based on the ESP length and outer diameter. For details, see Configuring DLS.

In the table, values in the first three columns are editable. Values in the other two are calculated automatically.

In the **DLS** column, the following color indication is used based on the maximum allowable DLS:

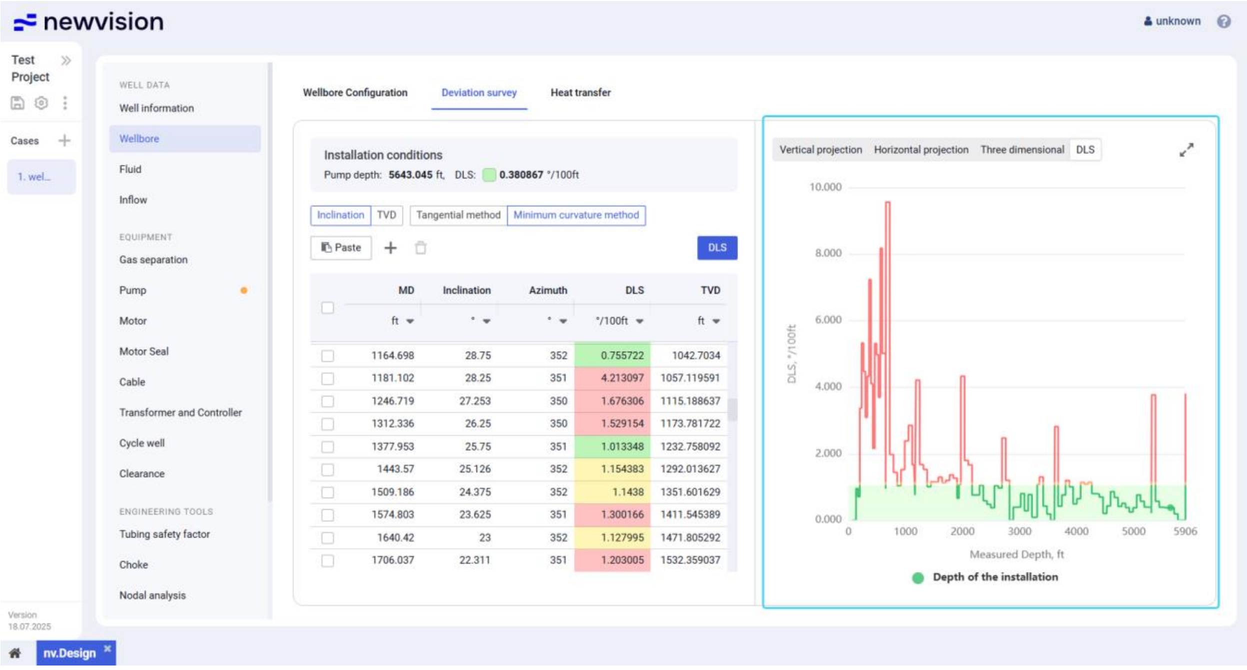
- Green fill: The value is well below the critical value and no actions are required.
- Yellow fill: The value is 0,89-0,9 of the critical value and requires attention.
- Red fill: The value is greater than the critical value and must be fixed.

Visualization Pane

The pane provides the following types of the well projections distributed on the corresponding tabs:

- **Vertical projection**
- **Horizontal projection**
- **DLS**
- **3D projection**

Important
Projections are displayed only if the deviation survey data table in the left part of the section does not contain errors.



On the **DLS** tab, sections suitable for equipment installation are highlighted with a green fill.

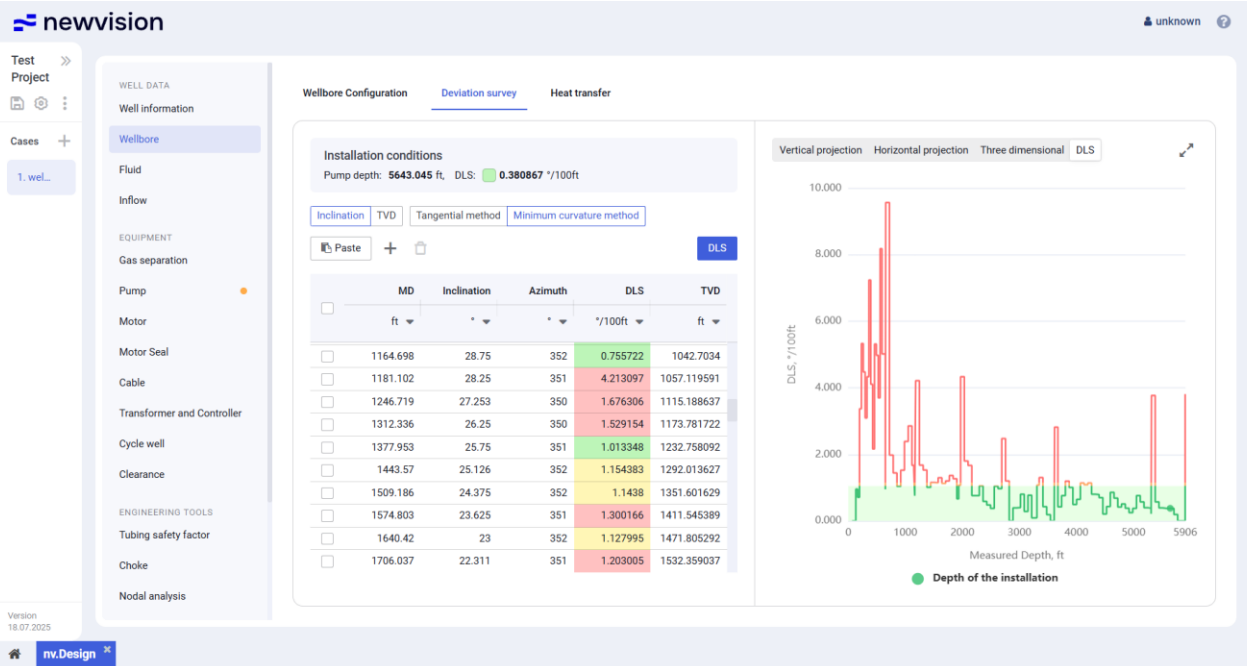
On other projections, depths are displayed as markers of different color.
To show or hide a marker, click its name under the profile.

You can also expand the pane to full screen or collapse it back to the original size using the **Expand (↗) / Collapse (↙)** buttons located in the upper-right corner of the pane.

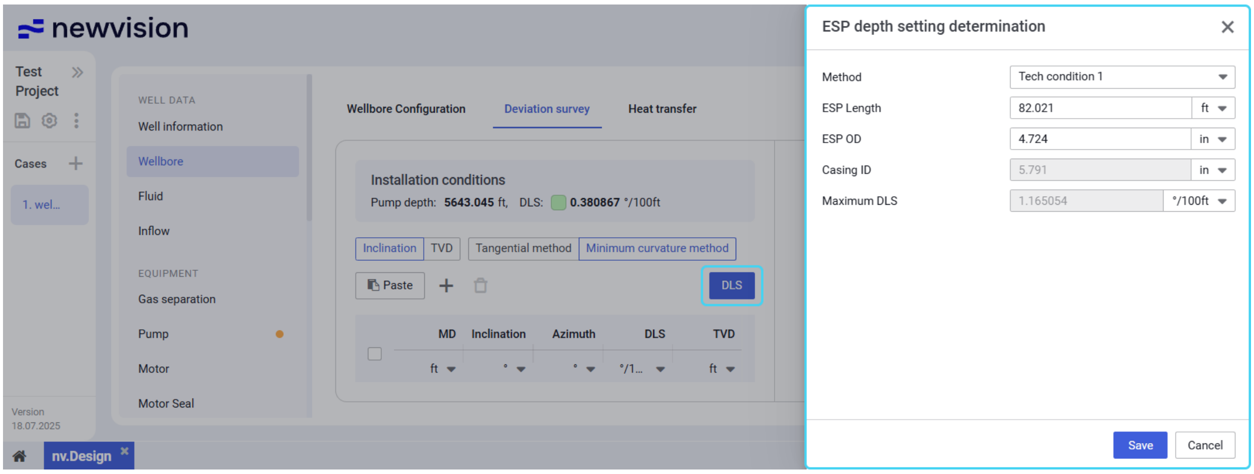
5.1.2.2.1. Configuring DLS

To configure the well tubing and casing parameters, perform the following actions:

1. Open the **nv.design** module.
   For details on navigation in the system, see System Interface.
2. In the left part of the working area, in the list of the module sections, click **Wellbore**, and then go to the **Deviation survey** tab.



3. At the top of the pane in the left part of the section, click **DLS**.
   The **ESP depth setting determination** window opens in the right part of the section.



4. In the window that appears, perform the following actions:
   a. From the **Method** list select the calculation method: **Tech Condition 1** (less strict) or **Tech Condition 2** (stricter).

b. *(Optional)* Edit values in the **ESP Length** and **ESP OD** fields.
   Values in the **Casing ID** and **Maximum DLS** fields are calculated automatically.

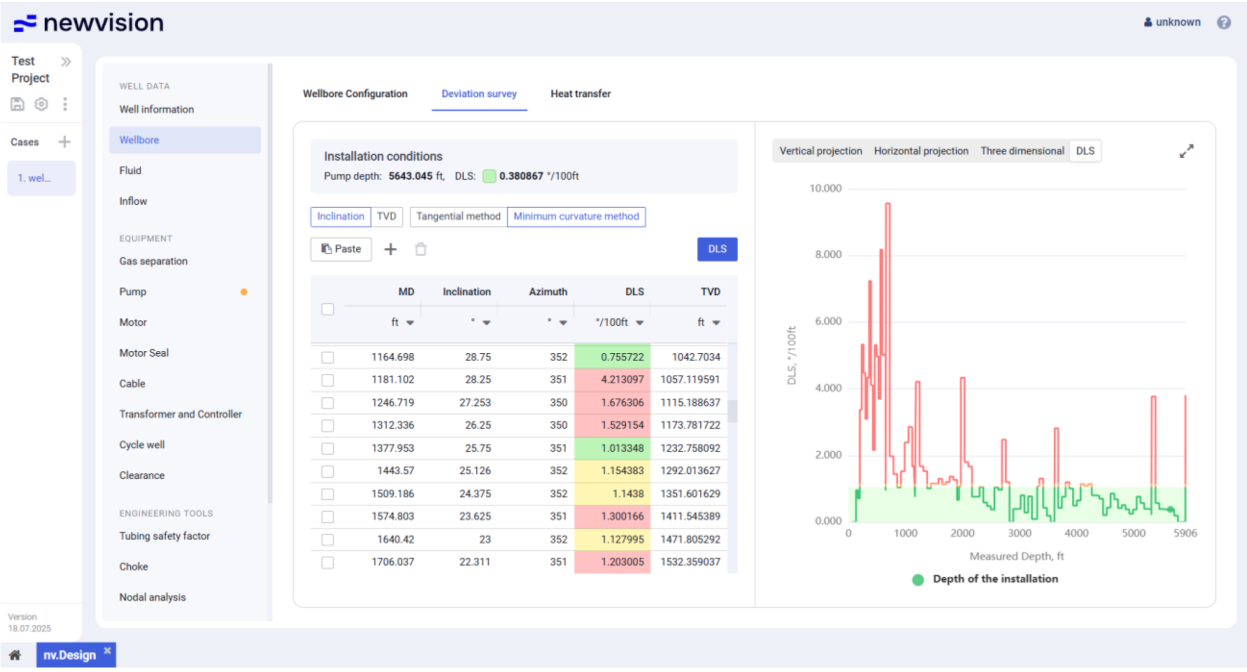
c. At the bottom of the window, click **Save**.

5. To save changes, in the left part of the module, click **Save (🖫)** under the name of the current project.

5.1.2.2.2. Running Deviation Survey Calculation

To configure deviation survey parameters and run a calculation, perform the following actions:

1. Open the **nv.design** module.
   For details on navigation in the system, see System Interface.
2. In the left part of the working area, in the list of the module sections, click **Wellbore**, and then go to the **Deviation survey** tab.



3. At the top of the pane in the left part of the section, select the parameter based on which the calculation will be performed: **Inclination** or **TVD**.

   ⓘ **Note**

   Values of the selected parameter must be entered in the table manually. Values of the other parameter will be calculated automatically.

4. To the right of the parameters selected at the previous step, select the calculation method:

   - The **Tangential method** assumes constant inclination and azimuth between survey points. Is simpler but less accurate.

- The **Minimum curvature method** models the well as a smooth arc and provides higher accuracy, especially over longer intervals.

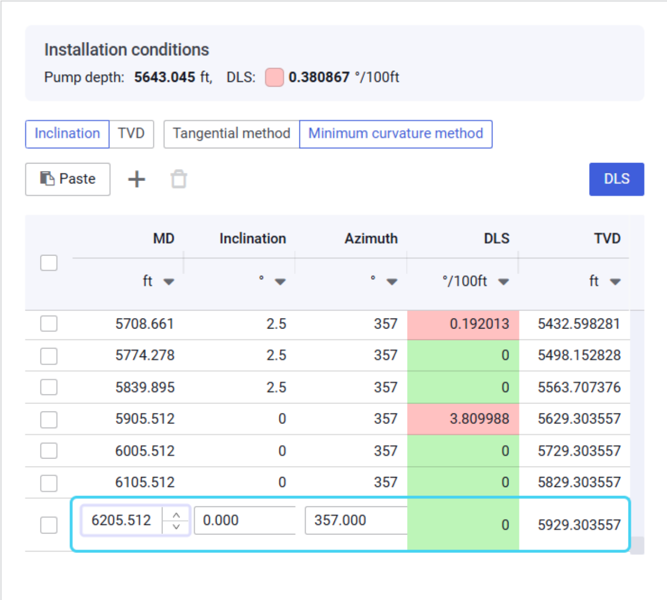
Note

By default, the **Minimum curvature method** is used as it offers the most reliable results for most wellbore profiles.

5. Above the table, click **DLS** and configure the maximum allowable dog leg severity. For details, see Configuring DLS.
6. Add new entries to the table. You can do it in the following ways:

- To add a new entry, perform the following actions:

  a. Above the table, click **Add (+)**.
  A new row appears in the table.
  b. In the new row, double-click values in the first three columns and enter the desired values.
  Values in the other two columns are calculated automatically.



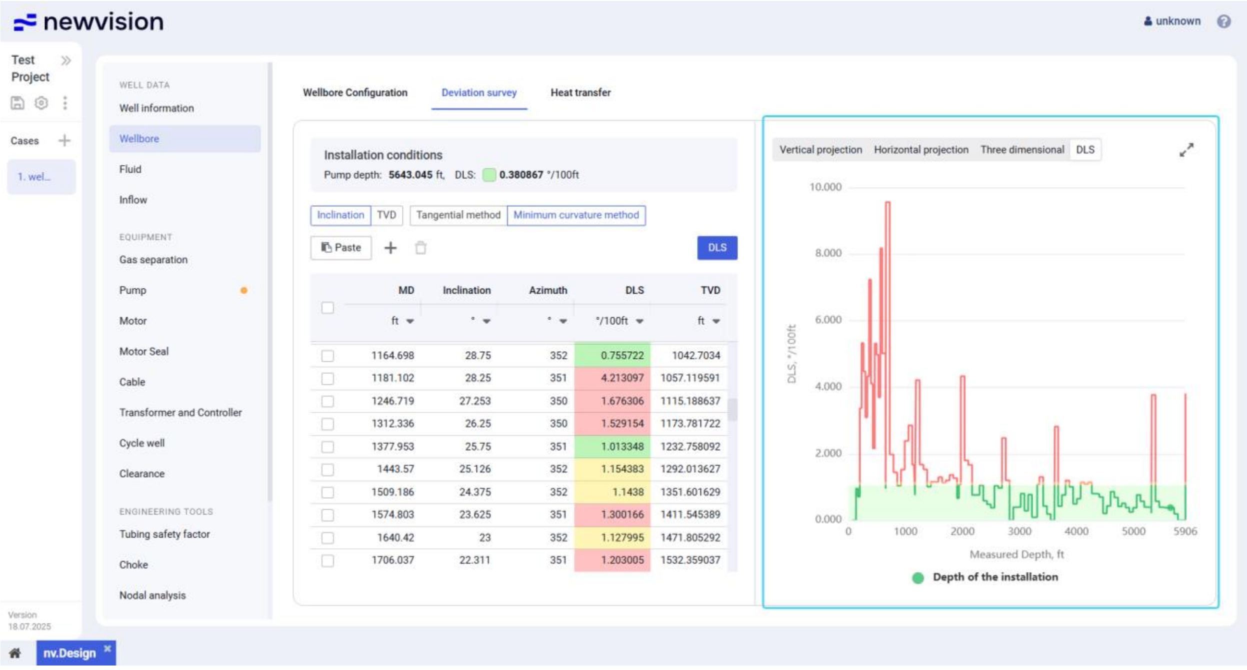
- To paste a row with data from another table, copy it to the clipboard, and then, above the table, click **Paste ( )**, or press Ctrl+V.
  The copied entry appears in the table.

  Note

  The inserted data must contain numerical values only. If the data includes a row with NaN (not a number) values, delete them after insertion.

7. *(Optional)* To delete an entry from the table, select it, and then, above the table, click **Delete ( )**.

8. Ensure that in the **Installation conditions** area above the table, the color of the square to the left of the **DLS** value is green. If it is red, make changes to the parameter values.
   When the configuration is completed and there are no errors, in the right part of the tab, the well projections are displayed.



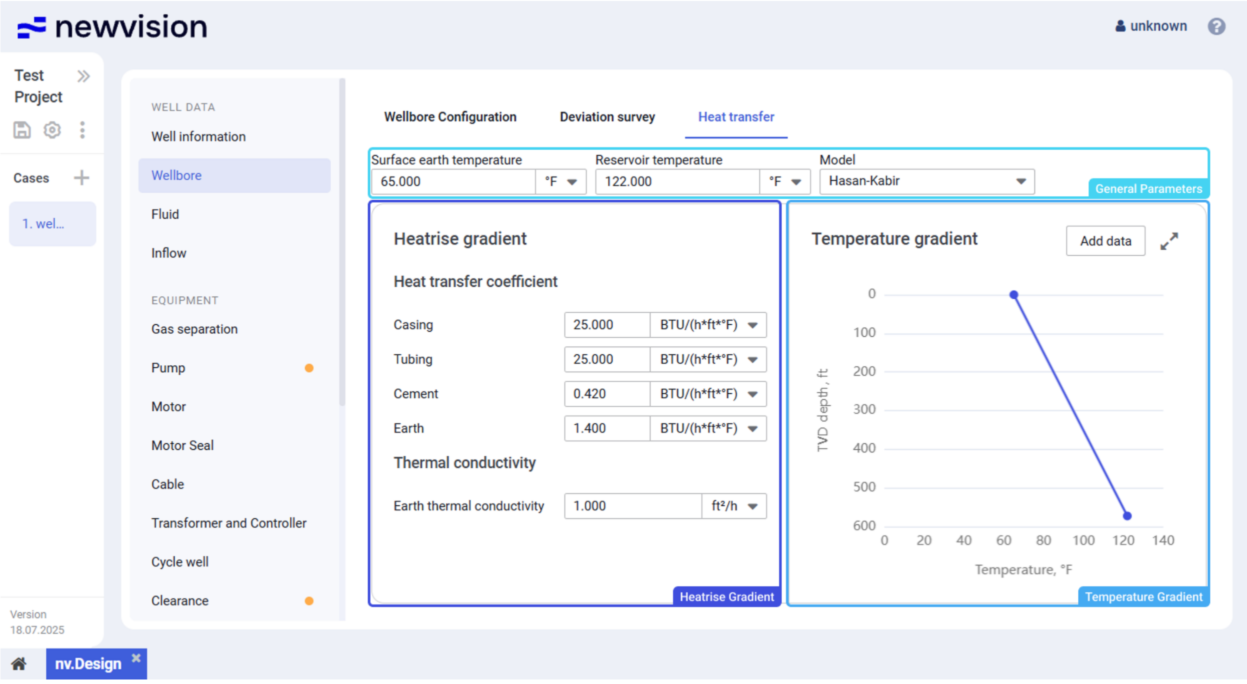
   On the **DLS** tab, sections suitable for equipment installation are highlighted with a green fill.
9. To save changes, in the left part of the module, click **Save (🖫)** under the name of the current project.

5.1.2.3. Heat transfer

On the **Heat Transfer** tab, you can model the temperature distribution along the wellbore.

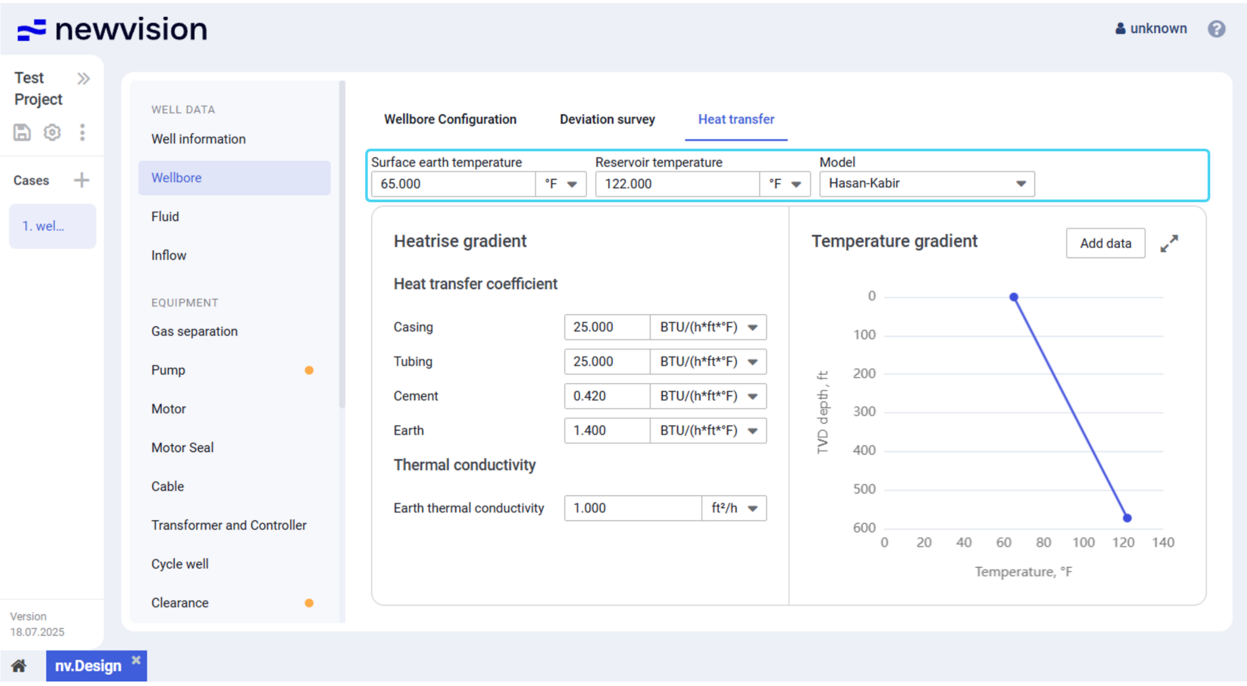
The tab consists of the following parts:

- General parameters at the top of the tab.
- **Heatrise gradient** pane in the left part of the tab.
- **Temperature gradient** pane in the right part of the tab.



General Parameters

General parameters are required for the temperature gradient modeling.



There, you need to specify the **Surface earth temperature** and **Reservoir temperature** values and select the calculation model from the **Model** list.

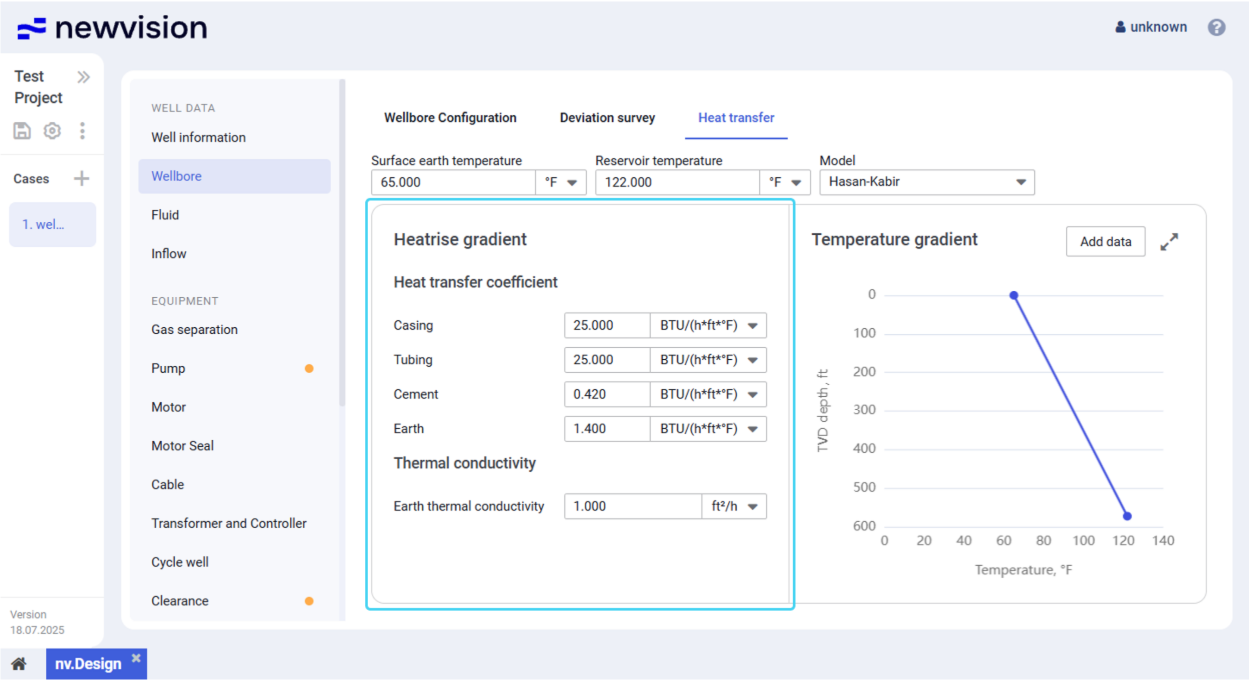
Two calculation models are available:

- **Hassan-Kabir:** Provides more accurate estimates as it takes into account heat transfer coefficients of the well casing, tubing, cement, and formation, as well as thermal conductivity of the surrounding formation.
  This method is based on a semi-analytical model developed by Hasan and Kabir, which solves the energy balance equations to estimate fluid and formation temperatures during steady-state or transient flow in the wellbore.
- **Rough Approximation:** Provides less accurate but faster estimates. It requires fewer input parameters and uses only a general (lumped) heat transfer coefficient. This model is suitable for quick estimations or cases where detailed thermal data is unavailable. It generates a simplified temperature profile along the wellbore.

Important
If precise physical properties are not available, it is recommended to use the default **Hassan-Kabir** model.

Heatrise Gradient

The pane contains well parameters that affect temperature distribution along the wellbore.



Depending on the selected model (see description above), different sets of parameters are available.

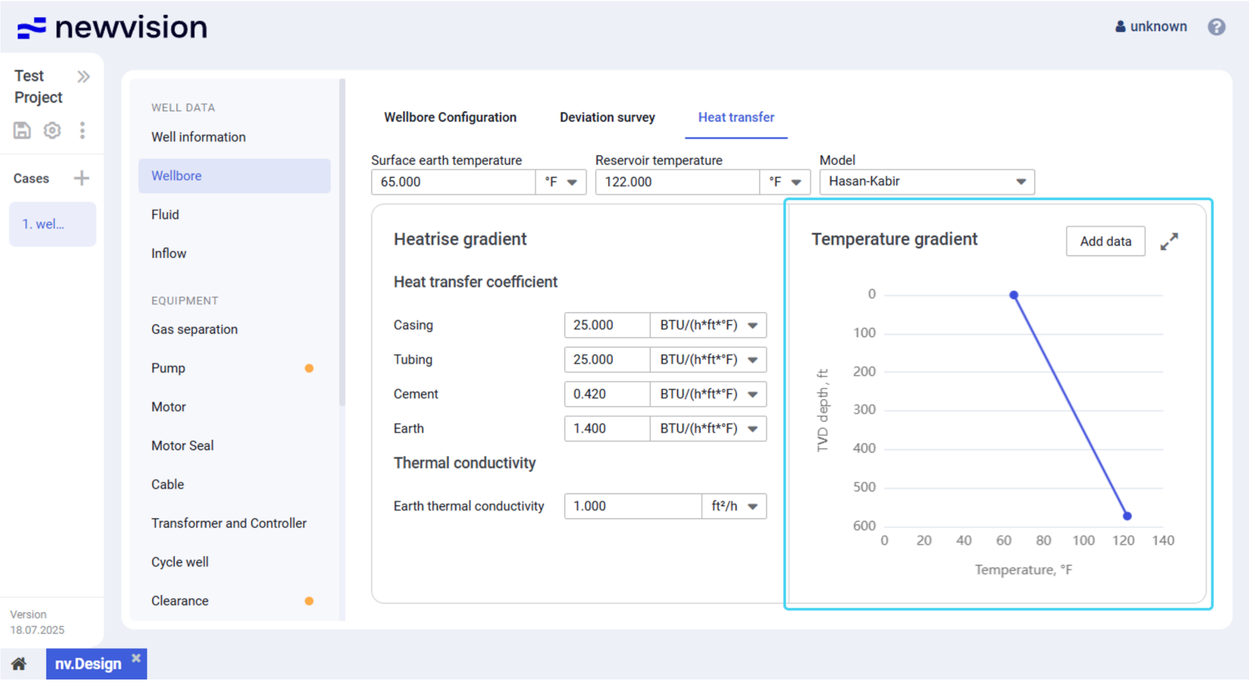
If the **Hassan-Kabir** model is selected, the pane contains two parameter groups:

- **Heat transfer coefficient**
- **Thermal conductivity**

If the **Rough Approximation** model is selected, only the **Overall heat transfer coefficient** value can be specified.

Temperature Gradient

The pane contains a chart representing the well temperature profile constructed based on the input data and selected calculation model.



To improve the profile accuracy, you can add more information about the wellbore temperature at different depths. For details, see Adding Well Test Data.

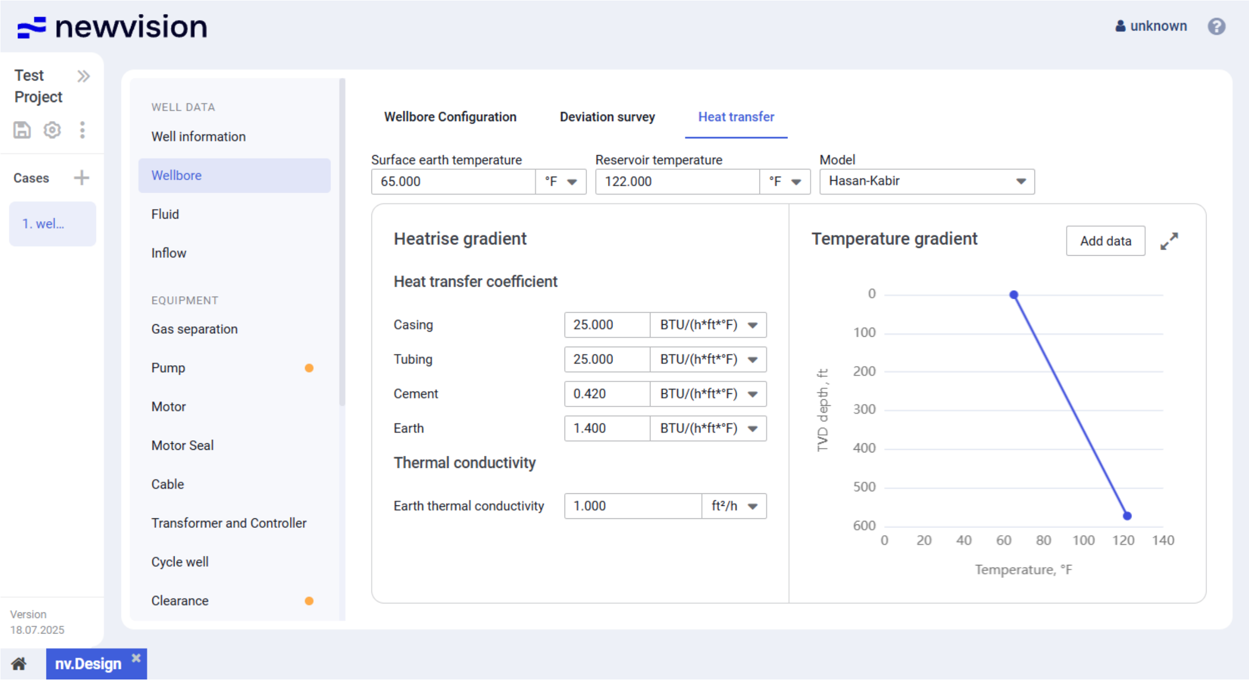
You can also expand the pane to full screen or collapse it back to the original size using the **Expand ( ) / Collapse ( )** buttons located in the upper-right corner of the pane.

5.1.2.3.1. Configuring Heat Transfer Parameters

To configure the well heat transfer parameters, perform the following actions:

1. Open the **nv.design** module.
   For details on navigation in the system, see System Interface.

2. In the left part of the working area, in the list of the module sections, click **Wellbore**, and then go to the **Heat transfer** tab.



3. At the top of the tab, in the **Surface earth temperature** and **Reservoir temperature** fields, enter the desired values.
4. From the **Model** list, select the calculation model. For details, see Heat Transfer.
5. *(Optional)* In the **Heatrise gradient** pane, edit values of the desired parameters.

   Note

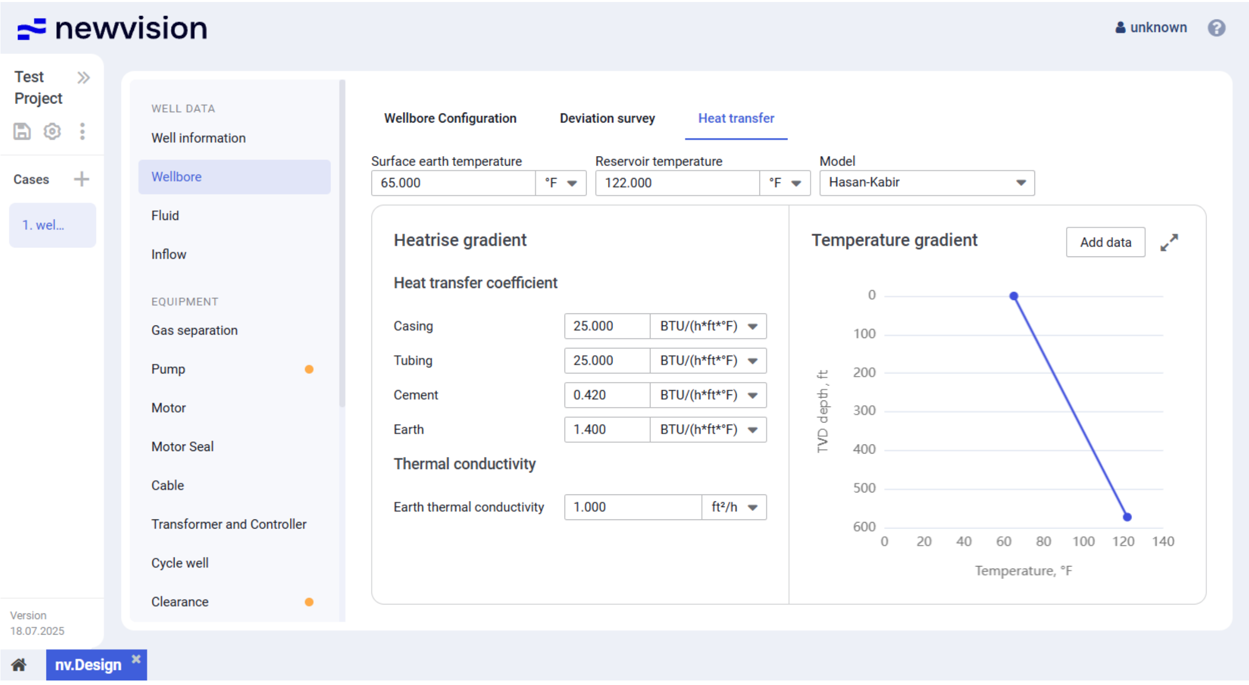
   The list of parameters available in this pane may differ depending on the model selected in Step 4.

6. *(Optional)* To enhance the accuracy of the well temperature profile, in the upper-right corner of the section, click **Add data** and enter available temperature data at different well depths. For details, see Adding Well Test Data.
7. After the configuration is completed, in the **Temperature gradient** pane, view the resulting temperature profile.
8. To save changes, in the left part of the module, click **Save ( )** under the name of the current project.

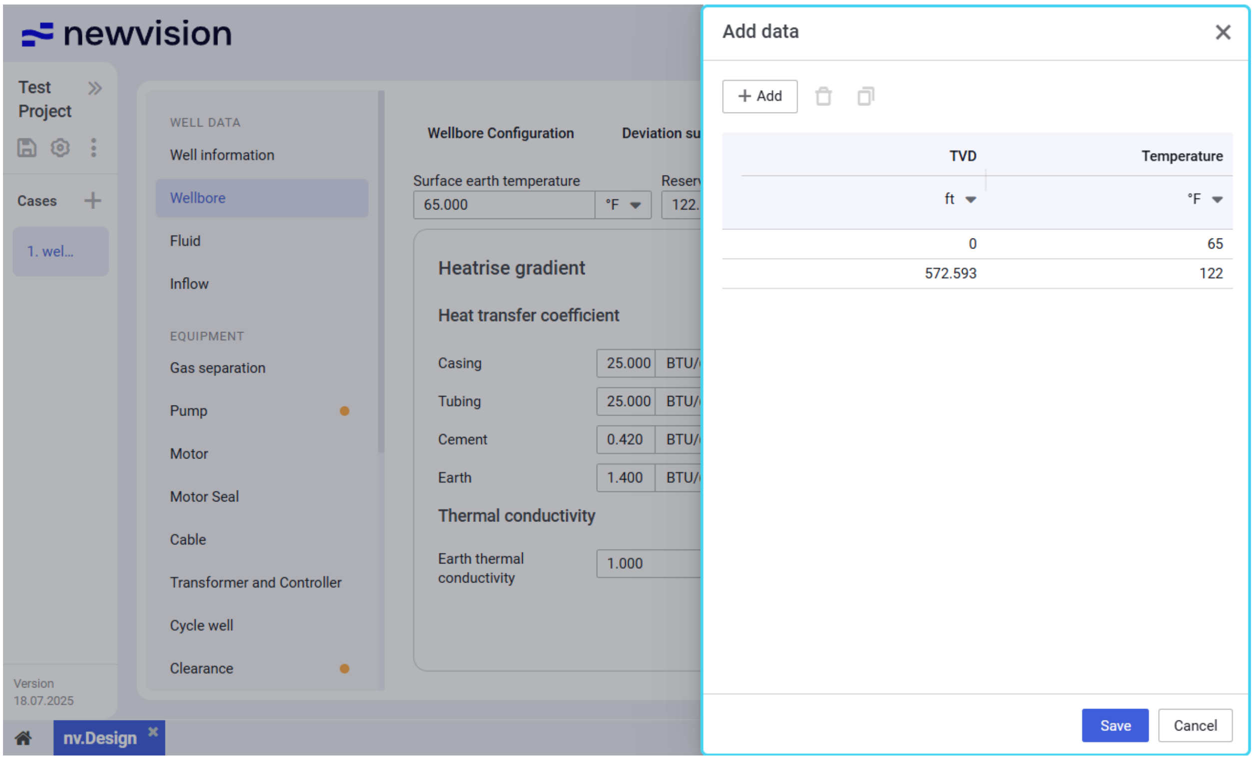
5.1.2.3.2. Adding Well Test Data

To add temperature data obtained during the well tests, perform the following actions:

1. Open the **nv.design** module.
   For details on navigation in the system, see System Interface.
2. In the left part of the working area, in the list of the module sections, click **Wellbore**, and then go to the **Heat transfer** tab.



3. At the top of the pane, in the right part of the section, click **Add data**.
   The **Add data** window opens in the right part of the section.



Note

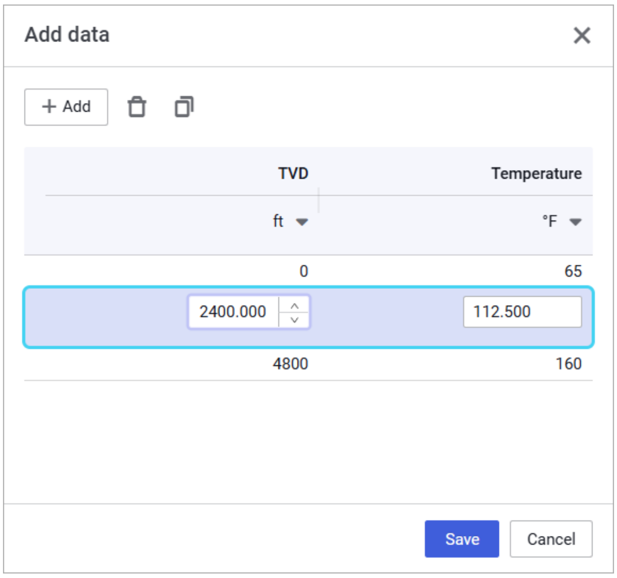
Two rows are added by default.

The first row is with a zero TVD and the temperature specified in the **Surface earth temperature** field at the top of the **Heat transfer** section.

The second row is with the TVD equal to the **Top of perforation depth (MD)** parameter from the **Wellbore Configuration** tab and the temperature specified in the **Reservoir temperature** field at the top of the **Heat transfer** section.

4. Add new entries to the table. You can do it in the following ways:

- To add a new entry, above the table, click **Add (+)**, and then, in the new row, double-click values in the **TVD** and **Temperature** columns and enter the desired values.



- To create a copy of an existing entry, select the entry that you want to copy in the table, and then, above the table, click **Duplicate ( )**.
  The copied entry appears in the table.

5. *(Optional)*
   - To edit an entry, double-click the desired value and make necessary changes.
   - To delete an entry, select it in the table, and then, above the table, click **Delete ( )**.
6. To save changes, in the left part of the module, click **Save ( )** under the name of the current project.

5.1.3. Fluid

The section provides information about the PVT properties of oil, water, and/or gas. It consists of two tabs:

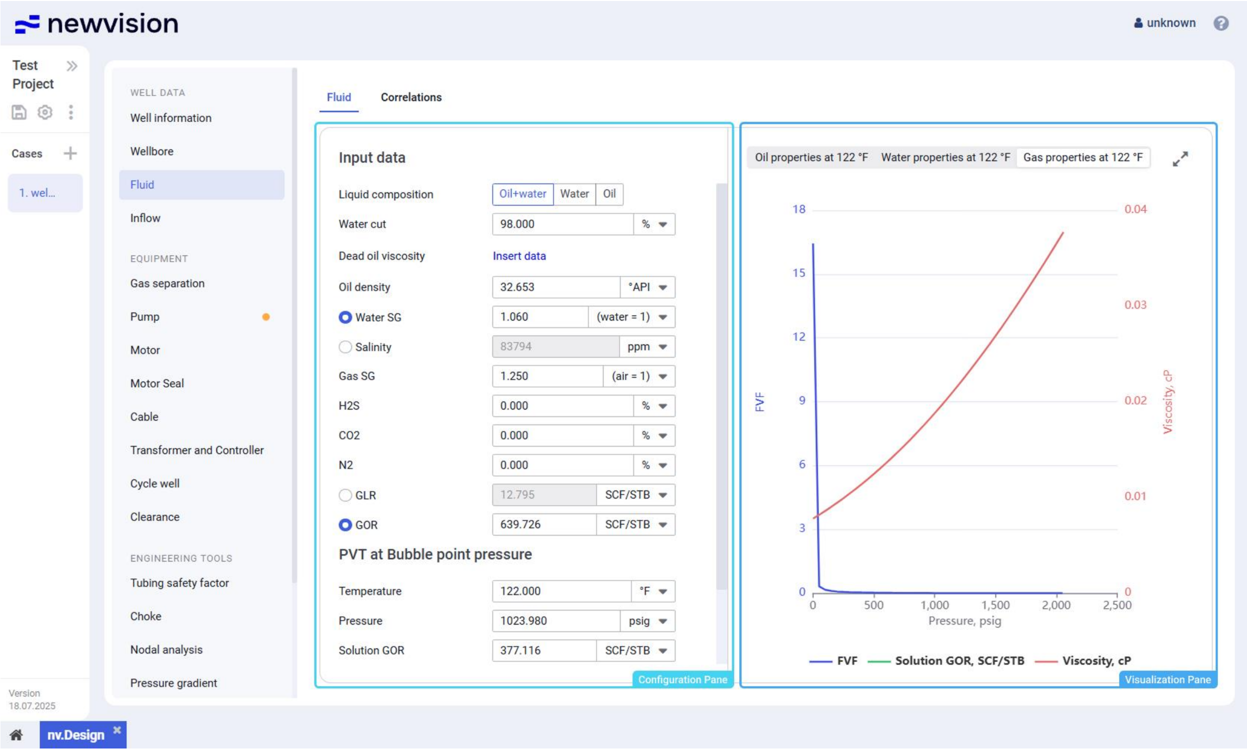
- Fluid
- Correlations

5.1.3.1. Fluid

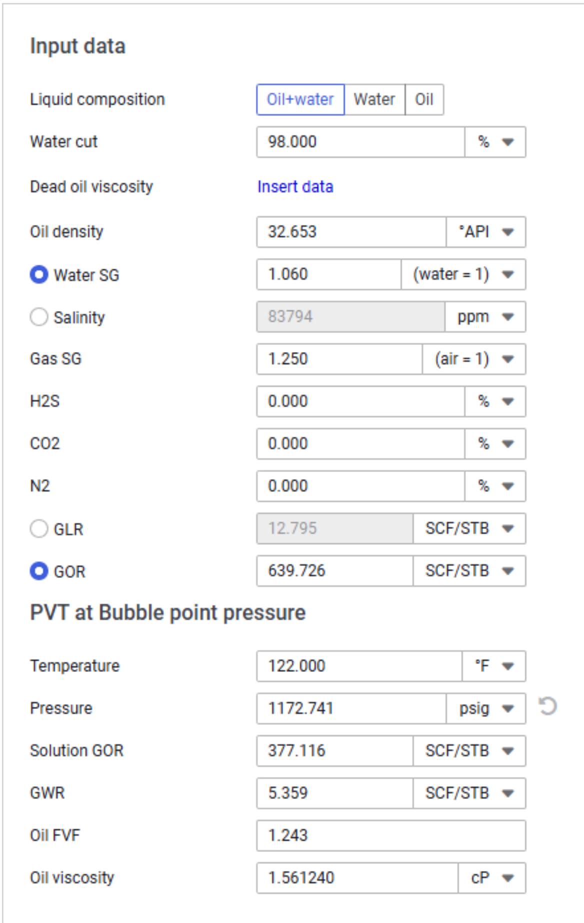
On the **Fluid** tab, you can configure PVT properties of the well fluid.

The tab consists of two panes:

- Configuration pane in the left part of the tab.
- Visualization pane in the right part of the tab.



Configuration Pane



The pane contains PVT property values distributed in two parameter groups:

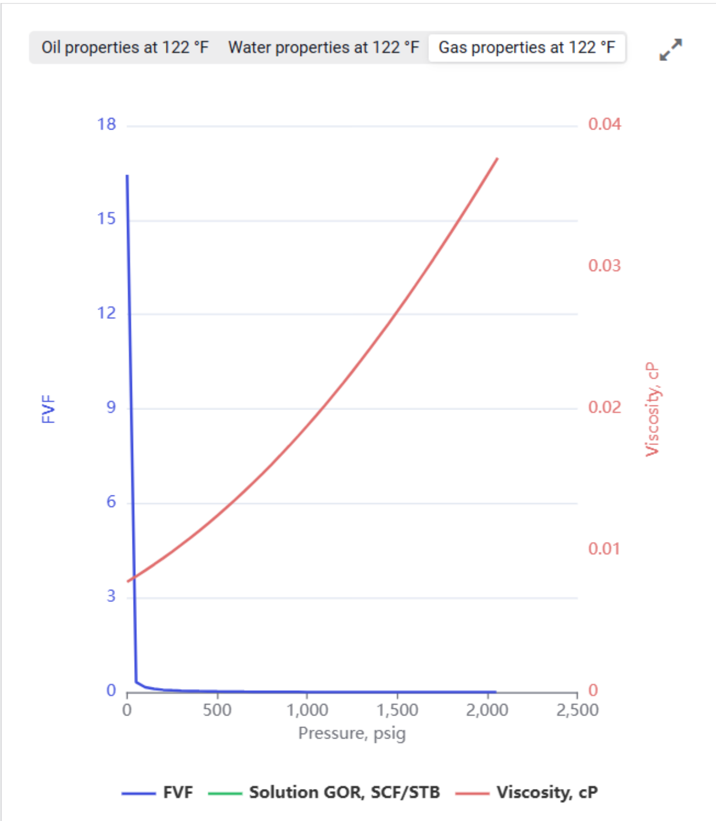
- **Input data:** Parameter values at standard conditions.
  To configure dead oil viscosity matching, to the right of the parameter name, click **Insert data**. For details, see Dead Oil Viscosity Matching.
- **PVT at bubble point pressure:** Parameter values at a specified temperature.
  The temperature is specified in the **Temperature** field.
  Visualization of the PVT properties at this temperature is displayed in the left part of the tab (see description below).

Visualization Pane

The pane contains charts that visualize the **FVF**, **Solution GOR**, and **Viscosity** values of oil, water, and gas at the temperature specified in the **Temperature** field in the configuration pane (see description above).

The pane consists of three tabs with charts of the corresponding fluid components:

- **Oil properties at X °C**
- **Water properties at X °C**
- **Gas properties at X °C**



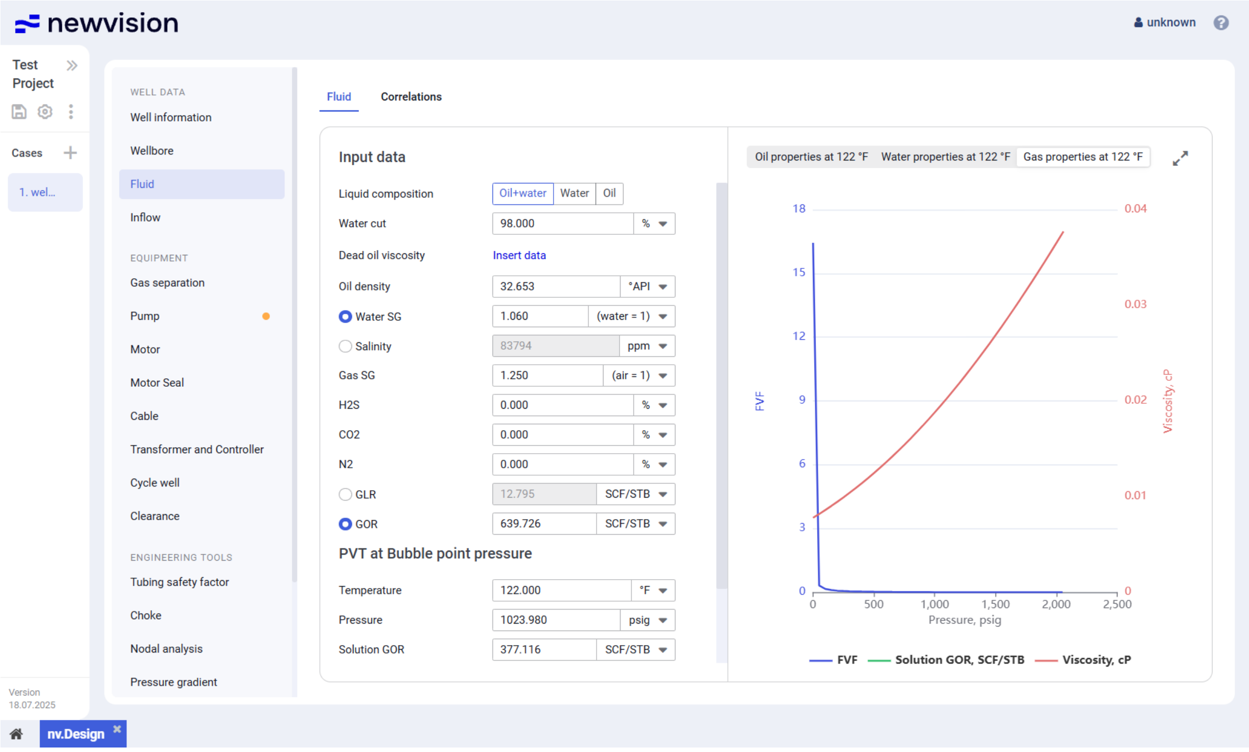
To show or hide a parameter on the chart, click the parameter name under it.

You can also expand the pane to full screen or collapse it back to the original size using the **Expand (** ⤢ **)** / **Collapse (** ⤡ **)** buttons located in the upper-right corner of the pane.

5.1.3.1.1. Configuring Fluid PVT Properties

To configure dead oil viscosity matching, perform the following actions:

1. Open the **nv.design** module.
   For details on navigation in the system, see System Interface.
2. In the left part of the working area, in the list of the module sections, click **Fluid**.
   To the right of the list, the **Fluid** tab opens.



3. In the left part of the tab, in the **Input data** parameter group, perform the following actions:
   a. To the right of the **Liquid composition** parameter name, select the well fluid composition option: **Oil+water**, **Water**, or **Oil**.
      In the list of available parameters below, only the parameters relevant to the selected composition remain.
   b. In the **Water cut** field, enter the desired value.
   c. *(Optional)* If the fluid composition includes high-viscosity oil, click **Insert data** and configure matching parameters so that available correlations could be applied. For details, see Dead Oil Viscosity Matching.

      Note
      If some calibration points have already been added, instead of **Insert data**, their number (e.g., **5 points**) is displayed.

   d. In the **Input data** parameter group, fill in the rest of the PVT properties under surface conditions.
      Go to the **Correlations** tab and select the correlations that are most

suitable for the input parameters. For details, see Appendix A: PVT Correlations.

Parameter values in the **PVT at Bubble point pressure** group are calculated automatically based on the selected correlations.

4. *(Optional)* Edit values in the **PVT at Bubble point pressure** group.

   Note

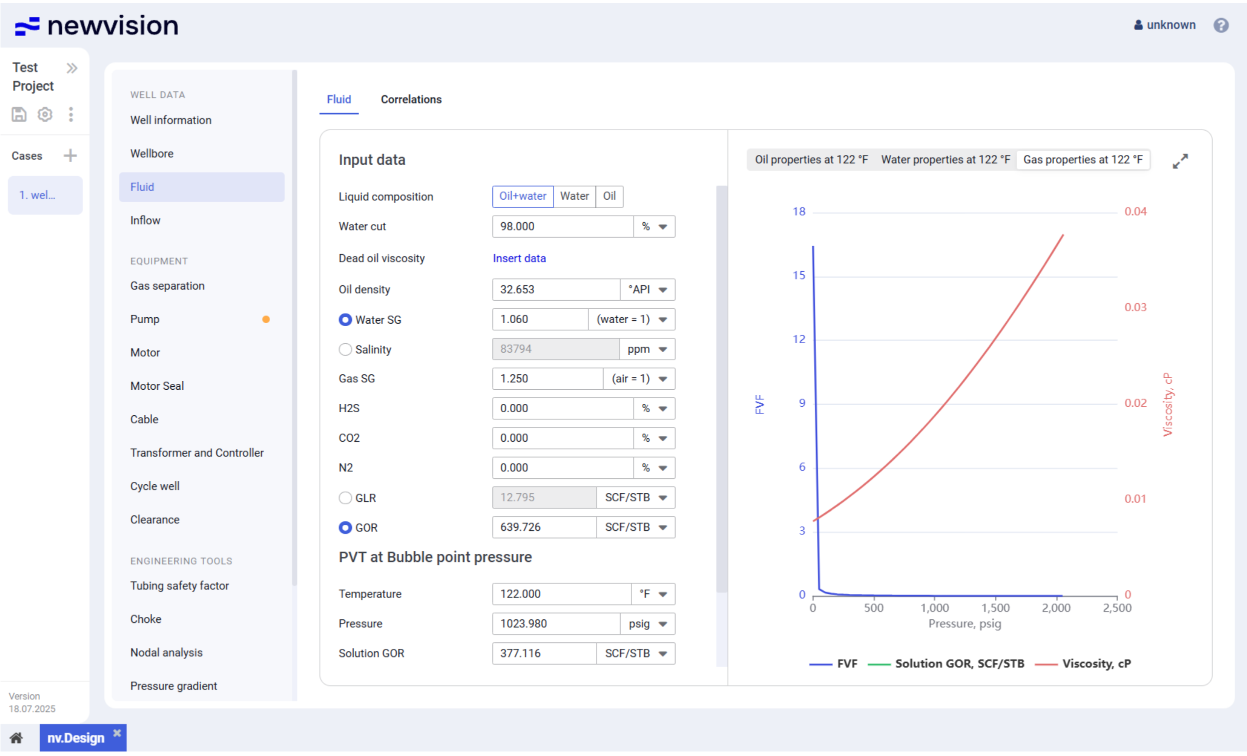
   After you modify any value in this parameter group, to the right of the corresponding field, the **Reset (⟲)** button appears. Using it, you can reset the parameter to the calculated value.

5. In the right part of the tab, view charts that visualize the **FVF**, **Solution GOR**, and **Viscosity** values of gas, water, and/or oil at the temperature specified in the **Temperature** field.
6. To save changes, in the left part of the module, click **Save (🖫)** under the name of the current project.

5.1.3.1.2. Dead Oil Viscosity Matching

To configure dead oil viscosity matching, perform the following actions:

1. Open the **nv.design** module.
   For details on navigation in the system, see System Interface.
2. In the left part of the working area, in the list of the module sections, click **Fluid**.
   To the right of the list, the **Fluid** tab opens.

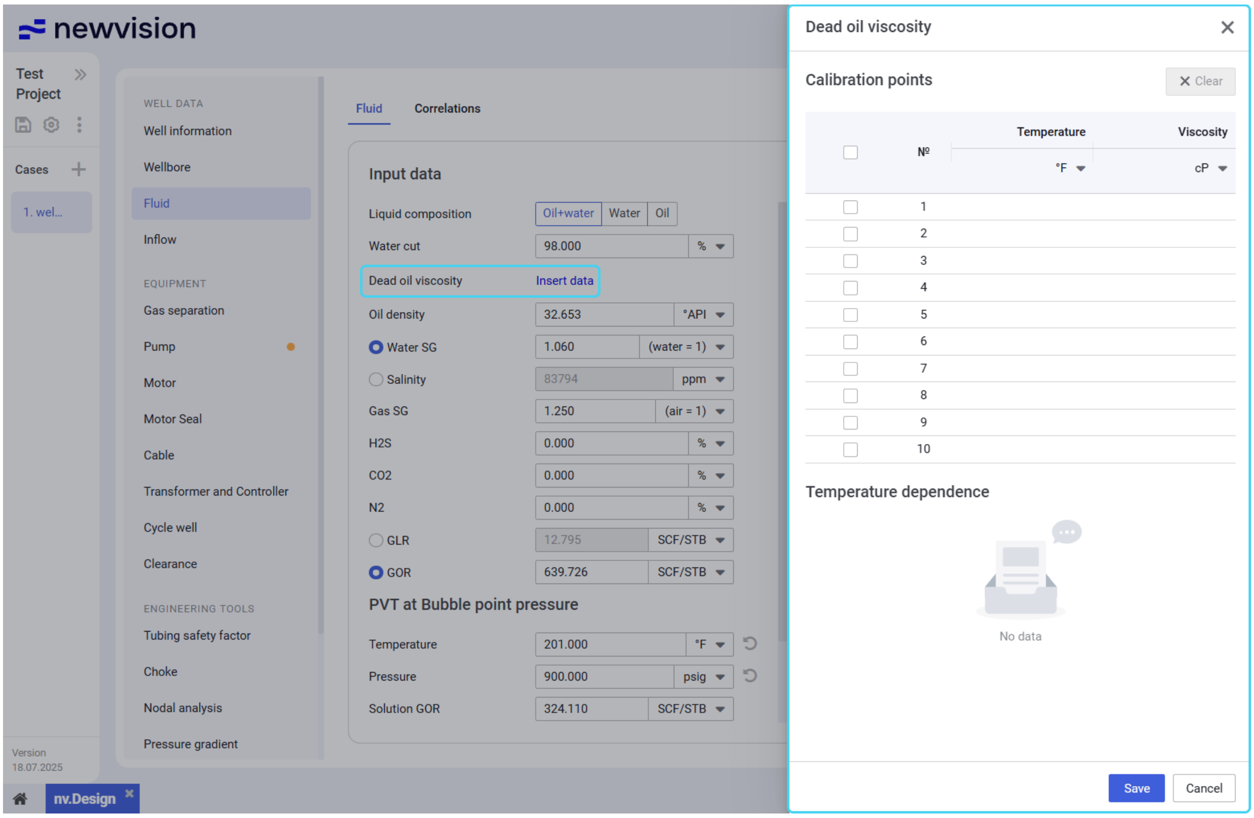


3. In the left part of the tab, under the **Input data** heading, click **Insert data**.

Note

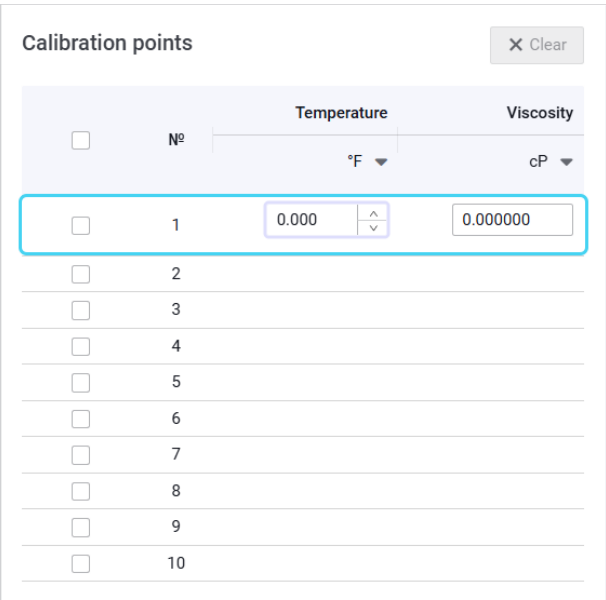
If some calibration points have already been added, instead of **Insert data**, their number (e.g., **5 points**) is displayed.

The **Dead oil viscosity** window opens in the right part of the tab.



4. In the window, add matching data to the **Calibration points** table. You can do it in the following ways:

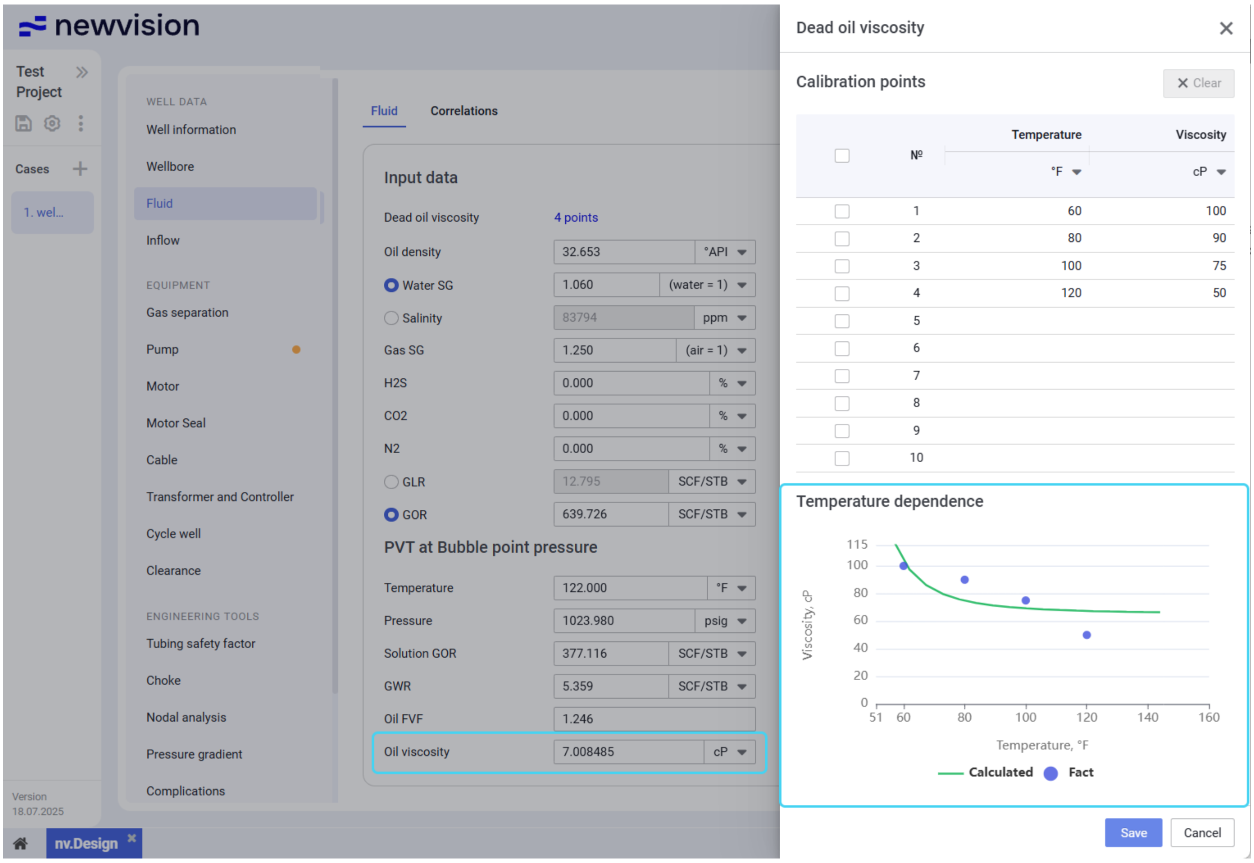
   - To add data manually, double-click cells in the **Temperature** and **Viscosity** columns and enter the desired values.



- To paste data from another table, copy it to the clipboard, and then press Ctrl+V.
  The copied entries appear in the table. The more data you add, the more accurate results the matching provides.

  Note
  The inserted data must contain numerical values only. If the data includes a row with NaN (not a number) values, delete them after insertion.

5. *(Optional)*
   - To edit values in the table, double-click the desired value and make necessary changes.
   - To clear data from a row, select its check box in the leftmost column, and then, above the table, click **Clear (✕)**.
6. After the configuration is completed, at the bottom of the window, click **Save**. Below the **Calibration points** table, the **Temperature dependence** chart appears. Under the **PVT at Bubble point pressure** heading in the left part of the tab, the **Oil viscosity** value is matched to the actual data.



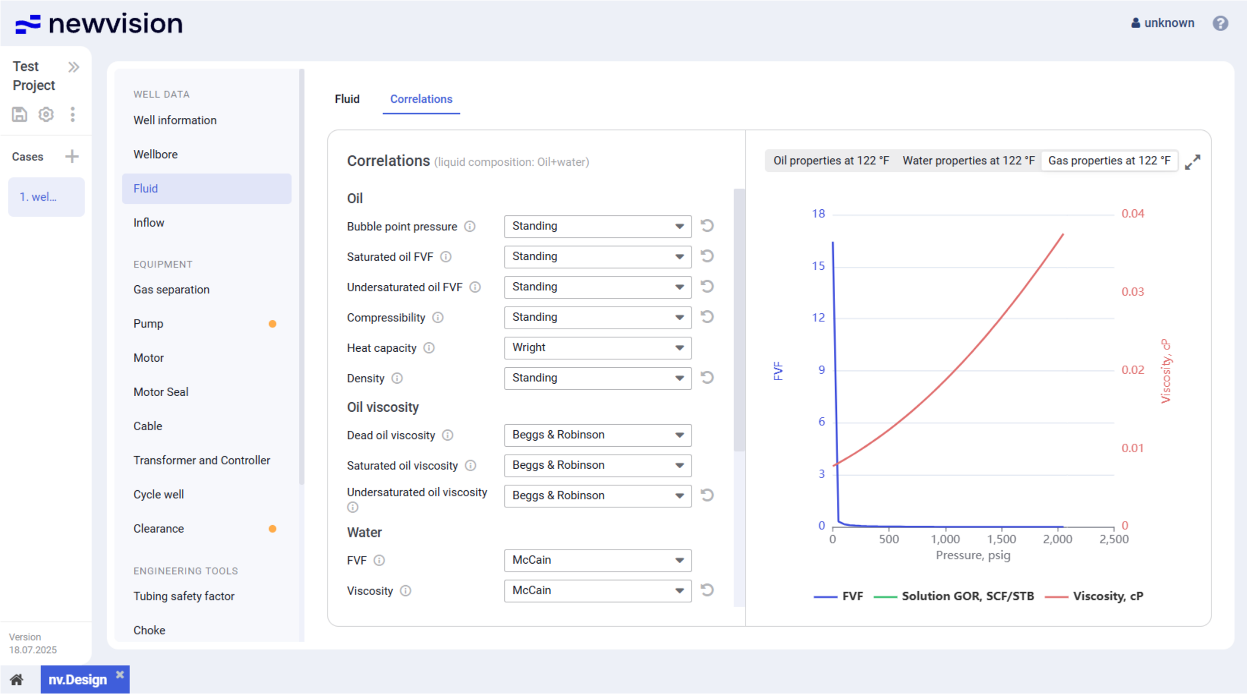
7. Close the window by clicking the cross icon (✕) in its upper-right corner.
8. To save changes, in the left part of the module, click **Save (🖫)** under the name of the current project.

5.1.3.2. Correlations

On the **Correlations** tab, you can select correlations that are used for the PVT property calculations.

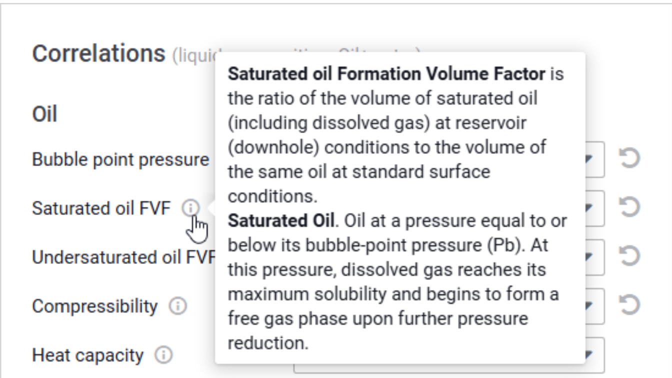
The tab consists of two panes:

- **Correlations** pane in the left part of the tab.
- Visualization pane in the right part of the tab.



In addition to the basic physical properties of oil, gas, and water, you can configure the interfacial tension between gas and water, as well as between gas and oil. Interfacial tension affects the flow regime, phase slip, and emulsion formation in multi-phase flow, which in turn impacts pressure and velocity calculations.

Next to the names of available parameters, the information icon (ⓘ) is displayed. On hovering over it, a hint with a brief description of the corresponding parameter appears.



ⓘ **Note**

After you change a correlation selected by default, to the right of the corresponding list, the **Reset (⟲)** button appears. Using it, you can change the correlation back to the default option.

In the right part of the tab, the same visualization pane is displayed. For details, see [Fluid.](#)

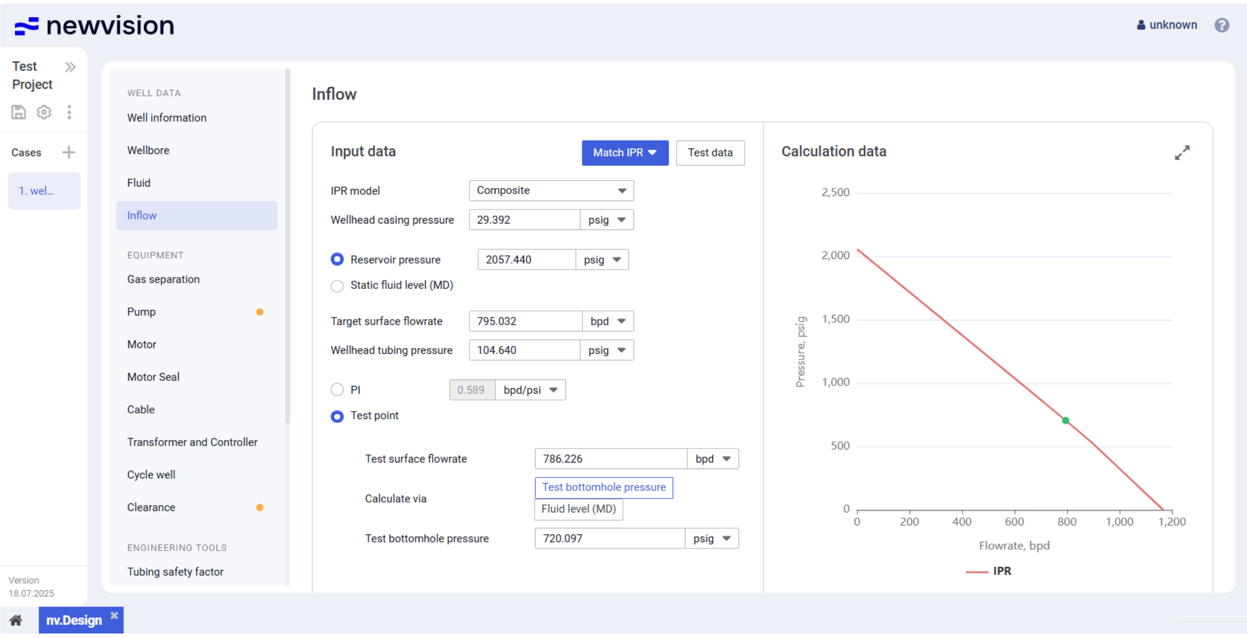
A detailed description of the correlations and the criteria for their selection are provided in [Appendix A: PVT Correlations.](#)

5.1.4.Inflow

The section provides information about the well inflow parameters that are used for building the IPR (Inflow Performance Relationship) curve.

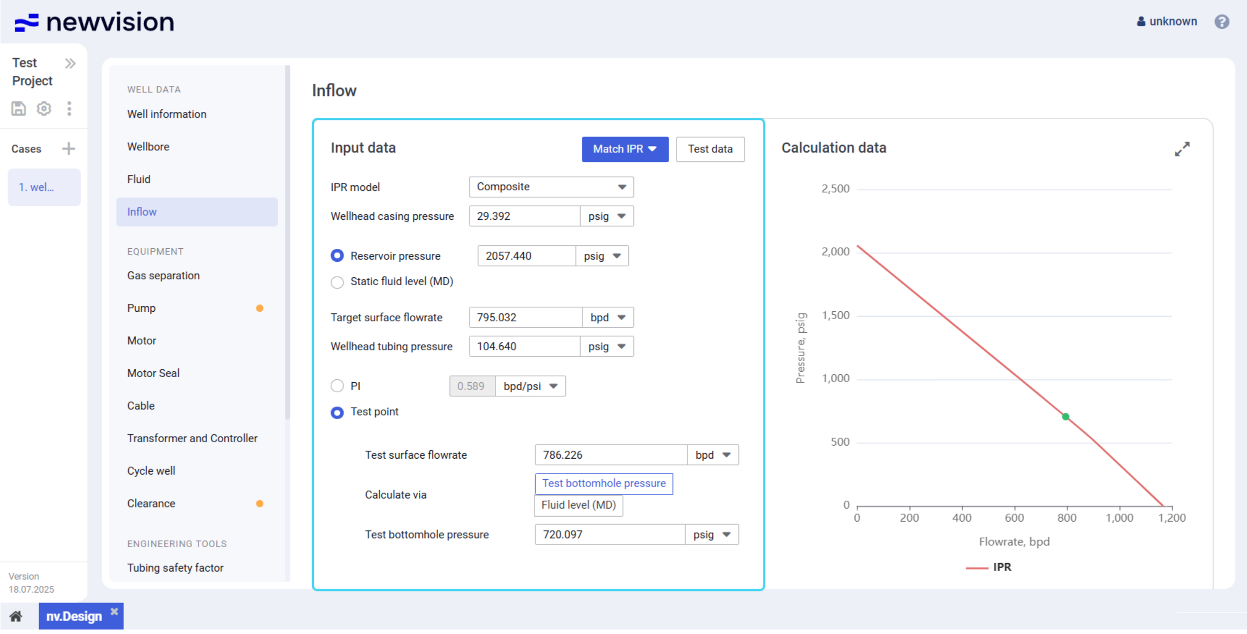
The section consists of two panes:

- **Input data**
- **Calculation data**



Input Data

The pane contains the well parameters used for the IPR construction.



The IPR configuration depends on the model that is used for calculation. The choice of the model should be determined by the reservoir type, well operating conditions, analysis goals, and available data.

For details on the IPR configuration, see Calculating IPR.

You can select one of the following models from the **IPR model** list:

Composite

This model combines several inflow models and is applied under complex operating conditions: high water cut (above 40–50%), multiphase flow (oil, water, gas), varying inflow regimes, and reservoir heterogeneity.
This approach requires a more comprehensive dataset but provides a more realistic estimate of well performance, especially when bottomhole pressure significantly deviates from bubble point pressure and phase transitions or inflows from different reservoir zones occur.

Vogel Model

This model assumes homogeneous flow (typically oil) and is most effective when bottomhole pressure is below bubble point pressure with minimal water production. It accounts for gas liberation due to pressure drop and provides reliable inflow prediction for undersaturated reservoirs.
However, the model's accuracy decreases with high water cut. In this case, the composite model is preferred. The PI model is not suitable under these conditions, as it fails to account for multiphase effects.

PI (Productivity Index)

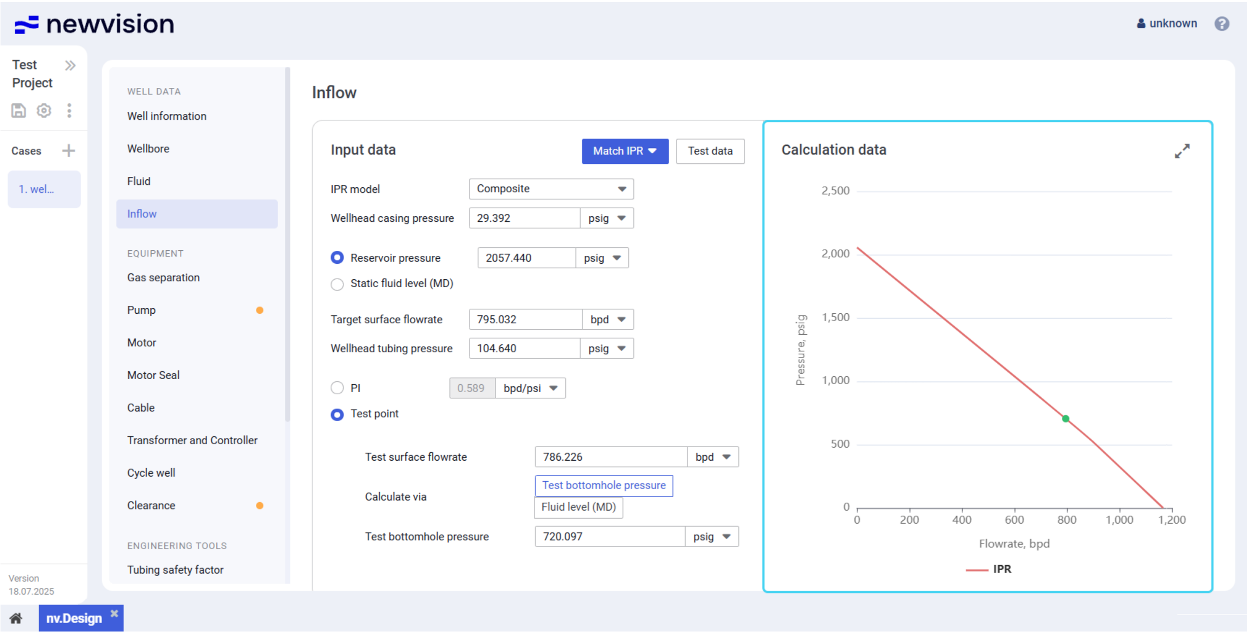
This model is based on a linear relationship between flow rate and pressure drawdown and is applicable only when bottomhole pressure is above bubble point

pressure and water cut is low.
In the presence of gas release or increasing water production, the model becomes unreliable because it does not reflect phase changes or increased flow resistance under multiphase flow conditions.

The calculation can be based either on the reservoir pressure value or, if it is unavailable, on the static fluid level. You can also select between calculation based on the productivity index (**PI**) and a set of custom parameters (**Test point**). For details, see Calculating IPR.

Calculation Data

The pane contains the IPR curve constructed based on the parameter values entered in the **Input data** pane.



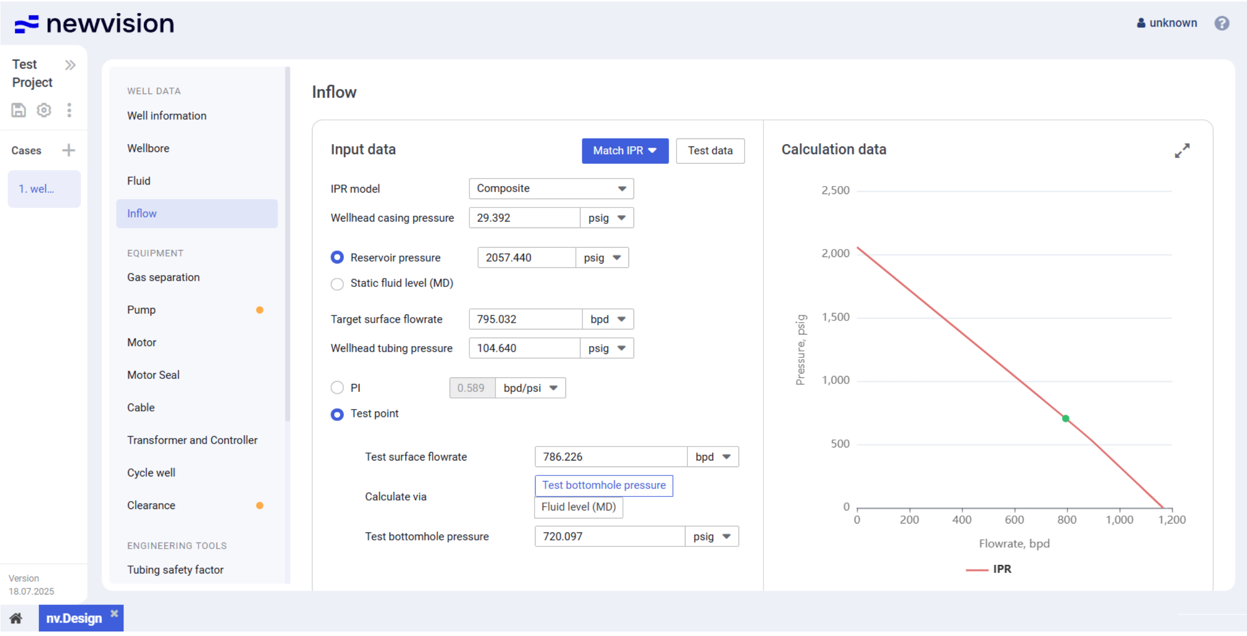
You can expand the pane to full screen or collapse it back to the original size using the **Expand ( ) / Collapse ( )** buttons located in the upper-right corner of the pane.

5.1.4.1.1. Calculating IPR

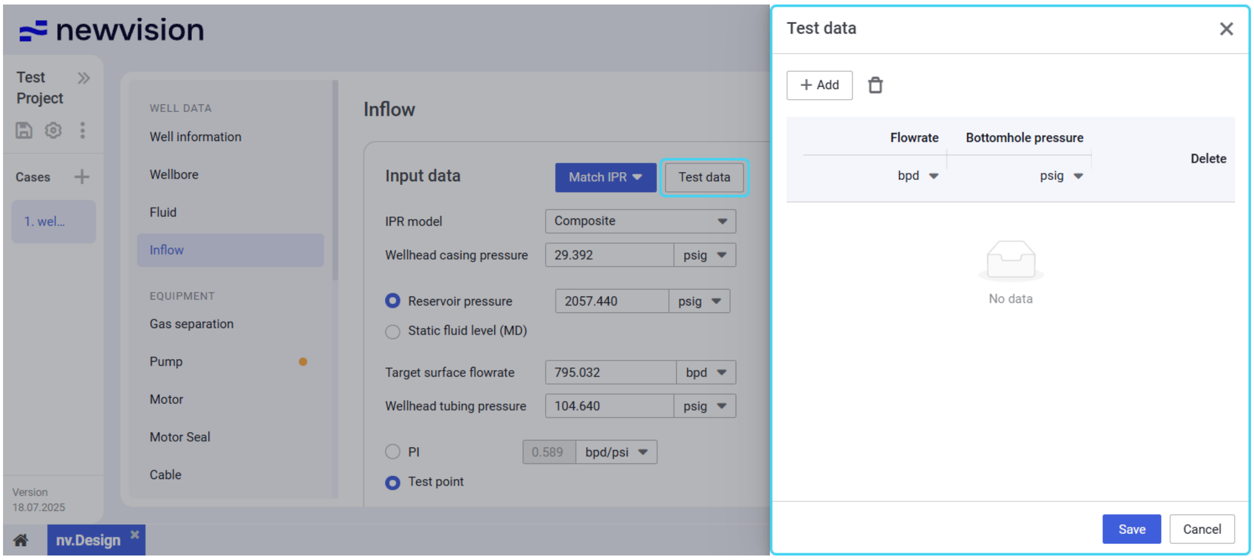
To configure deviation survey parameters and run a calculation, perform the following actions:

1. Open the **nv.design** module.
   For details on navigation in the system, see System Interface.

2. In the left part of the working area, in the list of the module sections, click **Inflow**. To the right of the list, the **Inflow** section opens.

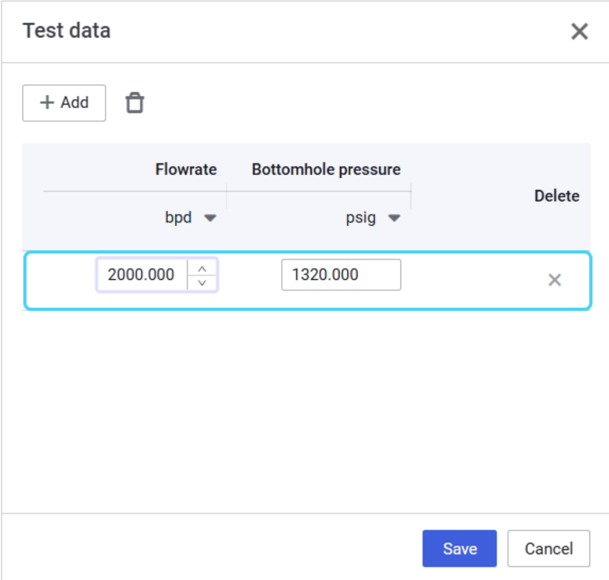


3. In the upper-right corner of the **Input data** pane, click **Test data**. The **Test data** window opens.



4. In the window, enter actual values of the flow rate and corresponding bottom hole pressures obtained during well tests:
   a. Above the table, click **Add (+)**.
      A new row appears in the table.

b. In the new row, double-click values in the **Flowrate** and **Bottomhole pressure** columns and enter the desired values.



c. Repeat Steps 1–2 for all available measurements.

Note

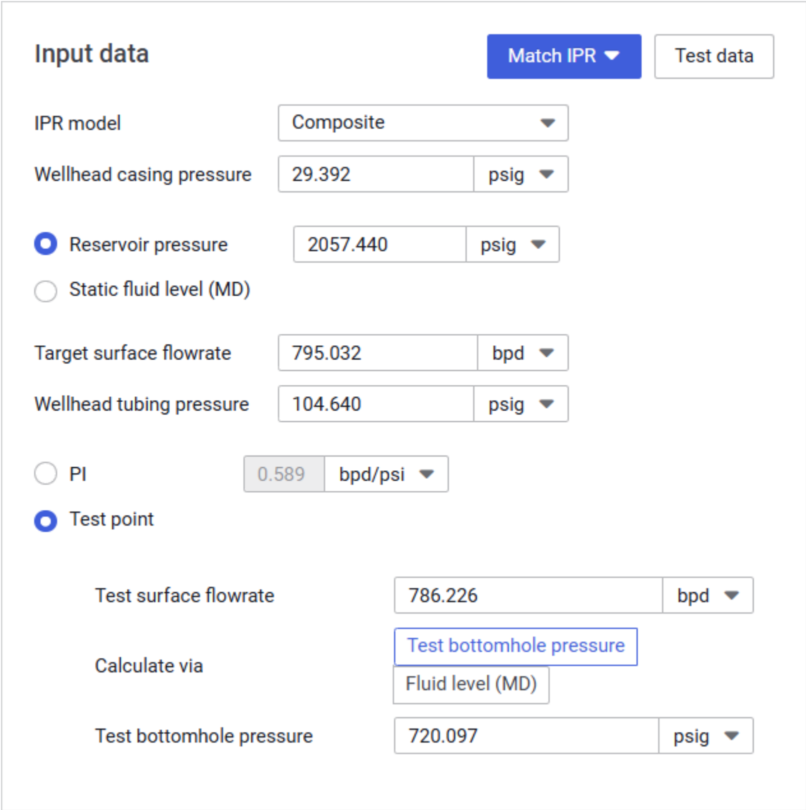
The more measurements you add, the more accurate results the calculation provides.

d. *(Optional)*

- To edit an entry, double-click the desired value and make necessary changes.
- To delete an entry, select it in the table, and then, above the table, click **Delete ( )**, or click the cross icon ( ) in the **Delete** column.

e. At the bottom of the window, click **Save**.

5. At the top of the **Input data** pane, from the **IPR model** list, select the appropriate model: **Composite**, **Vogel**, or **PI**. For description of these models, see Inflow.



6. In the **Wellhead casing pressure** field, enter the desired value.
7. Select the parameter that will be used for the calculation: **Reservoir pressure** or, if it is unavailable, **Static fluid level (MD)**.
8. *(Optional)* If the **Static fluid level (MD)** option is selected, fill in the **Wellhead casing pressure** and **Static fluid level (MD)** fields.
9. In the **Target surface flowrate** and **Wellhead tubing pressure** fields, enter the desired target values.
10. Select one more parameter based on which the calculation will be performed: productivity index (**PI**) or a set of custom parameters (**Test point**).
11. Depending on the option selected at the previous step, perform one of the following actions:
    - *(For **PI**)* In the **PI** field, enter the productivity index value.
    - *(For **Test point**)* Fill in the **Test surface flowrate** field, select the desired **Calculate via** option, and fill in the rest of the fields.
12. In the upper-right corner of the **Input data** pane, click **Match IPR** and select **PI** from the drop-down menu.
    In the **Calculation data** pane, the IPR curve is matched to the actual data and configured calculation parameters.

13. To save changes, in the left part of the module, click **Save ( )** under the name of the current project.

5.2. Equipment

Configuration of sections in this group depends on the artificial lift type selected in the **Well Information** section. For details, see Well Data.

For ESP, the group consists of the following sections:

- Gas separation
- Pump
- Motor
- Motor Seal
- Cable
- Transformer and Controller
- Cycle well
- Clearance

5.2.1. Gas Separation

The **Gas separation** section provides information about the separation parameters at the pump intake.

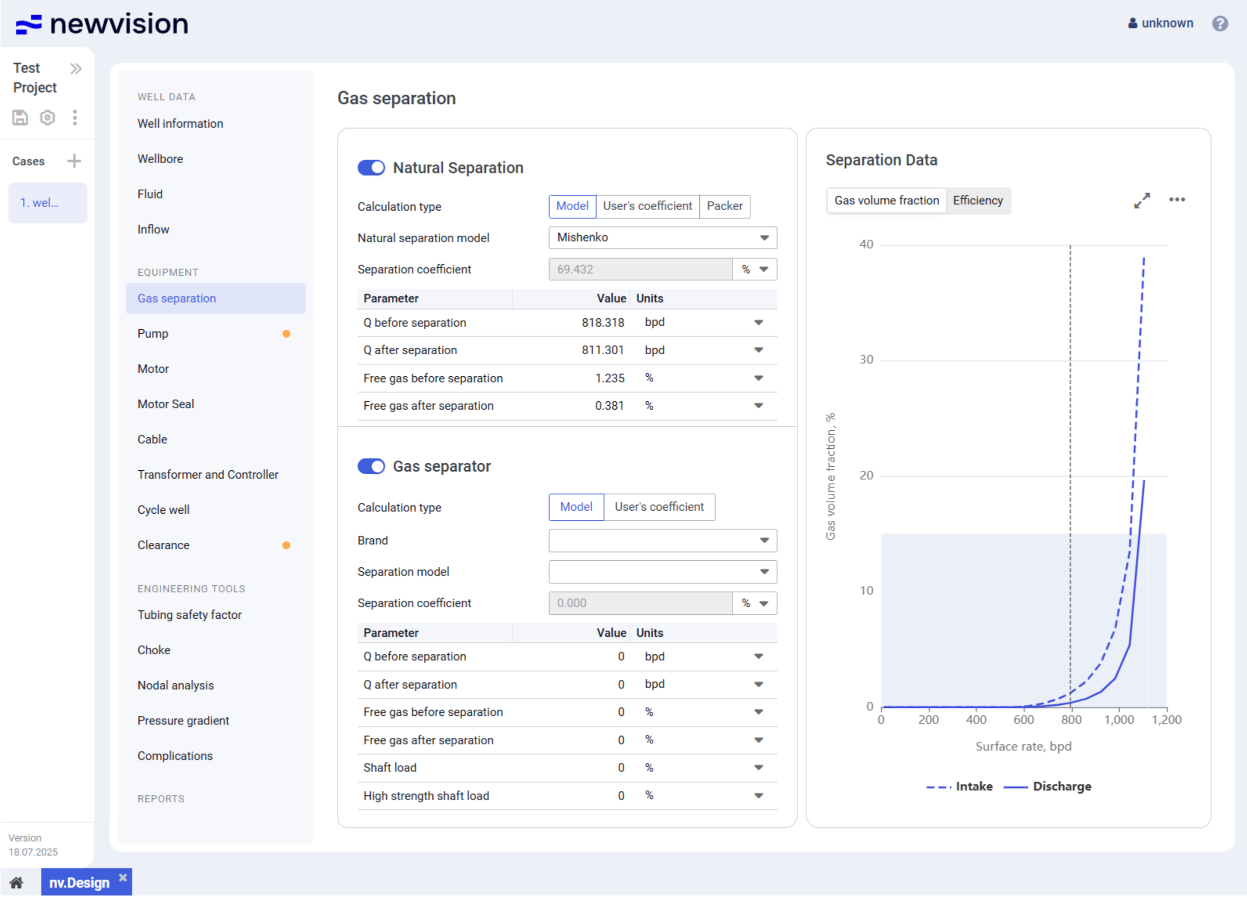
The section consists of the following parts:

- **Natural Separation** parameter group in the left part of the section.
- **Gas separator** parameter group in the left part of the section.
- **Separation Data** pane in the right part of the section.

Important

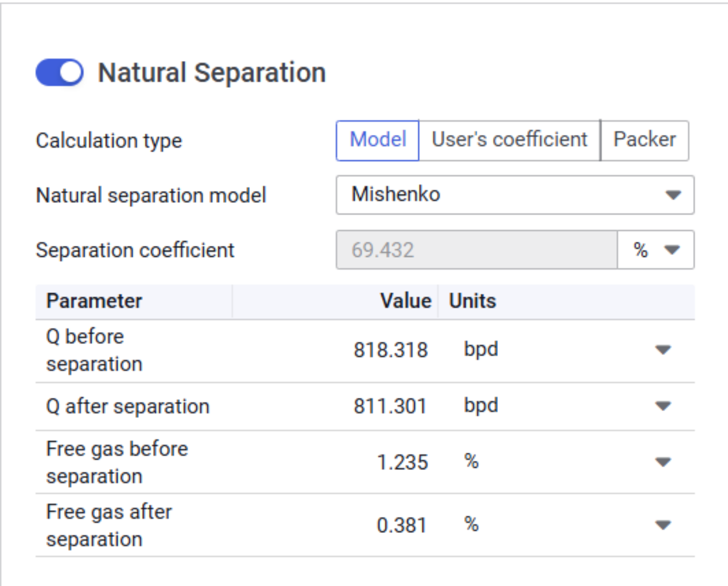
Gas separation calculations require the following data from other module sections:

- Pump section models and target parameters such as surface rate and pump frequency from the Pump section.
- Target tubing head pressure from the Inflow section.



Natural Separation

This parameter group provides controls for configuring the natural separation parameters.



To enable or disable natural separation, use the toggle to the left of the group name.

Note

If all separated gas enters the pump, the **Natural separation** group must be disabled.

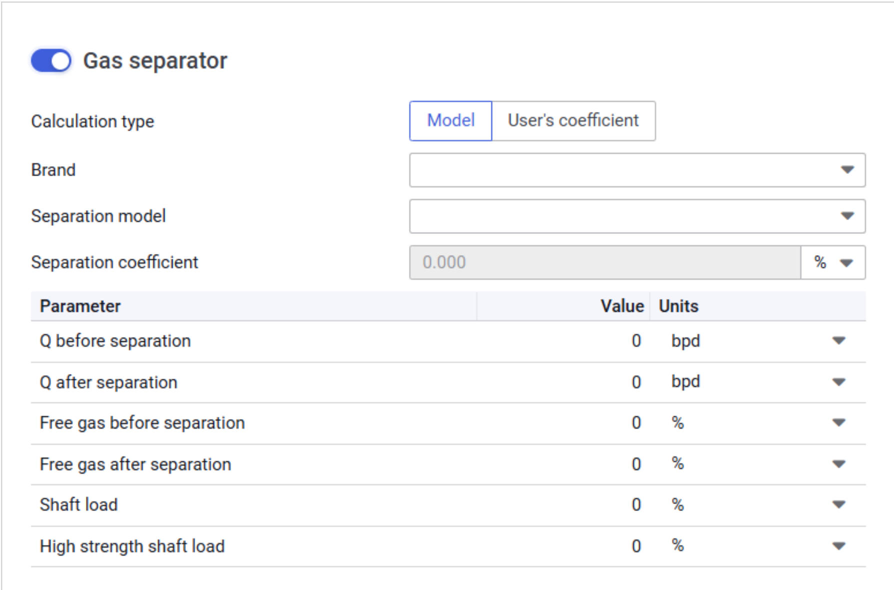
You can select one of the following calculation methods:

- **Model**: Calculation using one of the pre-defined models.
  You can select the model from the **Natural separation model** list:
  - **Mishenko**: Simplified approach where key physical forces, such as friction and gravity are treated with limited detail. Instead, the model focuses on the representation of phase transitions, particularly the release of gas from oil within the wellbore.
    It is commonly used under relatively simple well conditions and is especially effective when assessing gas liberation dynamics prior to surface separation equipment.
  - **Alhanati**: Comprehensive description of multiphase flow physics. The model is designed for scenarios where complex phase interactions must be considered. It is particularly suitable for directional and vertical wells, as it accounts for wellbore inclination, gravitational segregation, and phase slip. Due to its higher accuracy, this model is typically applied in challenging operating environments where realistic modeling of fluid behavior in the wellbore is critical for performance optimization.
- **User’s coefficient**: Calculation using a custom user-defined coefficient.
  You can enter it in the **Separation coefficient** field.
- **Packer**: Calculation via simulation of a packer.

Below these controls, there is a table with the values of the flow rate (Q) and free gas content before and after separation.

Gas Separator

This parameter group provides controls for configuring the separation parameters if a gas separator is used.



To enable or disable mechanical separation, use the toggle to the left of the group name.

You can select one of the following calculation methods:

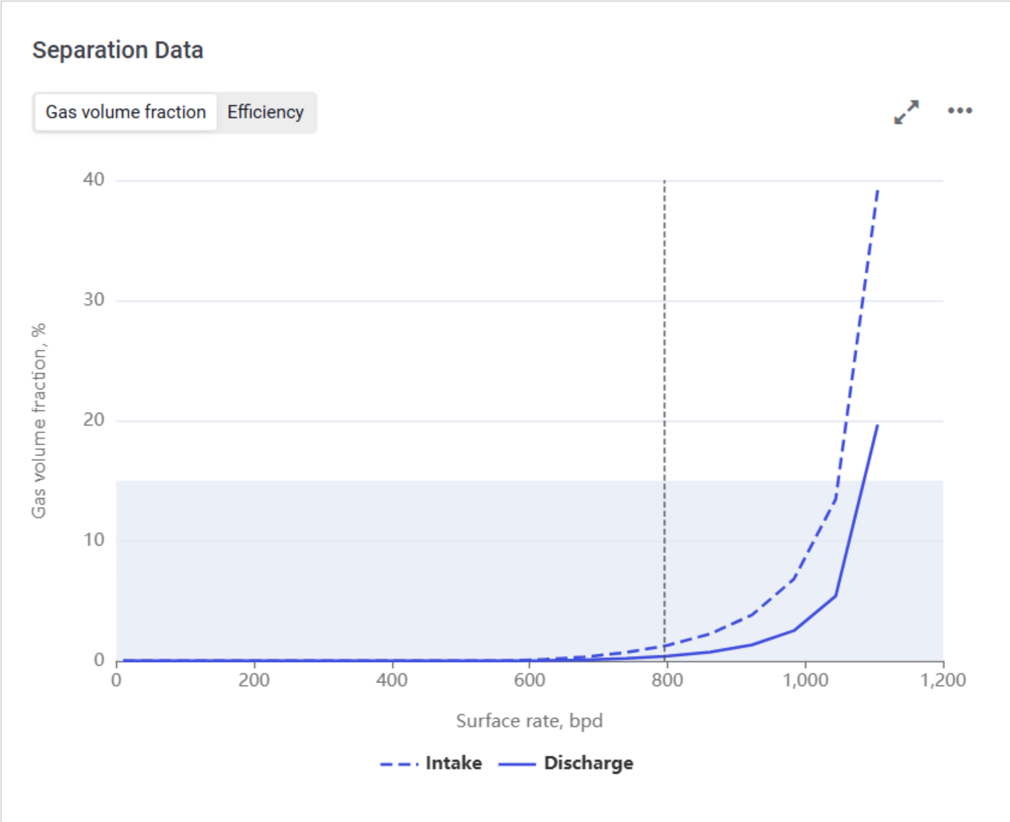
- **Model**: Calculation based on the specific gas separator model parameters.
  You can select the separator by selecting its manufacturer and model from the **Brand** and **Separation model** lists respectively.
- **User's coefficient**: Calculation using a user-defined coefficient.
  You can enter it in the **Separation coefficient** field.

Separation Data

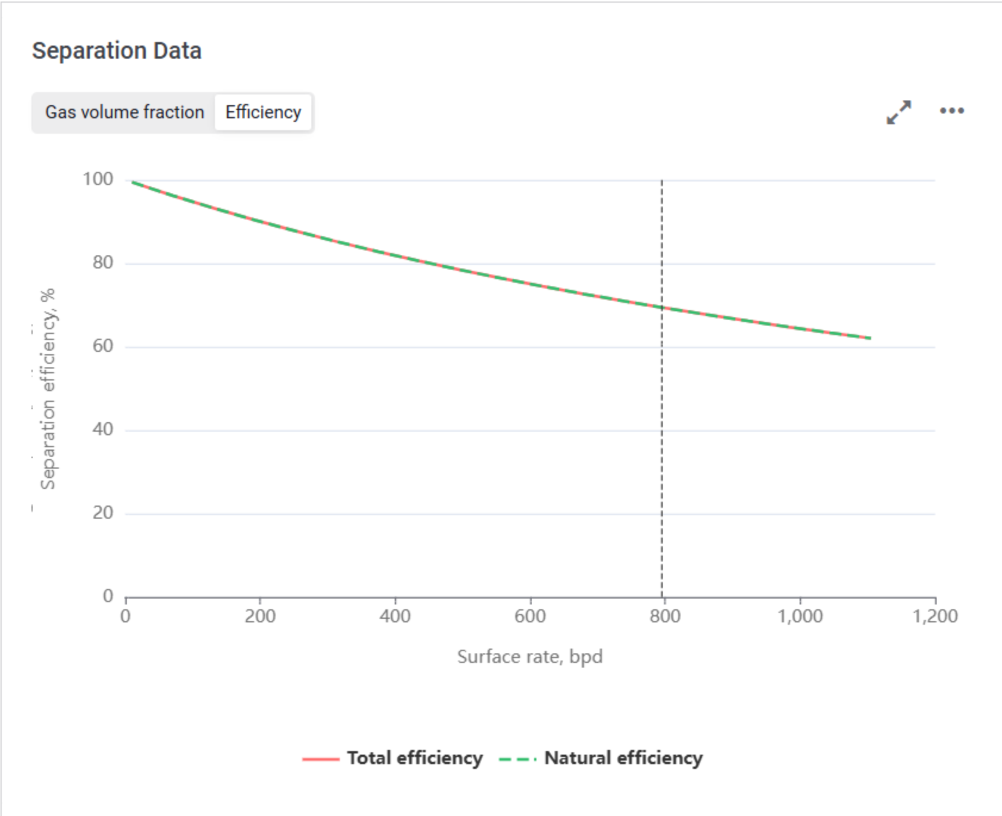
The pane provides visualization of the separation characteristics based on the parameters configured in the **Natural Separation** and **Gas separator** parameter groups (see description above).

The pane consists of two tabs:

- **Gas volume fraction**: Chart representing values of the gas volume fraction at intake and discharge depending on the surface flow rate.



- **Efficiency**: Chart representing total, natural and/or mechanical separation efficiency depending on the surface flow rate.



To show or hide a parameter on the chart, click the parameter name under it.

On hovering over any point on the chart, a window with information about the exact parameter values at this point is displayed.

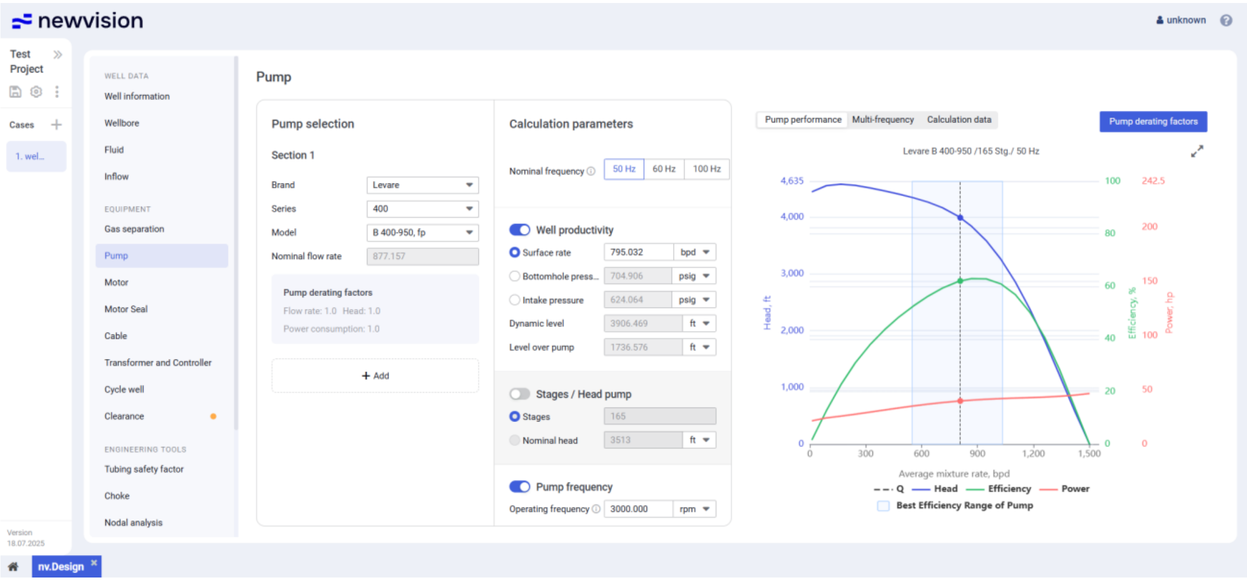
You can also expand the pane to full screen or collapse it back to the original size using the **Expand ( )** / **Collapse ( )** buttons located in the upper-right corner of the pane.

5.2.2.Pump

The **Pump** section provides information about the pump and target calculation parameters. This is the key section to which the equipment data must be added.
For details, see Configuring Pump Parameters.

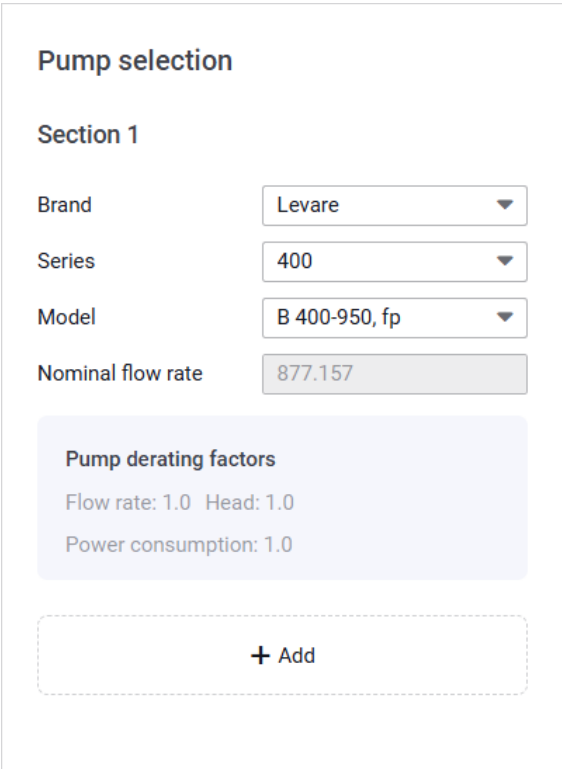
The section consists of three panes:

- **Pump selection** pane in the left part of the section.
- **Calculation parameters** pane in the central part of the section.
- Visualization pane in the right part of the section.



Pump Selection

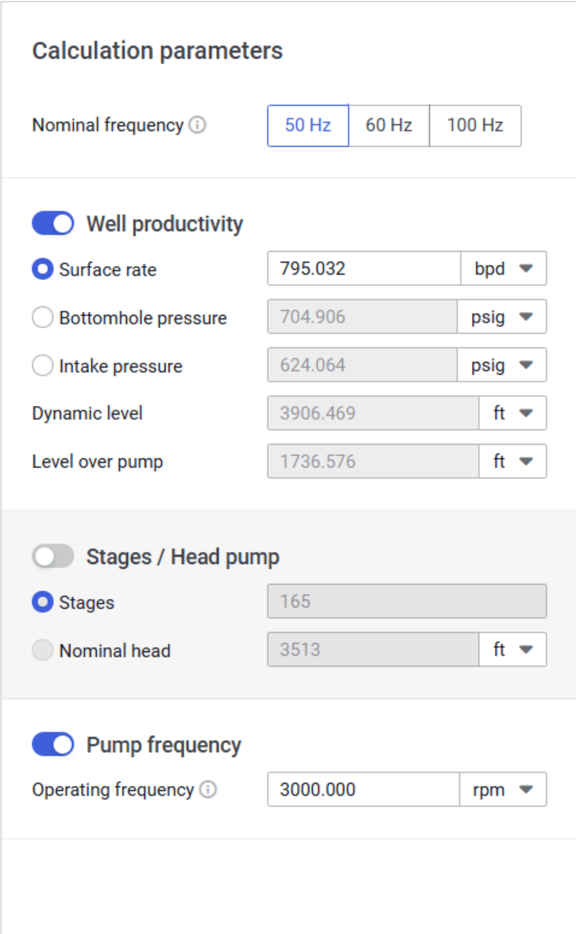
In this pane, you need to select a pump or several pump sections. To do this, click **Add (+)**, and then select the pump parameters from the corresponding lists.



At the bottom of each pump section, the **Pump derating factors** area is displayed. The default derating factor value is 1, which means the section is operational and working normally. You can edit the derating factor values in the **Derating factors** window. For details, see Configuring Pump Parameters.

Calculation Parameters

In this pane, you can configure target parameters of the pump that are required for the calculation.

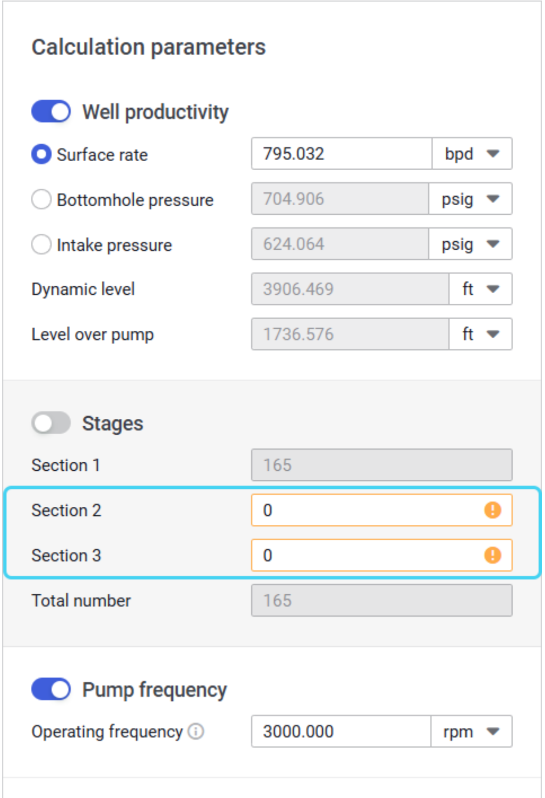


The pane contains three parameter groups:

- **Well productivity**
- **Stages**
- **Pump frequency**

You can select only two of these groups at the same time, the third will be calculated automatically. In case of conflicting inputs, other values are automatically recalculated.

Important
If there are several pump sections and the **Stages** parameter group is not selected, you still need to specify the number of stages for the second and third sections.



To select or deselect a parameter group, use the toggle to the left of the group name.

If only one pump section is selected in the **Pump selection** pane, at the top of the pane, the **Nominal frequency** parameter is displayed. Its value is used for calculating the pump's nominal flow rate and nominal head.
By default, the **50 Hz** option is selected.

Well productivity

In this group you can select one of the following target parameters and specify its value: **Surface rate**, **Bottomhole pressure**, or **Intake pressure**.

The **Surface rate** value is taken from the **Inflow** section. For details, see Inflow.

Stages

In this group, you can specify the number of stages of each pump section.

If there is only one section, instead of the number of stages, you can enter the nominal head value. The other parameter value is calculated automatically. If the number of stages is specified, the nominal head is calculated based on the catalog value obtained from the pump testing with water.

Pump Frequency

The group contains only one parameter, **Operating frequency**. By default, its value is set to 3600 rpm.

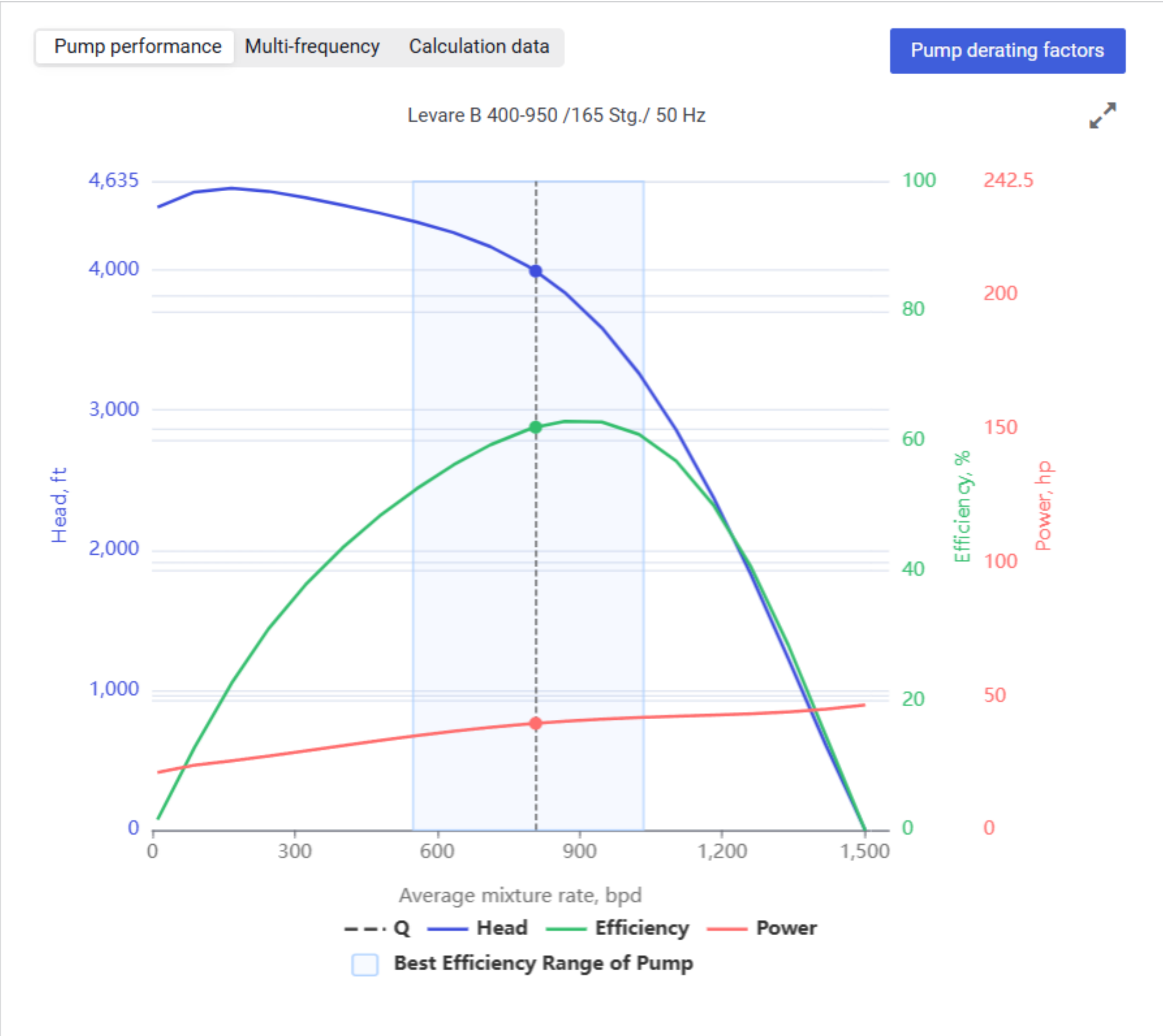
Visualization Pane

The pane contains charts that visualize pump operation characteristics.

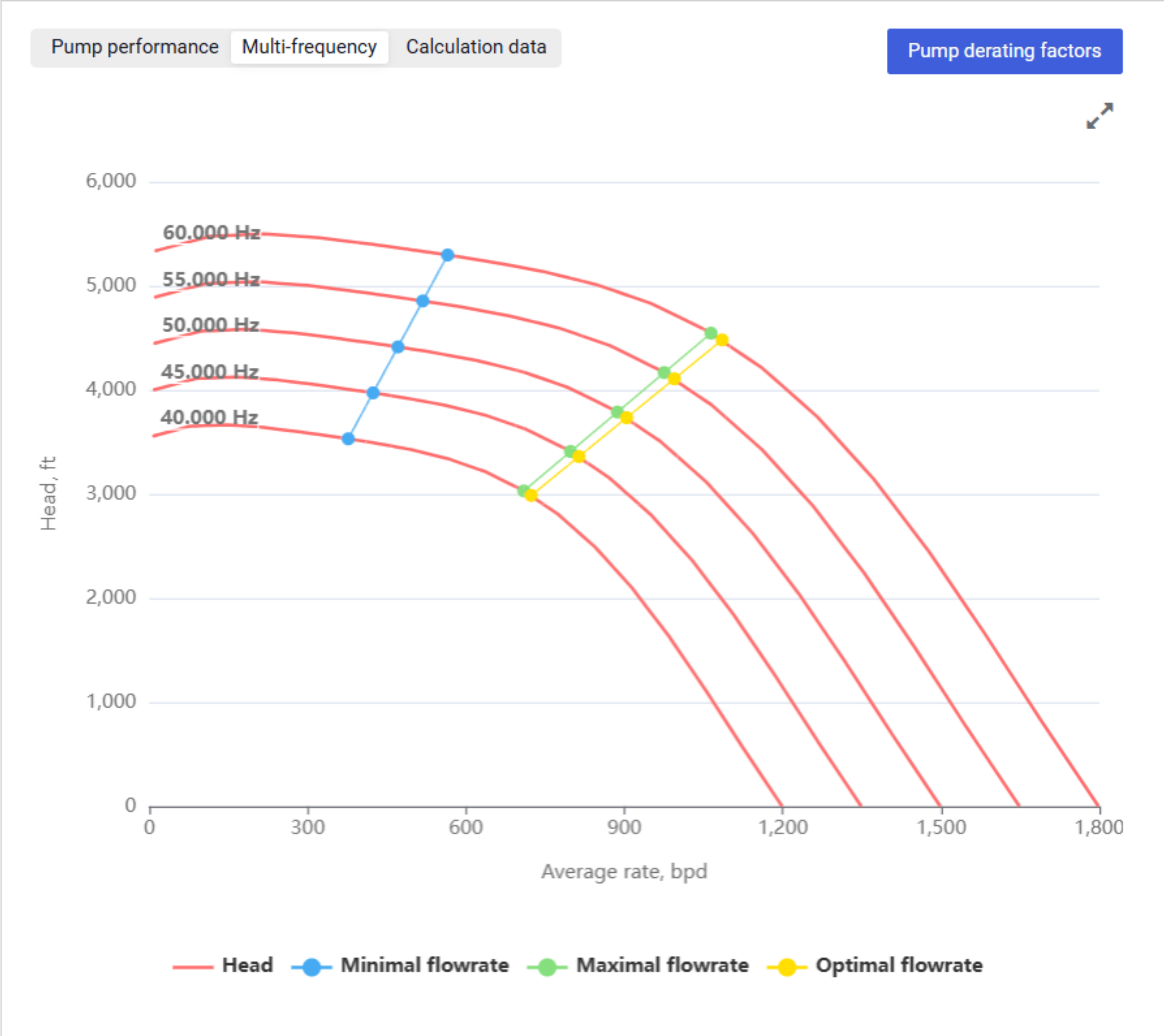
Depending on the number of pump sections, the pane may consist of different tabs.

If there is only one pump section, the following tabs are available:

- **Pump performance**: Provides the pump H-Q (head-flow) curve with values of the pump flow rate, head, efficiency, power, and operating range.



- **Multi-frequency**: Provides graphs of the pump head at various frequencies.



- **Calculation data**: Provides a table with values of the pump's pressure differential, efficiency, power consumption, shaft load, etc. These parameters help to select the most suitable motor, motor seal, cable, and surface equipment.

For example, the **Thrust load** value can be used to select a motor seal so that the thrust bearing load remains within acceptable limits.

Pump performance | Multi-frequency | Calculation data

Pump derating factors

Parameter	Value	Units
Δ Pressure	1803.991	psig
Efficiency	62.094	%
Average mixture rate	807.335	bpd
Power consumption	39.888	hp
Specific gravity	1.043	(mixture = 1)
Thrust load	664.367	lb
Total dynamic head	3994.081	ft
Shaft load	33	%
High strength shaft load	21	%

If there are two or three pump sections, the following tabs are available:

- **Complete unit**: Contains the same sub-tabs as a single-section pump (see description above) with integrated data for the whole pump configuration.
- **Section 1**: Provides the same data as the **Pump performance** tab (see description above) with the H-Q (head-flow) curve for the specific pump section.
- **Section 2**: Same as **Section 1**.
- **Section 3**: Same as **Section 1**.

To show or hide a parameter on the chart, click the parameter name under it.

On hovering over any point on the chart, a window with information about the exact parameter values at this point is displayed.

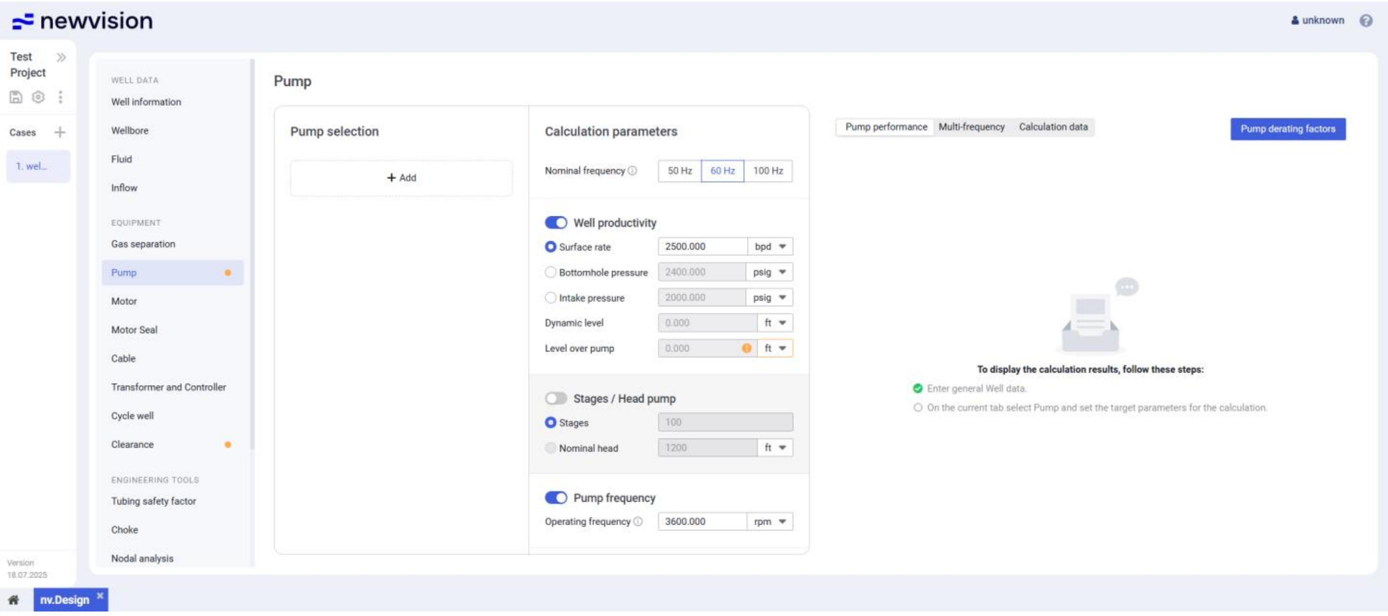
You can also expand the pane to full screen or collapse it back to the original size using the **Expand ( ) / Collapse ( )** buttons located in the upper-right corner of the pane.

5.2.2.1. Configuring Pump Parameters

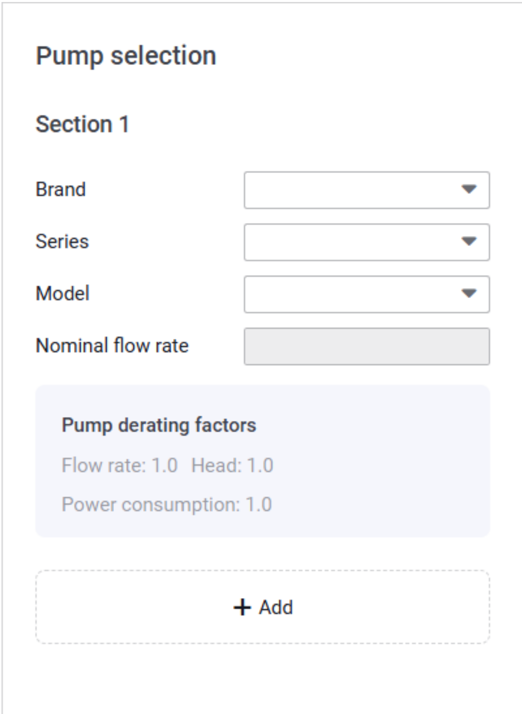
To configure parameters of the pump installed in the well, perform the following actions:

1. Open the **nv.design** module.
   For details on navigation in the system, see System Interface.

2. In the left part of the working area, in the list of the module sections, click **Pump**. To the right of the list, the **Pump** section opens.



3. In the **Pump selection** pane, click **Add (+)**. The **Section 1** parameter group appears.



4. Under the **Section 1** heading, select a manufacture, series and model of the first pump section from the corresponding lists.
5. *(Optional)* To add one or two more pump sections, repeat Steps 3–4.

6. *(Optional)* To edit pump derating factors for the pump sections, perform the following actions:
    a. In the upper-right corner of the section, click **Pump derating factors**.
    The **Derating factors** window opens.

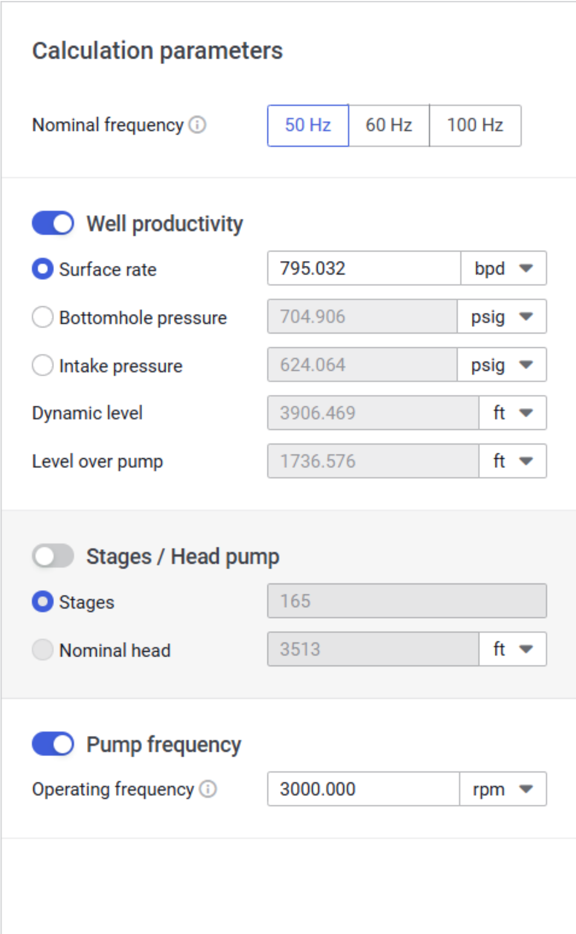
    b. In the window that opens, in the **Flow rate**, **Head**, and **Power consumption** fields, enter the derating factor values for the desired pump sections.
    In the right part of the window, tabs with charts representing the pump operation characteristics are adjusted according to the entered derating factors. For details on these charts, see Pump.
    Warnings, if there are any, are displayed below the charts.

    Note

    If the entered factors and/or other parameters configured in the **Pump** section are not feasible, charts are not displayed. In this case, you need to change the input data.

    c. At the bottom of the window, click **Save**.

7. In the **Calculation parameters** pane, enable two of the three parameter groups based on which further calculations will be performed. To do this, use the toggle to the left of the group name.

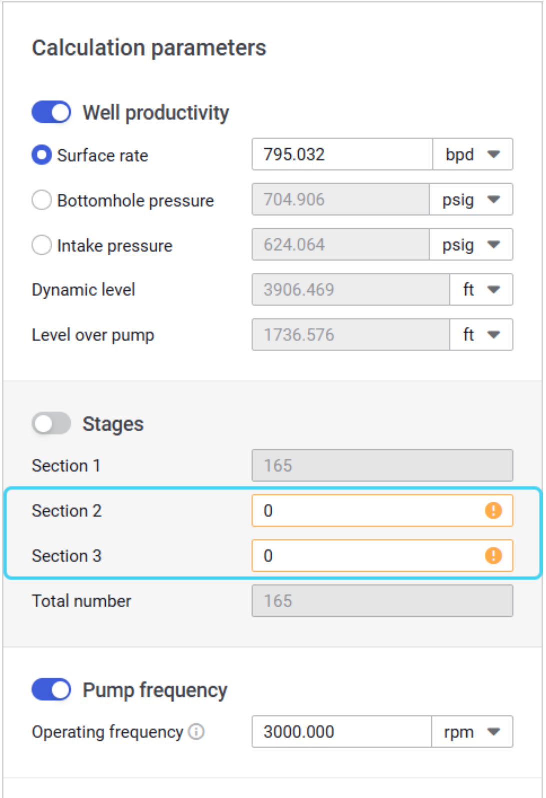


8. Depending on the selected groups, perform the following actions:

   - *(For **Well productivity**)* Select the target parameter (**Surface rate**, **Bottomhole pressure**, or **Intake pressure**) and specify its value.
     The other group parameters are calculated automatically.
   - *(For **Stages**)* Depending on the number of the pump sections, perform one of the following actions:
     - If there is only one section, select the parameter based on which the calculation will be performed (**Stages** or **Nominal head**) and specify it value.
       The other parameter is calculated automatically.
     - If there are two or three sections, specify the number of stages for the second and the third sections.
   - *(For **Pump frequency**)* Specify the pump operating frequency.
     The default value is 3 600 rpm.

Note

Even if the **Stages** parameter group is not enabled, if the pump consists of two or three sections, you still need to specify the number of stages for each of them.



9. After the configuration is completed, in the right part of the section, charts representing the pump performance are displayed. For details on the charts that are displayed in the visualization pane, see Pump.
10. To save changes, in the left part of the module, click **Save ( )** under the name of the current project.

5.2.3. Motor

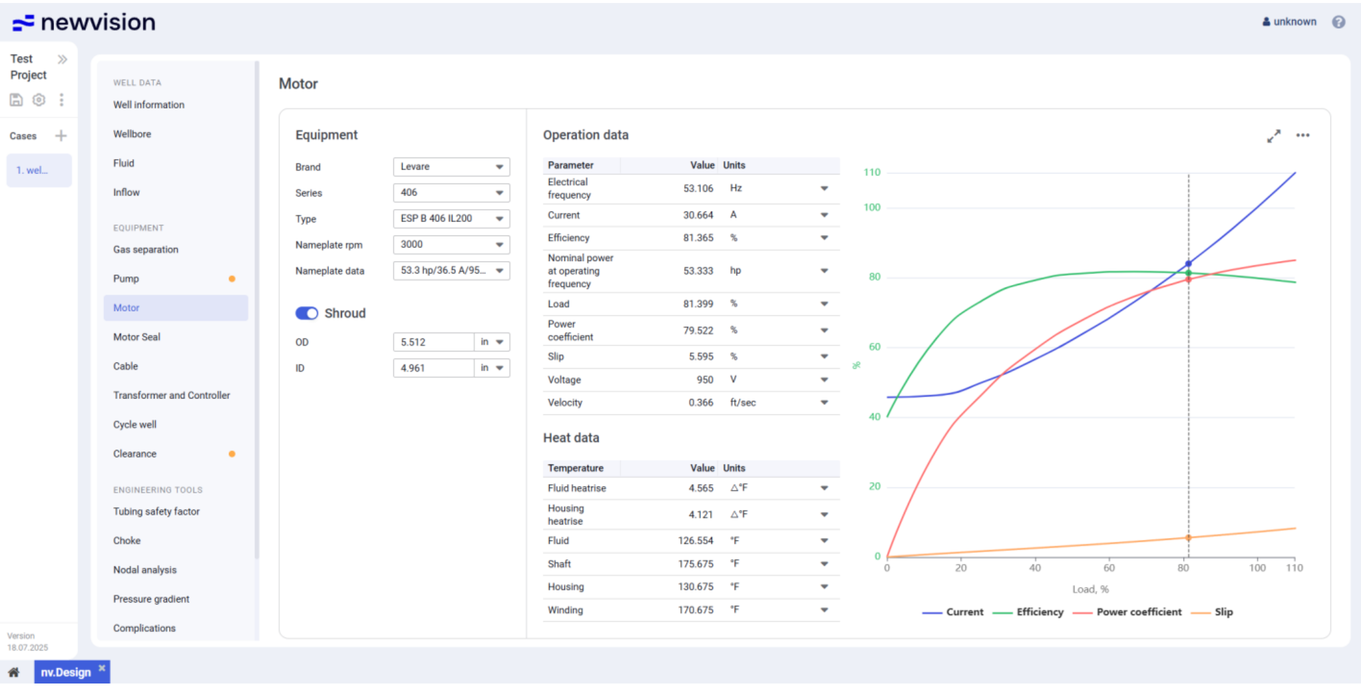
The **Motor** section provides information about the pump motor installed in the well.

Note

To perform calculations in this section, you need to specify general well parameters and pump data. For details, see Well Data and Pump.

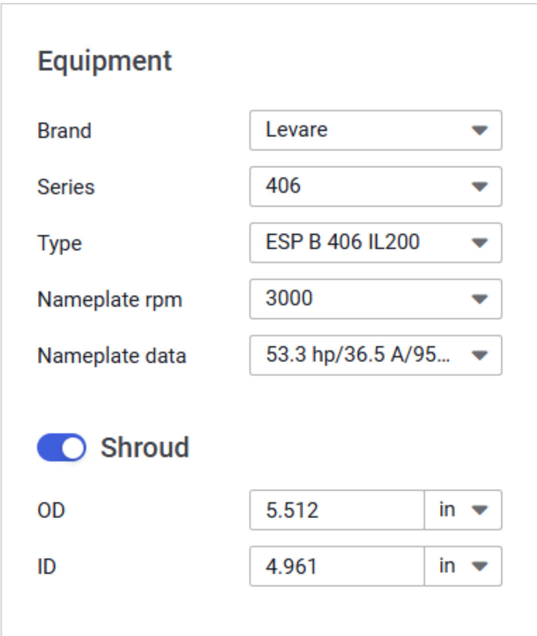
The section consists of the following parts:

- **Equipment** pane in the left part of the section.
- **Operation data** and **Heat data** tables in the central part of the section.
- Visualization pane in the right part of the section.



Equipment

The pane provides controls for the motor selection.



To select a motor, select the desired options from the parameter lists.

Note

The **nv.design** module supports calculations for permanent magnet (PM) motors, high-speed, and low-speed motors (for PCP lift type).

If a shroud is used, enable the **Shroud** parameter group using the corresponding toggle.

Note

To enable the **Shroud** group, all motor parameters must be specified.

In the **Shroud** group, you can edit default values of the shroud outer (**OD**) and inner (**ID**) diameters.

If the shroud is not used, the fluid velocity is calculated in the annular space between the casing and the motor housing.

Operation Data and Heat Data

The **Operation data** and **Heat data** tables provide calculation results for the selected motor configuration.

Operation data

Parameter	Value	Units
Electrical frequency	53.106	Hz
Current	30.664	A
Efficiency	81.365	%
Nominal power at operating frequency	53.333	hp
Load	81.399	%
Power coefficient	79.522	%
Slip	5.595	%
Voltage	950	V
Velocity	0.366	ft/sec

Heat data

Temperature	Value	Units
Fluid heatrise	4.565	△°F
Housing heatrise	4.121	△°F
Fluid	126.554	°F
Shaft	175.675	°F
Housing	130.675	°F
Winding	170.675	°F

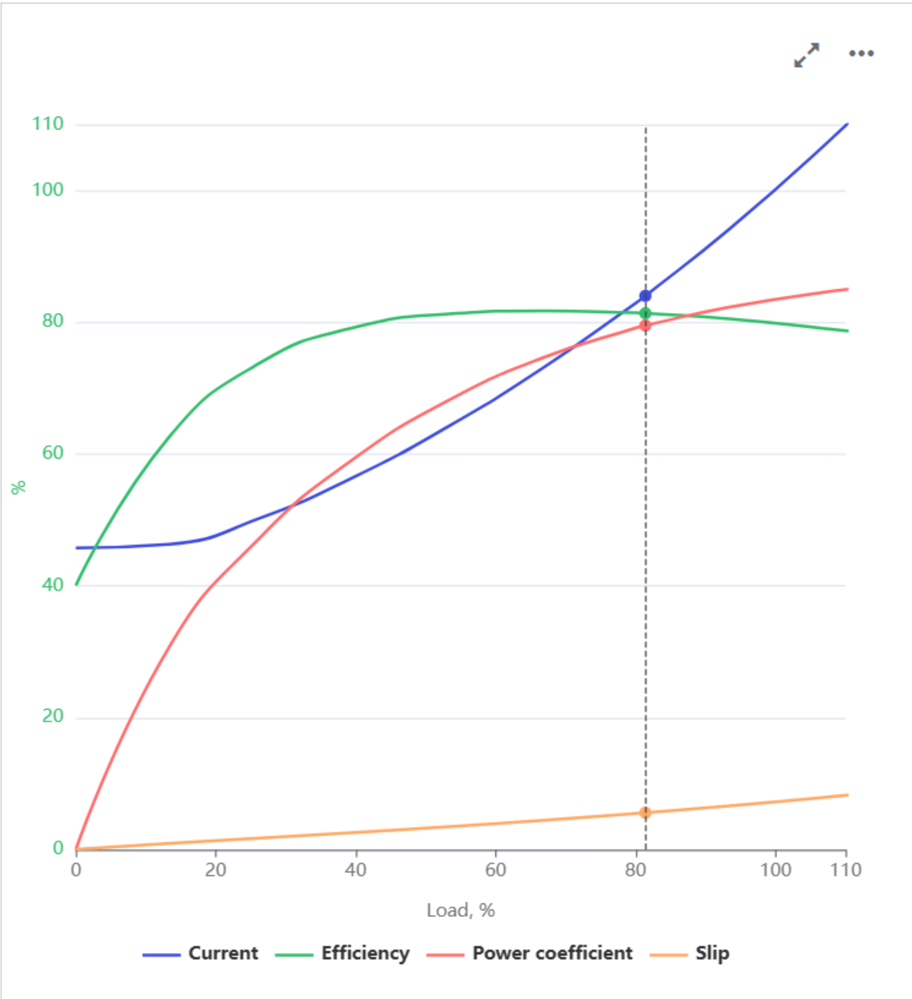
The **Electrical frequency** parameter corresponds to the rate at which the alternating current changes direction. It determines the rotational speed of the magnetic field in the motor stator and directly affects the shaft's rotational speed. This value is calculated based on the number of motor poles and the actual rotor speed. In induction motors, the rotor always spins slightly slower than the magnetic field—a phenomenon called slip (the **Slip** parameter in the table)—which is essential for generating torque.

> **Note**
> The **Electrical frequency** parameter is displayed and must be set by the dispatcher on the controller as a key operating parameter.

The **Velocity** parameter and parameters from the **Heat data** table can be used to select a motor with suitable dimensional specifications and maximum winding temperature.

Visualization Pane

The pane contains a chart that represents the motor performance parameters under varying motor loads (X-axis) along with their percentages compared to nominal values (Y axis).



On hovering over the chart, a vertical dashed line is displayed. The intersection points of the line with the parameter curves represent the motor operating points. On hovering over these points, a window with information about the exact parameter values at this point is displayed.

To show or hide a parameter on the chart, click the parameter name under it.

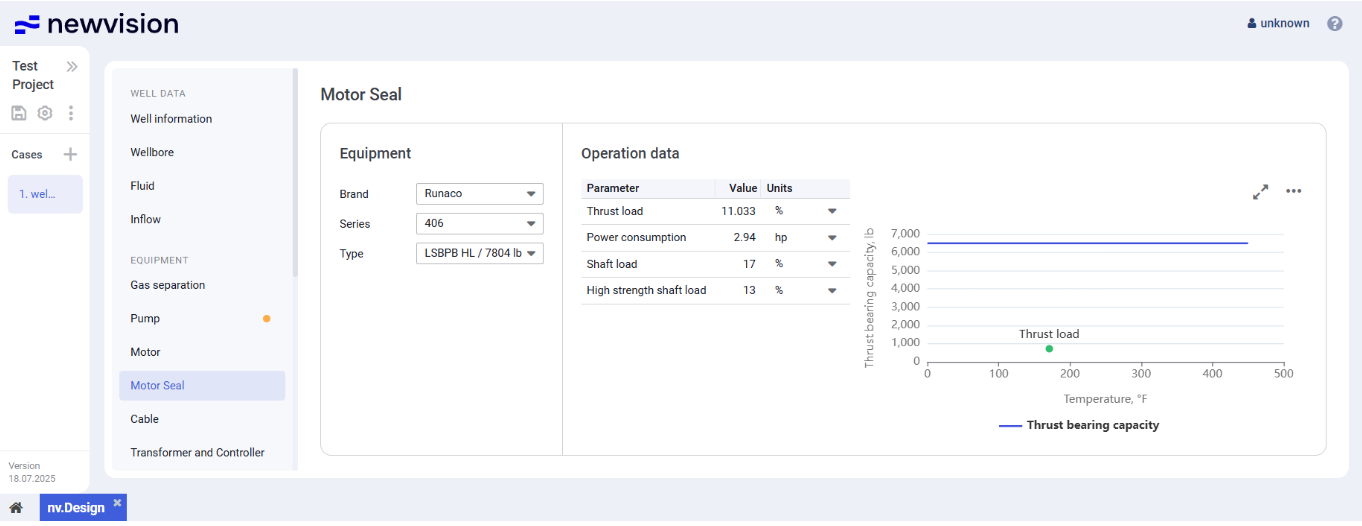
You can also expand the pane to full screen or collapse it back to the original size using the **Expand (** ⤢ **)** / **Collapse (** ⤡ **)** buttons located in the upper-right corner of the pane.

5.2.4. Motor Seal

The **Motor Seal** section provides information about the seal installed at the motor.

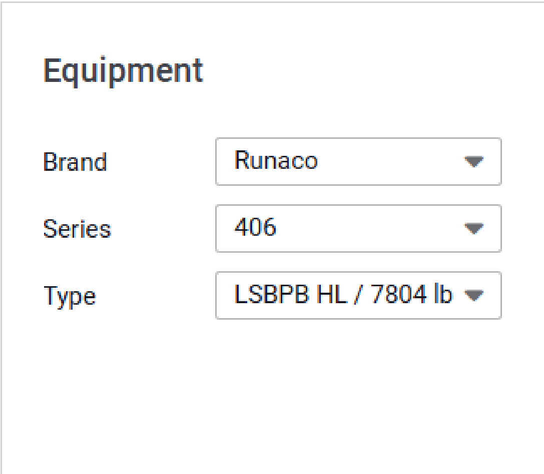
The section consists of the following parts:

- **Equipment** pane in the left part of the section.
- **Operation data** table in the central part of the section.
- Visualization pane in the right part of the section.



Equipment

The pane provides controls for the motor seal selection.



To select a seal, select the desired options from the parameter lists.

Operation Data

The **Operation data** table provides calculation results for the selected motor seal. The motor seal capacity and load are calculated based on the thrust load value from the **Calculation data** table in the Pump section.

Operation data

Parameter	Value	Units
Thrust load	11.033	%
Power consumption	2.94	hp
Shaft load	17	%
High strength shaft load	13	%

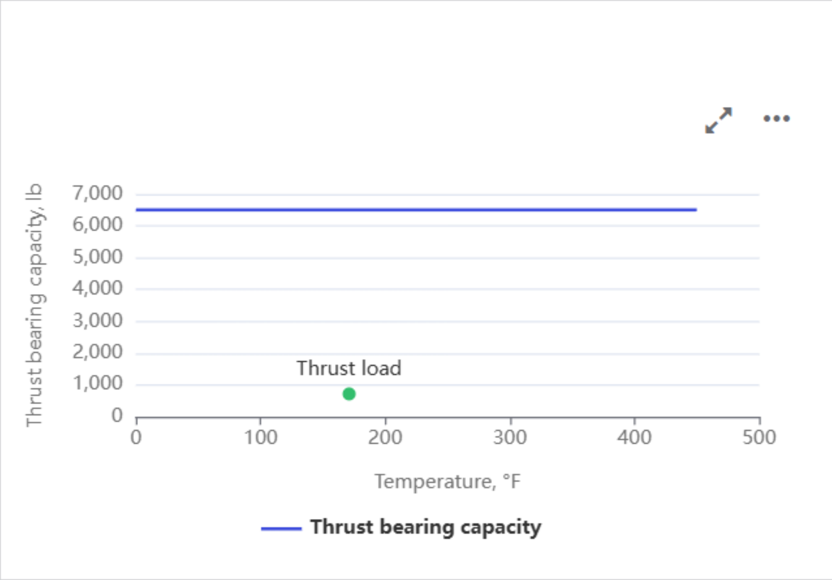
The table contains values of the following parameters expressed in percentages relative to their nominal values:

- **Thrust load**: Actual thrust load relative to the nominal thrust bearing capacity.
- **Power consumption**: Estimated energy consumption of the motor seal.
- **Shaft load**: Load on the shaft relative to the maximum allowable load for a standard-strength shaft.
- **High strength shaft load**: Load on the shaft relative to the maximum allowable load for a high-strength shaft.

If any of the calculated load values exceed acceptable thresholds, the system shows a warning that recommends selection of a motor seal with a higher thrust capacity.

Visualization Pane

The pane contains a motor seal performance chart displaying the **Thrust bearing capacity** parameter values at different operating temperatures.



The green dot represents the current operating point. On hovering over it, a window with information about the thrust load and corresponding temperature is displayed.

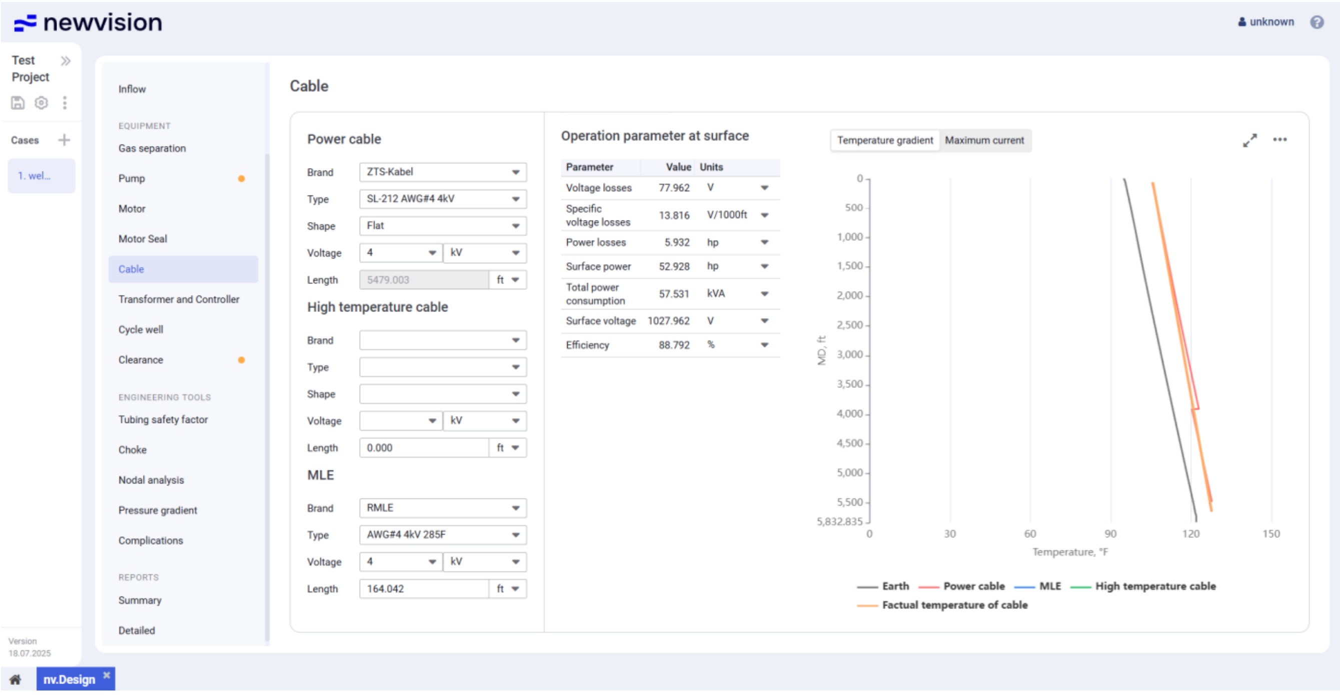
You can also expand the pane to full screen or collapse it back to the original size using the **Expand ( )** / **Collapse ( )** buttons located in the upper-right corner of the pane.

5.2.5.Cable

The **Cable** section provides information about the cable. You can configure up to three cable segments.

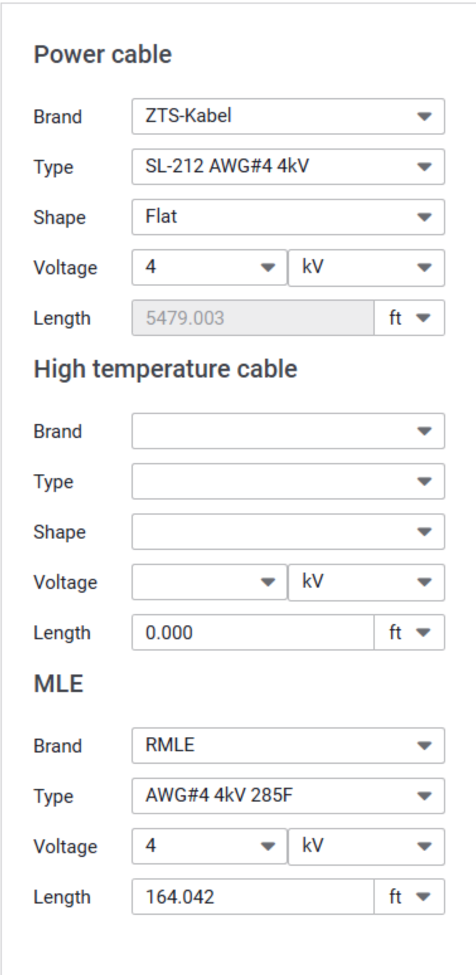
The section consists of the following parts:

- **Power cable**, **High temperature cable**, and **MLE** parameter groups in the left part of the section.
- **Operation parameter at surface** table in the central part of the section.
- Visualization pane in the right part of the section.



Power Cable, High Temperature Cable, and MLE

These parameter groups provide controls for selection and configuration of the cable segments.

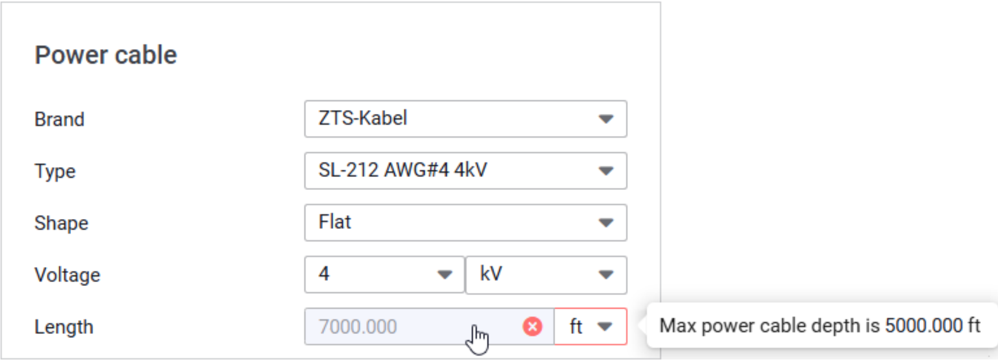


Power cable

This is the main parameter group. Power cable is typically laid from the surface to the ESP setting depth. Its length is calculated automatically and equals the installation depth specified in the **Wellbore** section. For details, see [Wellbore configuration].

The system also provides a warning mechanism that evaluates the maximum allowable cable power cable length based on the temperature down the wellbore. If the wellbore temperature exceeds the power cable's maximum nominal value, the error icon ( ) is displayed. In this case, a high-temperature cable must be used.

For example, if the ESP setting depth is 7 000 ft and the tooltip says 'Max power cable depth is 5 000 ft', that means that a high-temperature cable and/or motor lead extension (see description below) must be used for 2 000 ft.



High temperature cable

High temperature cables are recommended for high-temperature zones (e.g., due to hot fluid, high reservoir temperature, or significant operating currents) where considerable heat generation may occur.

Such cables are designed for enhanced thermal resistance and should be routed from the ESP setting depth to the depth at which the temperature becomes acceptable for a standard power cable.

MLE (Motor Lead Extension)

Extensions are used in the pump setting zone to connect the cable to the motor with a transition to a different thermal rating.

Note

Lengths of the high temperature cable and motor lead extension are entered manually. The length of the power cable is adjusted accordingly to maintain the total installation depth.

Operation Parameter at Surface

The **Operation parameter at surface** table provides calculation results for the selected cable configuration.

Operation parameter at surface

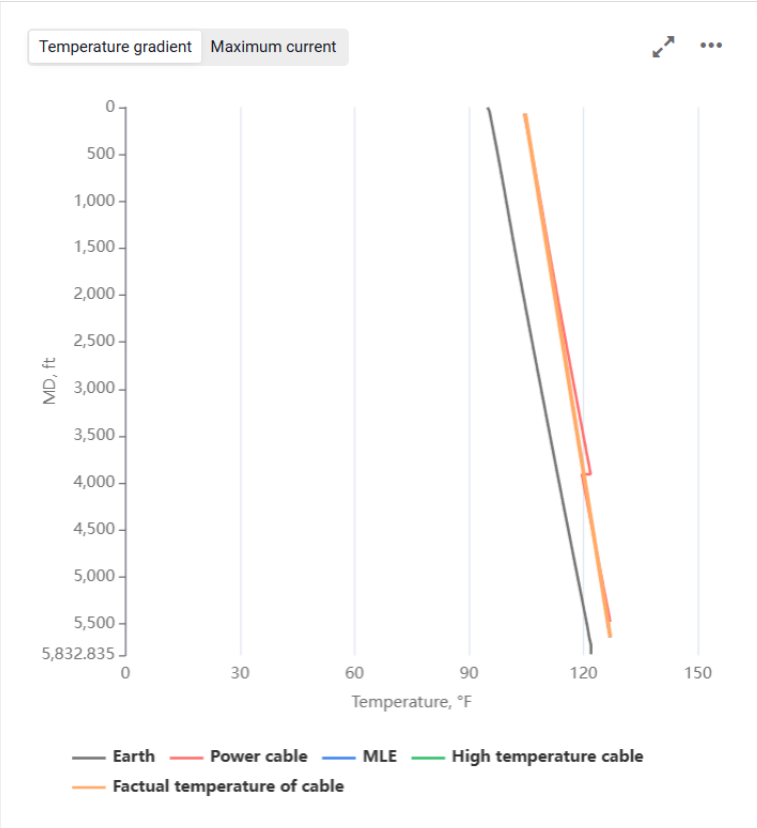
Parameter	Value	Units
Voltage losses	77.962	V
Specific voltage losses	13.816	V/1000ft
Power losses	5.932	hp
Surface power	52.928	hp
Total power consumption	57.531	kVA
Surface voltage	1027.962	V
Efficiency	88.792	%

Visualization Pane

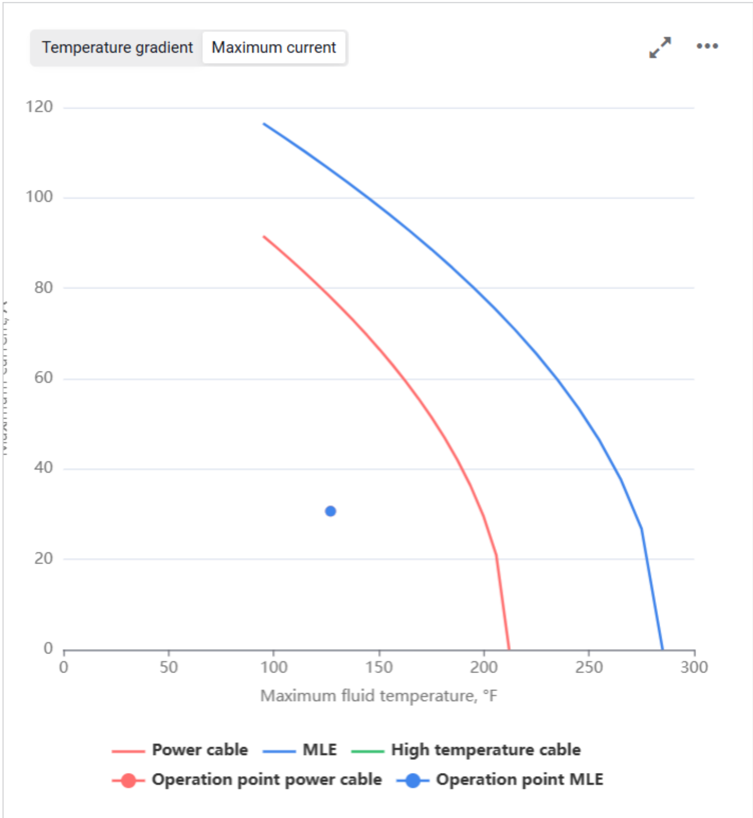
The pane consists of two charts distributed on different tabs:

- **Temperature gradient**: Chart representing temperature distribution along the submersible electric cable.
  The **Power cable**, **MLE**, and **High temperature cable** curves account for the following physical phenomena: temperature jumps when transitioning from gas to liquid, splices, insulation and armor losses, annulus thermal gradient considering inclination, etc.

The **Factual temperature of cable** curve reflects the dynamic longitudinal redistribution of temperature over time along the entire cable length.



- **Maximum current**: Chart representing dependence of the allowable current on the maximum temperature of the well fluid.



To show or hide a parameter on the chart, click the parameter name under it.

On hovering over any point on the chart, a window with information about the exact parameter values at this point is displayed.

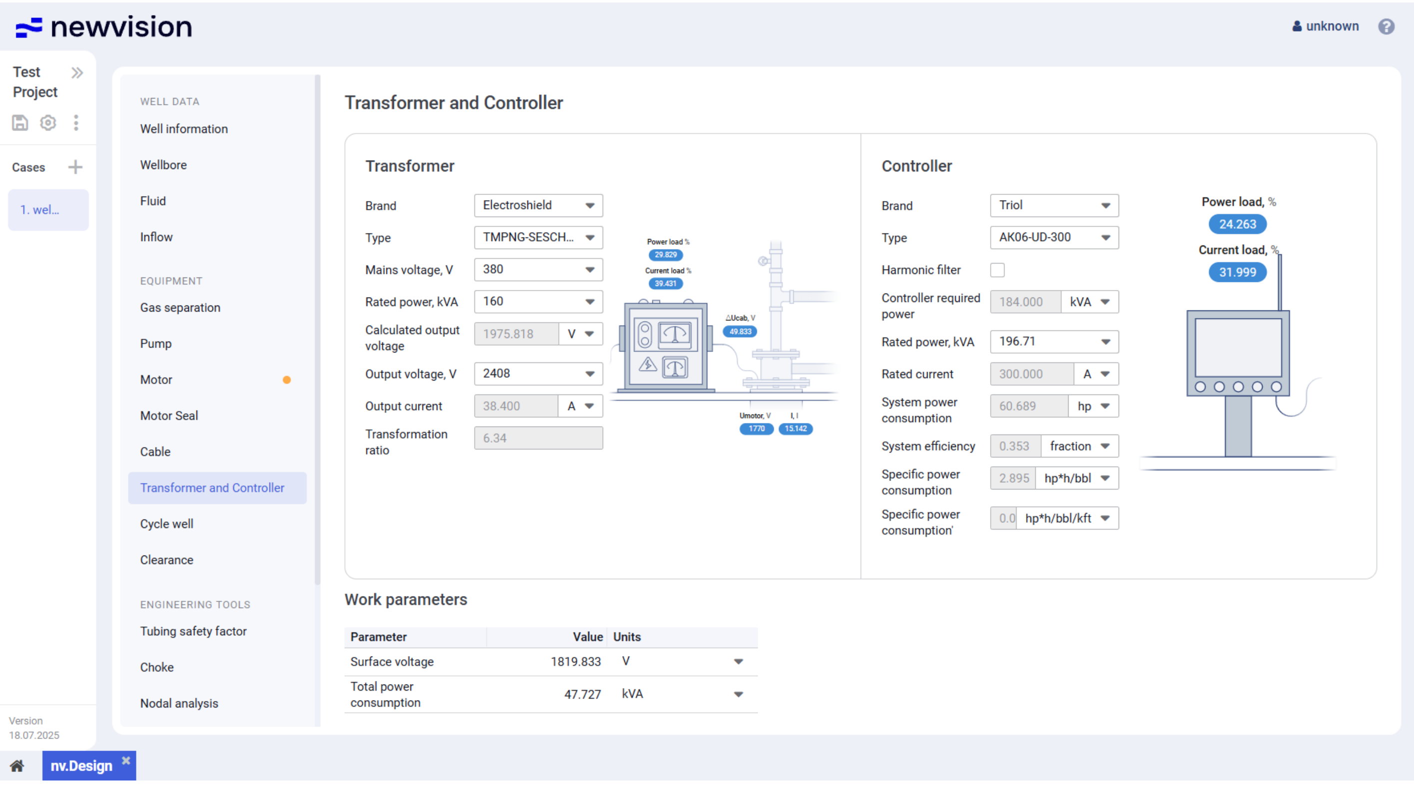
You can also expand the pane to full screen or collapse it back to the original size using the **Expand ( ) / Collapse ( )** buttons located in the upper-right corner of the pane.

5.2.6. Transformer and Controller

This section provides information about the surface equipment layout, specifically controller and transformer.

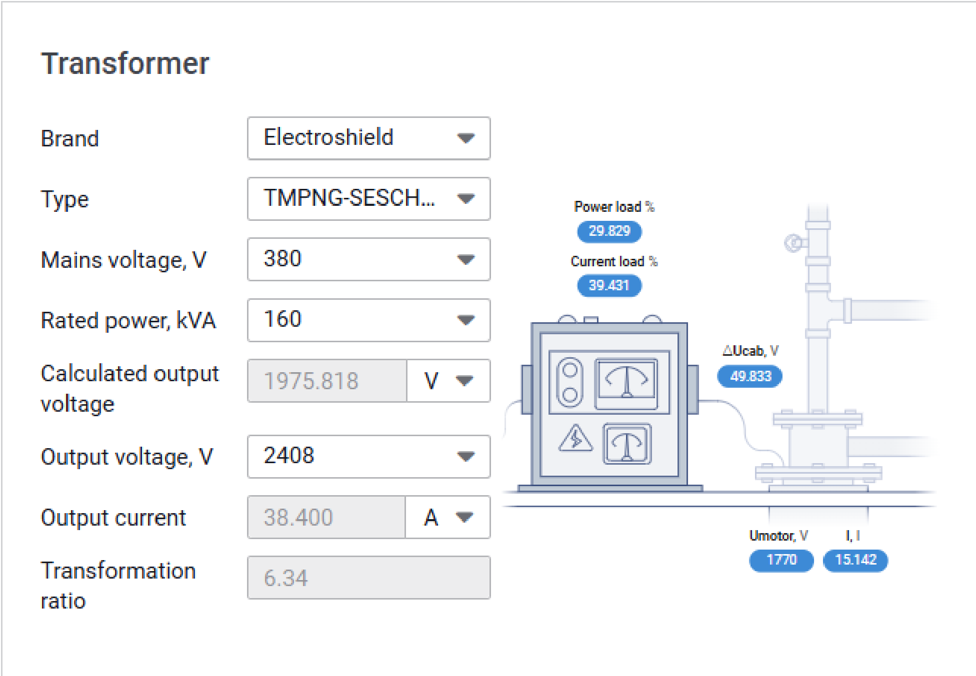
The section consists of the following panes:

- **Transformer**
- **Controller**
- **Work parameters**



Transformer

The pane provides controls for the transformer selection and configuration.



To select a transformer, select the desired options from the corresponding parameter lists.

The **Calculated output voltage** parameter refers to the voltage considering losses across all elements in the system. It is calculated based on other input parameters in the group.

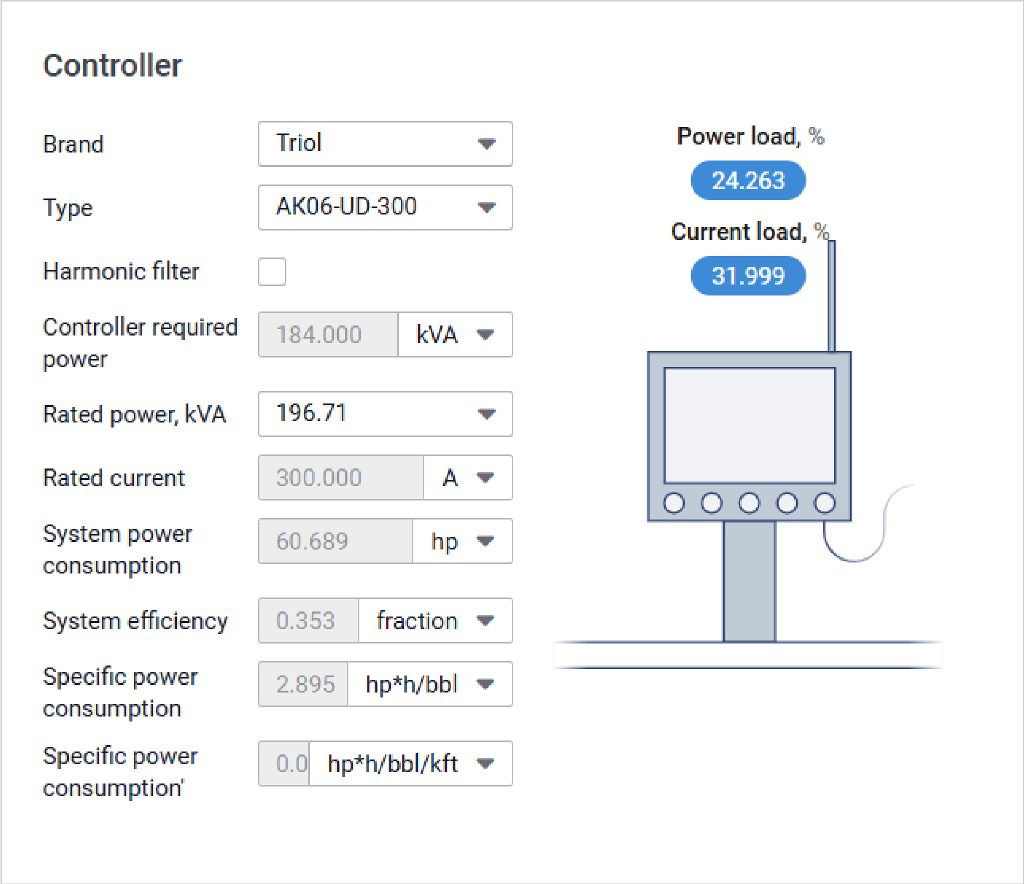
The **Output voltage** value corresponds to the selected tap voltage. It is selected from the list and must be as close as possible but slightly greater than the **Calculated output voltage** value.

The **Transformation ratio** parameter reflects the relationship between the input and output voltages of the transformer. The value is calculated automatically.

In the left part of the pane, a simplified visualization of the selected transformer configuration is displayed. Labels with values of the key parameters provide the ability to assess efficiency of the equipment.

Controller

The pane provides controls for the controller selection and configuration.



To select a controller, select the desired options from the corresponding parameter lists.

The control unit must be capable of handling both operating and starting voltage and current.

In the left part of the pane, a simplified visualization of the selected controller configuration is displayed. Labels with values of the key parameters provide the ability to assess efficiency of the equipment.

Work Parameters

The pane provides a table with values of the following operating parameters:

- **Surface voltage**: Based on this value, you can select the required transformer tap.
- **Total power consumption**: Based on this value, you can select a transformer with an appropriate nominal power.

Work parameters

Parameter	Value	Units
Surface voltage	1819.833	V
Total power consumption	47.727	kVA

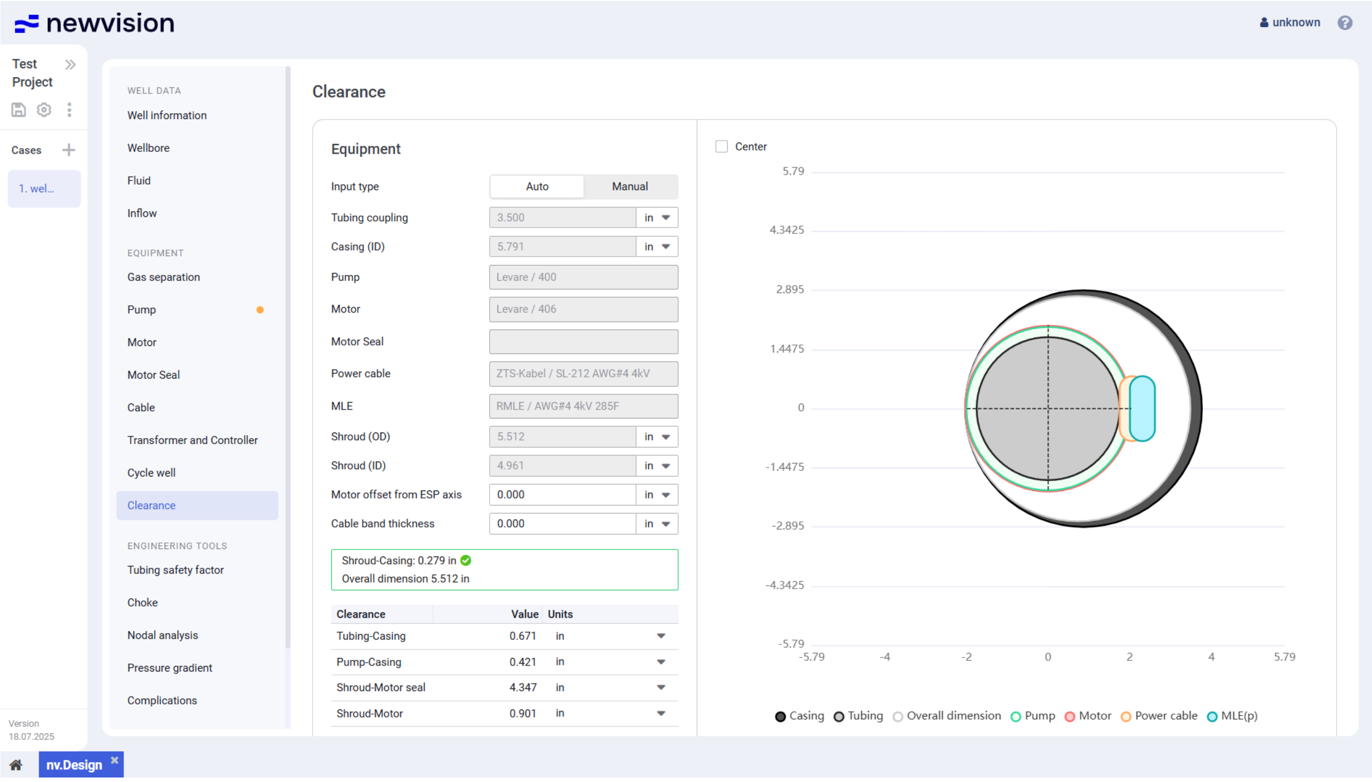
Both values are taken from the **Operation parameter at surface** table in the Cable section.

5.2.7.Clearance

The **Clearance** section provides information about the equipment dimensions and the minimum required clearance. This data is required to ensure that all downhole equipment can be safely run into the wellbore.

The section consists of the following parts:

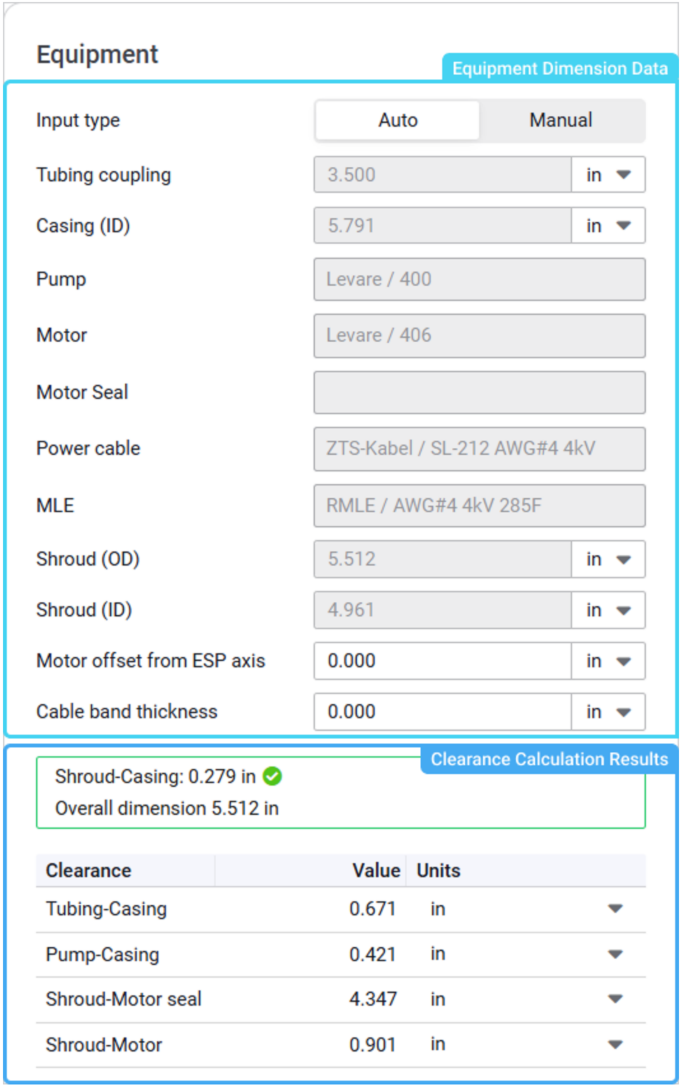
- **Equipment** pane in the left part of the section.
- Visualization pane in the right part of the section.



Equipment

The pane is divided into two parts:

- Equipment dimension data in the upper part of the pane.
- Clearance calculation results in the lower part of the pane.



To select a method of the equipment dimension data input, select the desired option of the **Input type** parameter:

- **Auto**: Data is filled in automatically from other **nv.design** module sections.
- **Manual**: Data is entered manually to perform preliminary clearance checks to determine whether clearance values fall within acceptable limits even before detailed calculations are performed.

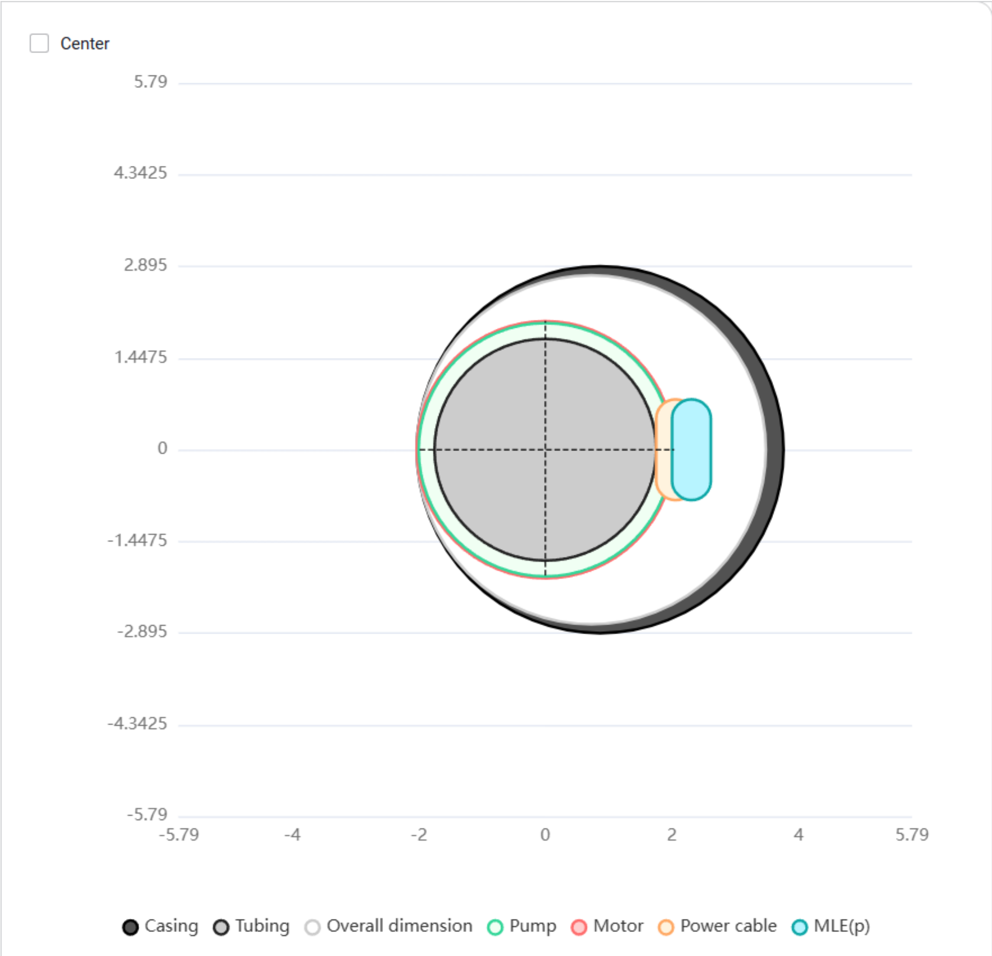
In the lower part of the pane, there is a table with the clearance calculation results.

At the top of the table, the summary data is displayed:

- **Equipment clearance**: Minimum clearance between the assembly components (taken from the table below).
  Green check mark ( ) next to the value indicates that the clearance is sufficient for feasibility and operational safety of the installation process.
  Red cross ( ) means that the clearance is too small and must be fixed.
- **Overall dimension**: Maximum outer diameter of the entire assembly based on the equipment dimensions.

Visualization Pane

The pane contains a simplified layout of the ESP string inside the well.



You can adjust the assembly layout to match the axis of the ESP and the production tubing to ensure proper placement and balance. To do this, in the upper-left corner of the pane, select the **Center** check box.

To show or hide a parameter on the layout, click the parameter name under it.

5.3. Reports

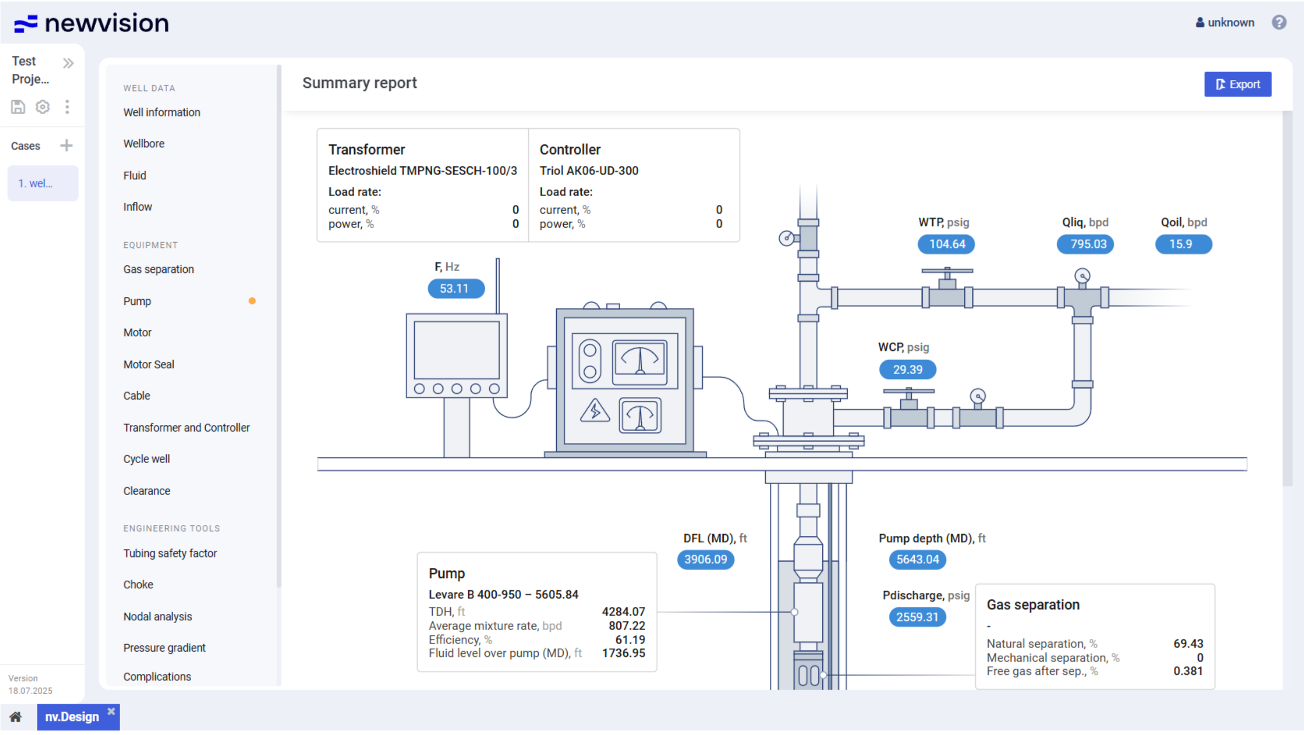
The group consists of the following sections:

- Summary
- Detailed

5.3.1.Summary

The **Summary** section provides a comprehensive graphical representation summarizing all input data, calculation results, selected equipment, and performance characteristics.

It can be used as a final output document that you can export to PDF or print for documentation, review, or decision-making purposes.

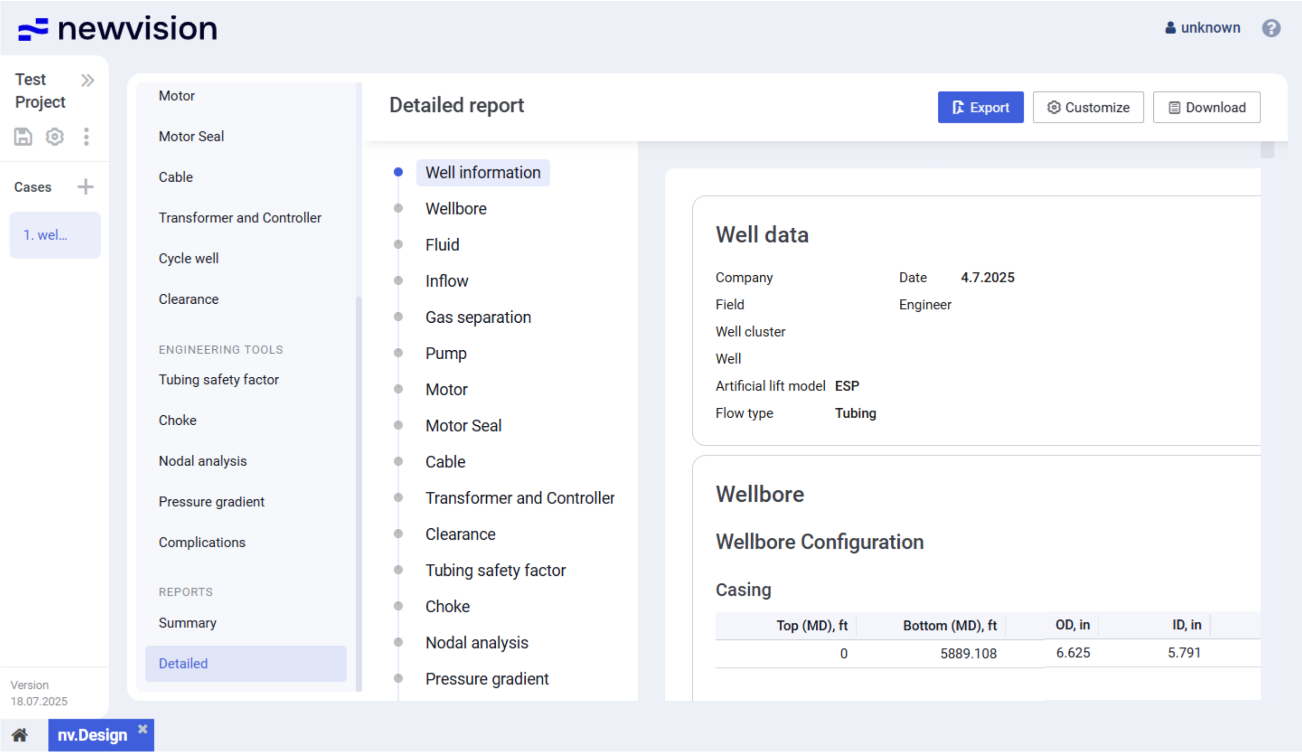


To export or print the report, in the upper-right corner of the report, click **Export ( )**, and then, in the standard browser window, select the desired action.

5.3.2.Detailed

The detailed report provides an in-depth breakdown of all user inputs, calculation results, selected models, and performance parameters for each section of the well configuration.

It includes tables, charts, equipment specifications, and calculation steps, making it suitable for technical review, auditing, and project documentation.



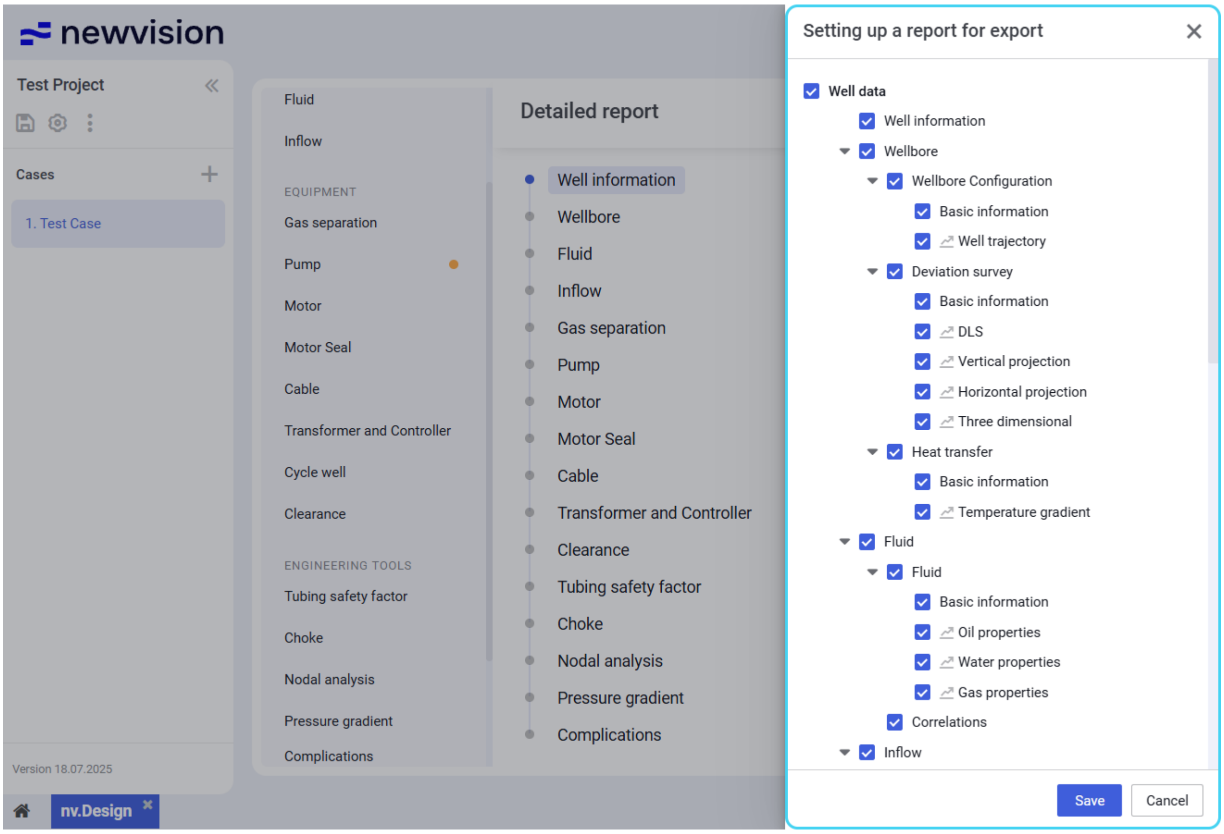
Well parameters in the report are organized into logical groups (sections). The list of sections is displayed in the left part of the report. You can navigate to the desired section by clicking its header in the list or by scrolling the report.

You can export the report to PDF and XLSX as well as print it.

To export the report to PDF or print it, in the upper-right corner of the report, click **Export ( )**, and then, in the standard browser window, select the desired action.

To export the report to XLSX, in the upper-right corner of the report, click **Download ( )**.

You can also configure the sections displayed in the report. To do this, in the upper-right corner of the report, click **Customize (⚙)**, and then, in the window that appears, select and/or clear check boxes of the sections that you want to show or hide in the report.



Note

Changes in the report configuration affect only the PDF export. Reports exported to XLSX contain all sections, including those that were hidden.

A1. OIL

A1.1. Bubble Point Pressure and Gas Solubility

Al-Marhoun

The Al-Marhoun correlation (1988) was developed to calculate the bubble point pressure of crude oil based on data from Middle Eastern oilfields. It takes into account temperature, gas-oil ratio, gas density, and oil density. It was specifically designed for Middle Eastern crude oils. The correlation provides good accuracy for high-sulfur oils and serves as an alternative to the Standing and Vasquez & Beggs correlations for certain regions.

Recommended applicability range:

- Oil density (API Gravity): 20 – 55 °API
- Gas-oil ratio: 25 – 1600 SCF/STB
- Temperature: 75 – 240 °F
- Pressure: 130 – 3500 psi

De Ghetto et al.

The De Ghetto et al. correlation (1995) provides several specialized formulas for calculating bubble point pressure based on oil density. The method is derived from data from Mediterranean and Venezuelan oilfields. The correlation offers high accuracy for heavy and medium crudes, where traditional correlations (Standing, Vasquez & Beggs) often produce significant errors. For extra-heavy oils (<10 °API), it is the only correlation that delivers acceptable accuracy.

Recommended applicability range:

- Oil density (API Gravity): 5 – 40 °API
- Gas-oil ratio: 20 – 1500 SCF/STB
- Temperature: 100 – 280 °F

Glaso

The Glaso correlation was developed based on an extensive database of crude oils from the North Sea and other regions. It accounts for the influence of gas-oil ratio, temperature, oil density, and gas specific gravity, making it applicable to various types of fluids. The method uses logarithmic transformations and polynomial relationships, providing high accuracy, especially for light and medium oils. Unlike earlier correlations (e.g., Standing), the Glaso correlation performs better for oils

containing dissolved gas over a wide pressure range.
Recommended applicability range:

- Oil density (API Gravity): 22 – 48 °API
- Gas-oil ratio: 90 – 2500 SCF/STB
- Temperature: 80 – 280 °F
- Pressure: 100 – 5000 psi

Lasater

The Lasater correlation is one of the earliest reliable methods for calculating the bubble point pressure of crude oil. The calculation is based on the mole fraction of dissolved gas. It shows particular accuracy for medium and heavy oils (< 40 °API). The method uses empirical relationships derived from the analysis of oils from Canada and the United States.
Recommended applicability range:

- Oil density (API Gravity): 15 – 45 °API
- Gas-oil ratio: 50 – 3500 SCF/STB
- Temperature: 100 – 300 °F
- Pressure: 100 – 5000 psi

Petrosky

The Petrosky correlation was developed for crude oils from the Gulf of Mexico. It demonstrates improved accuracy for this region compared to traditional methods. The correlation accounts for the thermodynamic properties of offshore shelf crudes and serves as an alternative to the Standing and Vasquez & Beggs correlations for offshore fields. The average error is ±6.5% compared to laboratory data.
Recommended applicability range:

- Oil density (API Gravity): 16 – 45 °API
- Gas-oil ratio: 200 – 1500 SCF/STB
- Temperature: 110 – 300 °F
- Pressure: 1500 – 4000 psi

Standing

The Standing correlation is used to calculate the bubble point pressure of crude oil based on the gas-oil ratio, gas specific gravity, oil gravity, and temperature. Originally developed for California crude oils, it has since been widely applied to other regions. The correlation is known for its simplicity, minimal input requirements, and good accuracy for light oils (25–40 °API). However, it tends to overestimate results for

heavy oils (<20 °API).
Recommended applicability range:

- Oil density (API Gravity): 16 – 45 °API
- Gas-oil ratio: 20 – 1500 SCF/STB
- Temperature: 100 – 300 °F

Vasquez & Beggs

The Vasquez & Beggs correlation improves the calculation of bubble point pressure by: normalizing gas specific gravity to a reference pressure of 100 psi; dividing oils into three groups based on API gravity; and accounting for temperature and gas-oil ratio. It was developed using a global database of 600 PVT analyses. The correlation also considers separation conditions. It is less accurate for heavy oils (<20 °API).
Recommended applicability range:

- Oil density (API Gravity): 15 – 45 °API
- Gas-oil ratio: 20 – 2070 SCF/STB
- Temperature: 75 – 295 °F

Kartoatmodjo & Schmidt

The Kartoatmodjo & Schmidt correlation provides two separate formulas: one for oils with API ≤ 30 and another for API > 30, allowing for higher accuracy across different fluid types. The method accounts for the influence of gas-oil ratio, temperature, oil gravity, and separator gas properties. A key feature is the use of a correction factor to account for gas separation conditions. It is particularly effective for Southeast Asian crudes and other regions with similar characteristics.
Recommended applicability range:

- Oil density (API Gravity): 14 – 45 °API
- Gas-oil ratio: 20 – 2500 SCF/STB
- Temperature: 100 – 300 °F

A1.2. Saturated Oil Formation Volume Factor

Al-Marhoun

The Al-Marhoun correlation (1988) was specifically developed for Middle Eastern crude oils based on an extensive PVT database. The method takes into account the effects of gas-oil ratio, oil and gas specific gravity, and temperature, offering improved accuracy compared to classical correlations such as Standing and Glaso. A key feature is the use of a power-law relationship optimized for Middle Eastern reservoir conditions. The formula is not applicable to oils with abnormal composition

(e.g., high content of harmful components).
Recommended applicability range:

- Oil density (API Gravity): 20 – 45 °API
- Gas-oil ratio: 100 – 2500 SCF/STB
- Gas specific gravity: 0.65 – 1.2
- Temperature: 100 – 300 °F

De Ghetto et al.
The De Ghetto et al. correlation represents an advanced method for calculating the formation volume factor of saturated oil, specifically designed for use with heavy and highly viscous oils (API < 25°). Unlike classical methods (e.g., Standing, Vasquez & Beggs), this correlation applies separate calculation approaches for light and heavy fluids, resulting in improved prediction accuracy. The formula incorporates the combined effects of gas-oil ratio, temperature, oil and gas densities through a system of power-law relationships.
Recommended applicability range:

- Oil density (API Gravity): 10 – 45 °API
- Gas-oil ratio: 50 – 3000 SCF/STB
- Temperature: 100 – 300 °F

Glaso
The Glaso correlation allows calculation of the formation volume factor of saturated oil based on the gas-oil ratio, gas and oil density, and temperature. It was developed for North Sea crude oils but is also applicable to other regions. The method is known for its high accuracy with light and medium oils but tends to be less precise for heavy fluids.

Recommended applicability range:

- Oil density (API Gravity): 22 – 48 °API
- Gas-oil ratio: 90 – 2500 SCF/STB
- Temperature: 80 – 280 °F

Lasater
The Lasater correlation (1958) is based on the analysis of North American crude oils with a focus on the effect of gas solubility. The method uses the mole fraction of gas in the system for calculation, which makes it particularly accurate for gas-saturated oils. The approach is physically based but requires knowledge of the oil's molecular weight. It tends to overestimate values for heavy oils. It does not account for sulfur or paraffin

content.
Recommended applicability range:

- Oil density (API Gravity): 15 – 40 °API
- Gas-oil ratio: 50 – 3500 SCF/STB
- Temperature: 100 – 220 °F

Petrosky

The Petrosky correlation is used to estimate the formation volume factor of saturated oil based on reservoir oil parameters such as gas-oil ratio, gas and oil density, and temperature. It was developed for crude oils from the Gulf of Mexico, but the correlation also shows good accuracy for similar reservoirs. The formula takes into account the influence of dissolved gas.
Recommended applicability range:

- Oil density (API Gravity): 15 – 40 °API
- Gas-oil ratio: 90 – 3000 SCF/STB
- Pressure: up to 7000 psi
- Temperature: 120 – 300 °F

Standing

The Standing correlation is one of the most widely used empirical models for estimating the formation volume factor of saturated oil. It is based on data from California oilfields and takes into account the gas-oil ratio, specific gravity of oil and gas, and reservoir temperature. Simple to apply, this correlation delivers acceptable accuracy for "black oil" models.
Recommended applicability range:

- Oil density (API Gravity): 22 – 58 °API
- Gas-oil ratio: 20 – 2100 SCF/STB
- Pressure: up to 5000 psi
- Temperature: 100 – 260 °F

Vasquez & Beggs

The Vasquez & Beggs correlation is one of the most versatile and widely used models for calculating the formation volume factor of saturated oil. It was developed based on an extensive database of over 600 oil samples. The formula categorizes oils into several groups based on API gravity. A distinguishing feature of the correlation is the normalization of gas parameters to standard separation conditions, which enhances

its accuracy.
Recommended applicability range:

- Oil density (API Gravity): 15 – 55 °API
- Gas-oil ratio: 0 – 3000 SCF/STB
- Gas specific gravity (air = 1): 0.58 – 1.18
- Temperature: 70 – 295 °F

Ahmed

The Ahmed correlation was developed as a modification of existing models to provide more accurate predictions of the saturated oil formation volume factor. It performs particularly well for heavy oils and considers the relationship between gas-oil ratio, fluid properties, and reservoir conditions. The model demonstrates good accuracy for Middle Eastern fields and yields reliable results for both heavy and medium crude oils.
Recommended applicability range:

- Oil density (API Gravity): 15 – 50 °API
- Gas-oil ratio: 50 – 3500 SCF/STB
- Gas specific gravity (air = 1): 0.65 – 1.2
- Temperature: 100 – 300 °F

Arps

The Arps correlation is a simplified linear formula used to estimate the formation volume factor of saturated oil. It relates the volume factor directly to the gas-oil ratio. The model is suitable for quick approximation calculations; however, it does not account for the effects of temperature, oil gravity, or gas gravity. This oversimplification limits its accuracy.
Recommended applicability range (exact boundaries are not defined; model is applicable within the "Black Oil" model):

- Oil density (API Gravity): 20 – 35 °API
- Gas-oil ratio: 100 – 1000 SCF/STB
- Gas specific gravity (air = 1): 0.65 – 1.0
- Temperature: 100 – 200 °F

Kartoatmodjo & Schmidt

The Kartoatmodjo & Schmidt correlation was developed based on an extensive database of over 740 crude oil samples. It is considered one of the most versatile models available. The correlation demonstrates good accuracy across a wide range of crude types—from light to heavy oils. A distinguishing feature of the method is its use of power-law relationships to account for the effects of temperature, gas-oil ratio, and fluid properties.

Recommended applicability range:

- Oil density (API Gravity): 14 – 59 °API
- Gas-oil ratio: 20 – 2900 SCF/STB
- Gas specific gravity (air = 1): 0.56 – 1.18
- Temperature: 75 – 320 °F

A1.3. Undersaturated Oil Formation Volume Factor

Al-Marhoun

The Al-Marhoun correlation was specifically developed to calculate the oil formation volume factor above the bubble point pressure. The model is based on data from Middle Eastern oilfields. It accounts for the effects of pressure, temperature, and fluid properties through a power-law relationship. The correlation demonstrates good accuracy over a wide range of conditions but is most accurate for medium and heavy crude oils.

Recommended applicability range:

- Oil density (API Gravity): 19 – 45 °API
- Gas-oil ratio: 25 – 1600 SCF/STB
- Pressure: < 10,000 psi
- Gas specific gravity (air = 1): 0.75 – 1.35
- Temperature: 75 – 240 °F

De Ghetto et al.

The De Ghetto et al. correlation was developed to calculate the oil formation volume factor above the bubble point pressure. It is based on the analysis of data from heavy (<22.3 °API), medium (22.3–31.1 °API), and light (>31.1 °API) crude oils, making it suitable for a wide range of reservoir types. The model accounts for the effects of pressure, temperature, gas-oil ratio, and fluid properties. It is also suitable for reservoirs with abnormal oil characteristics.

Recommended applicability range:

- Oil density (API Gravity): 15 – 45 °API
- Gas-oil ratio: 15 – 1500 SCF/STB
- Pressure: < 8000 psi

- Gas specific gravity (air = 1): 0.65 – 1.3
- Temperature: 120 – 320 °F

A1.3.3. Glaso

The Glaso correlation is considered one of the most reliable models for calculating the oil formation volume factor in the undersaturated zone. It was developed based on North Sea crude oils. The model incorporates the effects of pressure, temperature, and fluid properties through logarithmic relationships. A key feature of the method is its high accuracy across a wide range of crude oils—from light to heavy. However, it is less accurate for oils with extreme properties (very light or very heavy).

Recommended applicability range:

- Oil density (API Gravity): 22 – 48 °API
- Gas-oil ratio: 90 – 2600 SCF/STB
- Pressure: < 8000 psi
- Gas specific gravity (air = 1): 0.65 – 1.27
- Temperature: 80 – 280 °F

Petrosky

The Petrosky correlation was specifically developed for crude oils from the Gulf of Mexico. It provides high accuracy in calculating the oil formation volume factor in the undersaturated zone. The model incorporates the effects of pressure, temperature, and fluid properties using power-law relationships. A distinctive feature of the method is its adaptability to different oil types within the defined limits. The average error is ±3–5% within the recommended applicability range. It performs especially well for reservoirs with high gas-oil ratios.

Recommended applicability range:

- Oil density (API Gravity): 16 – 45 °API
- Gas-oil ratio: 90 – 3000 SCF/STB
- Pressure: < 10,000 psi
- Gas specific gravity (air = 1): 0.6 – 0.9
- Temperature: 120 – 300 °F

Standing

The Standing correlation is a classical method for calculating the oil formation volume factor in the undersaturated zone. It was developed based on data from California oilfields and is widely used in the petroleum industry due to its simplicity and reliability. The model accounts for oil compressibility through an exponential dependence on pressure. The average error is ±5–8% within the recommended applicability range.

Recommended applicability range:

- Oil density (API Gravity): 22 – 58 °API
- Gas-oil ratio: 20 – 2100 SCF/STB
- Pressure: < 5000 psi
- Gas specific gravity (air = 1): 0.63 – 1.05
- Temperature: 100 – 250 °F

Vasquez & Beggs

The Vasquez & Beggs correlation is one of the most versatile and accurate models for calculating the oil formation volume factor in the undersaturated zone. It was developed using an extensive database of more than 600 crude oil samples. The correlation accounts for separation conditions and categorizes oils into several groups based on density, which enables high accuracy across different reservoir types.

Recommended applicability range:

- Oil density (API Gravity): 15 – 55 °API
- Gas-oil ratio: 0 – 3000 SCF/STB
- Pressure: < 10,000 psi
- Gas specific gravity (air = 1): 0.56 – 1.18
- Temperature: 70 – 295 °F

Lasater

The Lasater correlation offers an alternative approach for calculating the oil formation volume factor in the undersaturated zone, based on the mole fraction of dissolved gas. It was developed using data from Canadian and U.S. oilfields. The model performs particularly well for oils with high gas-oil ratios. However, the correlation is less accurate for heavy oils (<25 °API).

Recommended applicability range:

- Oil density (API Gravity): 20 – 48 °API
- Gas-oil ratio: 100 – 3500 SCF/STB
- Pressure: < 5000 psi
- Gas specific gravity (air = 1): 0.65 – 1.2
- Temperature: 100 – 250 °F

Ahmed

The Ahmed correlation is a modern model for calculating the oil formation volume factor in the undersaturated zone. It was developed based on a wide dataset from Middle Eastern and North African oilfields. A distinctive feature of this formula is its non-traditional approach to modeling oil compressibility through a double exponential relationship, which more accurately reflects the behavior of oils with a nonlinear volume factor dependence on pressure.

Recommended applicability range:

- Oil density (API Gravity): 25 – 40 °API
- Gas-oil ratio: 50 – 2000 SCF/STB
- Pressure: < 10,000 psi
- Temperature: 100 – 250 °F

Arps

The Arps correlation is one of the earliest practical models for estimating oil volume changes in the undersaturated zone. It was developed based on empirical data from U.S. oilfields. The method uses a linear approximation of the relationship between formation volume factor and pressure, making it simple to apply but limited in accuracy under complex reservoir conditions. At elevated pressures (> 2000 psi), the error can reach up to 10%.

Recommended applicability range:

- Oil density (API Gravity): 20 – 40 °API
- Gas-oil ratio: 100 – 1500 SCF/STB
- Pressure: < 3000 psi
- Temperature: 100 – 220 °F

Kartoatmodjo & Schmidt

The Kartoatmodjo & Schmidt correlation (1994) was developed based on an expanded global database that includes crude oil samples from various regions around the world. The method provides an advanced approach for calculating formation volume factor in the undersaturated zone, accounting for the nonlinear dependence on pressure and fluid properties. A key feature is the use of a power function to more accurately describe oil volume changes.

Recommended applicability range:

- Oil density (API Gravity): 14 – 45 °API
- Gas-oil ratio: 20 – 2500 SCF/STB
- Pressure: < 8000 psi

- Temperature: 100 – 300 °F

A1.4. Compressibility

Standing

The Standing correlation, developed in 1947, is one of the earliest and most widely used methods for estimating oil compressibility. Standing proposed an empirical relationship that links compressibility with pressure, temperature, gas-oil ratio, and the specific gravities of oil and gas. The method performs particularly well for conventional crude oils with moderate gas content.

Recommended applicability range:

- Oil density (API Gravity): 20 – 45 °API
- Gas-oil ratio: 50 – 800 SCF/STB
- Temperature: 100 – 220 °F

Vasquez & Beggs

The Vasquez & Beggs correlation is an enhanced method for calculating oil compressibility, developed from an extensive PVT database. Unlike earlier models (such as Standing), this correlation explicitly accounts for the effects of pressure, temperature, gas-oil ratio, and other oil properties through a set of empirical coefficients. The method provides good accuracy across a wide range of crude oils—from light to medium.

Recommended applicability range:

- Oil density (API Gravity): 15 – 45 °API
- Pressure: < 10,000 psi
- Gas-oil ratio: 50 – 3500 SCF/STB
- Temperature: 100 – 300 °F

Glaso

The Glaso (1980) correlation for oil compressibility is based on generalized data from North Sea oilfields. The method incorporates the effects of pressure, temperature, gas-oil ratio, and oil density, offering more accurate estimates compared to classical approaches (e.g., Vasquez & Beggs). A notable feature of this model is the separation of calculation formulas for different pressure ranges—above and below the bubble point.

Recommended applicability range:

- Oil density (API Gravity): 18 – 52 °API
- Pressure: 500 – 8000 psi

- Gas-oil ratio: 50 – 3000 SCF/STB
- Temperature: 100 – 300 °F

De Ghetto et al.

This correlation was developed based on a large volume of experimental PVT data for heavy and extra-heavy crude oils, as earlier models (e.g., Standing, Vasquez & Beggs) produced significant errors for oils with API gravity below 25. The key feature of the model is the classification of fluids into multiple categories based on density, with a separate compressibility formula provided for each class. Its main limitation is that it is not universal—it performs best within the scope of the original data set.
Recommended applicability range:

- Oil density (API Gravity): 10 – 45 °API
- Pressure: < 5000 psi
- Gas-oil ratio: 0 – 2000 SCF/STB
- Temperature: 80 – 260 °F

De Ghetto et al.

This correlation was developed based on a large set of experimental PVT data for heavy and extra-heavy crude oils, as previously existing models (such as Standing and Vasquez & Beggs) produced significant errors when API gravity was below 25. The key feature of the method is the classification of fluids into several categories based on oil density. Each class has its own dedicated oil compressibility correlation. The main limitation is its lack of universality—it performs best within the bounds of the original dataset.
Recommended applicability range:

- Oil density (API Gravity): 10 – 45 °API
- Pressure: < 5000 psi
- Gas-oil ratio: 0 – 2000 SCF/STB
- Temperature: 80 – 260 °F

Petrosky

The Petrosky correlation was specifically developed for crude oils from the Gulf of Mexico, but it is also applicable to other regions. Key features of the model include consideration of gas-oil ratio, gas specific gravity, oil density, and temperature. It is optimized for light and medium crude oils. Compared to the Standing correlation, it yields more accurate results under high-temperature conditions.
Recommended applicability range:

- Oil density (API Gravity): 15 – 45 °API

- Pressure: < 8000 psi
- Gas-oil ratio: 100 – 2500 SCF/STB
- Temperature: 100 – 300 °F

Al-Marhoun

The Al-Marhoun (2003) correlation was developed to provide a more accurate estimation of oil compressibility, based on a comprehensive dataset from Middle Eastern reservoirs. The method accounts for the effects of pressure, temperature, gas-oil ratio, and fluid properties, offering improved accuracy compared to classical correlations. A distinctive feature is the use of power-law relationships optimized for various thermobaric (temperature-pressure) conditions.
Recommended applicability range:

- Oil density (API Gravity): 18 – 44 °API
- Pressure: 500 – 8000 psi
- Gas-oil ratio: 50 – 3000 SCF/STB
- Temperature: 100 – 300 °F

Lasater

The Lasater (1958) correlation was developed based on the analysis of crude oils from Canadian and U.S. fields. The method uses an empirical relationship linking oil compressibility with pressure, gas-oil ratio, and fluid properties. A key feature of this approach is its emphasis on the influence of gas solubility, making it particularly useful for oils with high gas content. At pressures above 3000 psi, the correlation may underestimate compressibility—other models are recommended for such conditions.
Recommended applicability range:

- Oil density (API Gravity): 20 – 45 °API
- Pressure: 100 – 3000 psi
- Gas-oil ratio: 50 – 1500 SCF/STB
- Temperature: 100 – 250 °F

Ahmed

The empirical correlation proposed by Tarek Ahmed is used to estimate the isothermal compressibility of crude oil. It is based on the analysis of PVT data for light and medium crude oils and is applicable when laboratory measurements are not available. The model accounts for the effects of pressure, dissolved gas, temperature, and oil density. It is known for its simplicity and reliable results under typical reservoir conditions. The correlation is well-suited for early-stage design or reservoir simulators

where a quick property estimation is needed.
Recommended applicability range:

- Oil density (API Gravity): 20 – 45 °API
- Pressure: < 5000 psi
- Gas-oil ratio: 0 – 2000 SCF/STB
- Temperature: 100 – 300 °F

Kartoatmodjo & Schmidt

This correlation is a modern method for calculating oil compressibility, developed using an extensive database of PVT analyses. Unlike classical approaches (e.g., Standing, Vasquez & Beggs), this method is specifically optimized for heavy and highly viscous crude oils, showing particular accuracy under challenging conditions. The formula captures the combined influence of pressure, temperature, gas-oil ratio, and oil density through a system of power-law relationships.
Recommended applicability range:

- Oil density (API Gravity): 10 – 50 °API
- Pressure: < 8000 psi
- Gas-oil ratio: 20 – 2500 SCF/STB
- Temperature: 80 – 320 °F

A1.5. Heat Capacity

Wright

The Wright (1991) correlation was developed to calculate the isobaric heat capacity of crude oils over a wide range of temperatures and pressures. The method is based on generalized experimental data for various types of crude, including heavy and bituminous oils. A distinguishing feature of the model is its consideration of oil density, temperature, and pressure through polynomial relationships.
Recommended applicability range:

- Oil density (API Gravity): 10 – 50 °API
- Pressure: < 5000 psi
- Temperature: 50 – 350 °F

A1.6. Oil Density

McCain

The McCain (1990) correlation is one of the most reliable methods for calculating the density of reservoir oil. It was developed using an extensive PVT database from U.S. oilfields. A key feature of this method is its consideration of the effects of dissolved

gas, pressure, and temperature on oil density. The correlation is widely used in engineering calculations due to its strong accuracy and physical relevance.
Recommended applicability range:

- Temperature: 100 – 300 °F
- Oil density (API Gravity): 18 – 45 °API
- Gas-oil ratio: 50 – 3000 SCF/STB
- Pressure: 500 – 10,000 psi

Ahmed

This correlation was developed by Tarek Ahmed and published in his classic work Reservoir Engineering Handbook (1989). It is intended for estimating the density of gas-saturated crude oil under standard conditions. The correlation is widely used in PVT analysis when laboratory data is unavailable. It expresses oil density as a function of gas-oil ratio, oil specific gravity, and gas specific gravity.
Recommended applicability range:

- Oil density (API Gravity): 10 – 50 °API
- Gas-oil ratio: 0 – 2000 SCF/STB
- Gas specific gravity (air = 1): 0.6 – 1.3

Katz

The Katz (1942) correlation is one of the earliest and most well-known empirical models for estimating reservoir oil density, accounting for the effect of dissolved gas. It is based on extensive experimental data. This correlation was widely used before the development of more advanced models such as Standing and Vasquez & Beggs.
Recommended applicability range:

- *Temperature: 60 – 220 °F*
- *Oil density (API Gravity): 15 – 45 °API*
- *Gas-oil ratio: 20 – 1000 SCF/STB*
- *Pressure: 100 – 5000 psi*

Standing

The Standing (1947) correlation is a classical method for calculating oil density under reservoir conditions. It accounts for the effects of dissolved gas, pressure, temperature, and the properties of both oil and gas. Based on experimental data from California oilfields, the correlation remains widely used today in black oil

models.
Recommended applicability range:

- Temperature: 60 – 250 °F
- Oil density (API Gravity): 15 – 45 °API
- Gas-oil ratio: 20 – 1500 SCF/STB
- Pressure: 50 – 5000 psi

A2. WATER

A2.1. Formation Volume Factor

McCain

The McCain (1990) correlation is a classical method for calculating the formation water volume factor. The method accounts for the effects of pressure, temperature, salinity (TDS), and dissolved gas, offering a physically grounded model with high accuracy. A key feature is the separate treatment of water compressibility and thermal expansion. For formation waters with TDS > 50,000 ppm, a salinity correction is required.
Recommended applicability range:

- Temperature: 100 – 400 °F
- Salinity (TDS): 0 – 200,000 ppm
- Gas content: 0 – 50 SCF/STB
- Pressure: 14.7 – 10,000 psi

A2.2. Viscosity

McCain

The McCain (1991) correlation estimates the viscosity of formation water based on temperature, pressure, and salinity. It accounts for the effect of dissolved salts, making it more accurate than simple correlations for pure water. The model is based on experimental data and is widely used in the oil and gas industry. It provides good accuracy for moderately to highly saline waters, but for highly mineralized water (near the applicability limits), comparison with laboratory data is recommended.
Recommended applicability range:

- Salinity: up to 200,000 ppm
- Temperature: 30 – 300 °F
- Pressure: < 10,000 psi

Beggs & Brill

The Beggs & Brill (1973) correlation was developed to calculate water viscosity in oil production processes. It is especially applicable to multiphase flow in wells. The formula accounts for the effects of temperature and pressure but does not include a correction for salinity, making it more suitable for relatively fresh formation waters.
Recommended applicability range:

- Salinity: not considered; suitable for low-salinity water
- Temperature: 60 – 300 °F
- Pressure: < 10,000 psi

Matthews & Russell

The Matthews & Russell (1967) correlation allows for estimating the viscosity of formation water by considering temperature, pressure, and salinity. It is based on experimental data and is suitable for engineering calculations in the oil and gas industry. Unlike McCain's method, this correlation uses a simpler model but remains popular due to its reliability under standard conditions.
Recommended applicability range:

- Salinity: up to 200,000 ppm
- Temperature: 60 – 400 °F
- Pressure: < 10,000 psi

HP Petroleum

HP Petroleum is a modern commercial software package for modeling PVT properties, incorporating advanced correlations for calculating water viscosity. Unlike classical correlations, HPPFP uses more sophisticated models that account for:

- Temperature effects (from cryogenic to high-temperature conditions),
- Pressure (including ultra-high pressures),
- Salinity (including complex salt compositions),
- Dissolved gases (H_2S, CO_2).

Recommended applicability range:

- Temperature: 30 – 500 °F
- Salinity: up to 300,000 ppm
- Pressure: < 10,000 psi

A2.3. Oil Viscosity

A2.3.1. Dead Oil Viscosity

Beal

The Beal correlation is one of the earliest but still widely used empirical models for estimating the viscosity of dead (degassed) oil. It is based on experimental data from North American crude oils. The correlation links viscosity with oil density and temperature.

Recommended applicability range:

- Oil density (API Gravity): 14 – 40 °API
- Temperature: 100 – 220 °F
- Viscosity: 1 – 1000 cP (accuracy decreases for values > 100 cP)

Beggs & Robinson

The Beggs & Robinson correlation estimates the viscosity of dead (degassed) oil based on oil density and temperature. It performs well for light and medium crude oils (above 22°API) but is less accurate for heavy oils (below 16°API) and highly viscous fluids.

Recommended applicability range:

- Oil density (API Gravity): 16 – 58 °API
- Temperature: 70 – 295 °F
- Viscosity: 0.5 – 50 cP

Bergman

The Bergman correlation (2004) was developed specifically for heavy and bituminous crude oils, where classical models (such as Beggs & Robinson) often produce significant errors. This model is based on an extensive database that includes high-viscosity oil samples and provides more accurate predictions under complex conditions.

Recommended applicability range:

- Oil density (API Gravity): 5 – 30 °API
- Temperature: 60 – 300 °F
- Viscosity: 10 – 20,000 cP

De Ghetto

The De Ghetto correlation was developed to estimate the viscosity of dead oil based on data from Mediterranean and Middle Eastern crude oils. It is particularly useful for medium and heavy oils, where many classical correlations (such as Beggs &

Robinson) yield significant errors. The correlation is well-suited for high-sulfur crude oils.
Recommended applicability range:

- Oil density (API Gravity): 10 – 45 °API
- Temperature: 80 – 300 °F
- Viscosity: 1 – 500 cP

De Ghetto (Agip)

The De Ghetto et al. correlation (developed for Agip) is designed to estimate the viscosity of dead oil, with a focus on heavy and bituminous crudes. It is based on a comprehensive database including samples from various regions and provides two separate formulas for heavy and light oils.
Recommended applicability range:

- Oil density (API Gravity): 10 – 48 °API
- Temperature: 60 – 300 °F
- Viscosity: 1 – 50,000 cP

Petrosky

The Petrosky (1990) correlation was developed based on the analysis of PVT properties of crude oils from Gulf of Mexico fields. A key feature of the model is its adaptation to high-temperature conditions and oils with elevated gas content, which are typical for the region. The correlation performs well for paraffinic oils.
Recommended applicability range:

- Oil density (API Gravity): 15 – 45 °API
- Temperature: 80 – 320 °F
- Viscosity: 0.5 – 200 cP

Egbogah

The Egbogah correlation was specifically developed for accurate prediction of dead oil viscosity, especially under high-temperature conditions and for heavy fluids. Unlike classical methods (Beal, Beggs & Robinson), this correlation incorporates an enhanced temperature dependence and modified coefficients, providing better accuracy for oils with API < 25°. The formula is based on statistical analysis of data from Canadian oil fields, making it particularly useful for oils with atypical properties.
Recommended applicability range:

- Oil density (API Gravity): 10 – 45 °API
- Temperature: 50 – 300 °F

- Viscosity: 1 – 100,000 cP

Kartohadiprodjo & Schmidt

This correlation was developed based on an extensive database comprising over 4,500 crude oil samples from around the world. It is considered one of the most universal and accurate methods for estimating dead oil viscosity, especially across a wide range of oil densities. Additionally, it accounts for the nonlinear dependence of viscosity on both temperature and oil gravity. It is claimed to outperform Beggs & Robinson and Glaso correlations in terms of accuracy, particularly for heavy oils.
Recommended applicability range:

- Oil density (API Gravity): 6 – 50 °API
- Temperature: 70 – 295 °F
- Viscosity: 1 – 10,000 cP (highest accuracy in the range of 10 – 1,000 cP)

Khan

The Khan correlation is a modified version of the classical Beggs & Robinson method, specifically developed for accurate prediction of dead oil viscosity across a wide range of temperatures and oil gravities. The method introduces additional correction factors that enhance accuracy for heavy oils and high-temperature conditions. The formula is based on statistical analysis of data from Pakistani oil fields but has demonstrated good applicability to other regions.
Recommended applicability range:

- Oil density (API Gravity): 10 – 45 °API
- Temperature: 70 – 300 °F
- Viscosity: 1 – 10,000 cP (highest accuracy in the range of 10 – 1,000 cP)

Glaso

The Glaso correlation was developed based on PVT data analysis for North Sea crude oils. It estimates dead oil viscosity at atmospheric pressure using oil density and temperature. Compared to the Beal and other early correlations, Glaso offers a wider temperature applicability range. It is particularly suitable for North Sea oils but has been validated on fields in other regions as well.
Recommended applicability range:

- Oil density (API Gravity): 15 – 50 °API
- Temperature: 50 – 300 °F
- Viscosity: 0.5 – 50 cP

A2.3.2. Saturated Oil Viscosity

Beggs & Robinson

The Beggs & Robinson correlation estimates the viscosity of saturated oil containing dissolved gas. It is based on data from North American crude oils and involves two steps: calculating the viscosity of dead oil, and then applying a correction for the presence of dissolved gas. The correlation is known for its simplicity and reliable accuracy for light and medium oils (20–45 °API).

Recommended applicability range:

- Oil density (API Gravity): 16 – 58 °API
- Temperature: 70 – 295 °F
- Viscosity: 0.5 – 50 cP
- Solution gas–oil ratio (GOR): 20 – 2000 SCF/STB

Beal

The Beal correlation is one of the earliest fundamental methods for calculating the viscosity of saturated oil. It was developed based on experimental data from North American crude oils. The method defines viscosity as a function of bubble point pressure, temperature, and oil density using a set of empirical coefficients. Its key feature is simplicity and reliability under standard conditions, although additional adjustments may be required for heavy oils or extreme conditions.

Recommended applicability range:

- Oil density (API Gravity): 15 – 45 °API
- Temperature: 100 – 220 °F
- Viscosity: 0.5 – 50 cP

Bergman

The Bergman correlation (2004) is designed to estimate the viscosity of saturated oil based on the viscosity of dead oil and solution gas-oil ratio. It is most suitable for medium-density oils with moderate gas content but may introduce errors for heavy oils, condensates, or extreme gas-oil ratios. The formula is simple to apply but should not replace laboratory measurements when working with non-standard fluids.

Recommended applicability range:

- Oil density (API Gravity): 15 – 45 °API
- Temperature: 70 – 300 °F
- Viscosity: 0.5 – 50 cP
- Gas-oil ratio: 50 – 2000 SCF/STB

De Ghetto

The De Ghetto empirical correlation was developed based on an extensive analysis of experimental data for saturated oil. It was primarily designed for application to Brazilian oilfield conditions but has demonstrated good versatility and applicability beyond this region.

Recommended applicability range:

- Oil density (API Gravity): 16 – 45 °API
- Temperature: 20 – 260 °F
- Viscosity: 0.1 – 1000 cP
- Gas-oil ratio: 10 – 2000 SCF/STB

De Ghetto Agip

The De Ghetto correlation, developed by Agip, is designed to estimate the viscosity of saturated oil based on its density, gas-oil ratio, and temperature. It is derived from a statistical analysis of various oil types, including heavy and highly viscous oils, making it more versatile than many other methods. The formula includes correction factors to account for the influence of oil density and dissolved gas content, allowing for application across a wide range of conditions.

Recommended applicability range:

- Oil density (API Gravity): 6 – 50 °API
- Temperature: 80 – 300 °F
- Viscosity: 0.5 – 1000 cP
- Gas-oil ratio: 50 – 2000 SCF/STB

Petrosky

The Petrosky correlation was specifically developed for Gulf of Mexico crude oils, considering the high temperatures and pressures typical of deepwater reservoirs. It provides high accuracy for light to medium oils (20–40 °API) and includes a correction for gas-oil ratio. Compared to Beggs & Robinson, it demonstrates 10–15% better accuracy for Gulf of Mexico conditions.

Recommended applicability range:

- Oil density (API Gravity): 15 – 45 °API
- Temperature: 80 – 320 °F
- Viscosity: 0.5 – 50 cP
- Gas-oil ratio: 100 – 2500 SCF/STB

Egbogah

The Egbogah correlation was specifically developed for heavy and bituminous oils (5–25 °API). It accounts for the effects of gas-oil ratio, dead oil viscosity, and temperature. This model is especially useful for "cold" reservoirs and crudes with high asphaltene content. It is not applicable to light oils.

Recommended applicability range:

- Oil density (API Gravity): 5 – 25 °API
- Temperature: 60 – 250 °F
- Viscosity: 50 – 50,000 cP
- Gas-oil ratio: 20 – 800 SCF/STB

Chu & Connally

The Chu & Connally correlation estimates the viscosity of saturated oil based on dead oil viscosity and gas-oil ratio. It is especially useful for light and medium oils and is widely used in engineering calculations. The model accounts for the nonlinear effect of dissolved gas on oil viscosity, but it is less accurate for heavy oils (API < 20) and highly viscous fluids (>50 cP).

Recommended applicability range:

- Oil density (API Gravity): 15 – 50 °API
- Temperature: 70 – 295 °F
- Viscosity: 0.5 – 50 cP
- Gas-oil ratio: 50 – 3500 SCF/STB

Standing

Standing proposed an empirical correlation to estimate the viscosity of saturated oil based on data from California oil fields. The method relates viscosity to pressure, temperature, gas-oil ratio, and oil density. The correlation is simple to apply and suitable for "Black oil" models without significant amounts of non-hydrocarbon components. At high gas-oil ratios, it may overestimate viscosity.

Recommended applicability range:

- Oil density (API Gravity): 15 – 45 °API
- Temperature: 100 – 250 °F
- Pressure: < 5000 psi
- Gas-oil ratio: 90 – 1500 SCF/STB

Kartotomojo & Schmidt

The early version of the Kartotomojo & Schmidt (1991) correlation was developed as an improvement over the Standing and Beggs & Robinson models. It provides more accurate viscosity predictions for a wide range of crude oils, especially for fields in Southeast Asia. This version of the correlation uses a power-law dependency on gas-oil ratio and dead oil viscosity, delivering better accuracy for heavy and high-viscosity oils.

Recommended applicability range:

- Oil density (API Gravity): 10 – 45 °API
- Temperature: 100 – 300 °F
- Viscosity: 1 – 5000 cP
- Gas-oil ratio: 50 – 2500 SCF/STB

Khan

The Khan correlation was developed for predicting saturated oil viscosity by accounting for the effects of gas-oil ratio, temperature, and oil density. It is particularly useful across a wide range of oil properties, including heavy fluids. Its main advantage is versatility, as it is applicable to light, medium, and heavy crude oils. Additionally, the model accounts for the significant impact of high gas-oil ratios on viscosity.

Recommended applicability range:

- Oil density (API Gravity): 15 – 45 °API
- Temperature: 100 – 300 °F
- Viscosity: 1 – 1000 cP
- Gas-oil ratio: 200 – 2500 SCF/STB

Glaso

Glaso (1980) proposed a generalized correlation for estimating oil viscosity, taking into account gas-oil ratio, oil and gas density, and temperature. It is better suited for light and medium crude oils than Standing's method, especially under high gas-oil ratios. The correlation offers improved accuracy compared to older models due to the generalization of a large dataset. However, it is not recommended for heavy oils (API < 15°).

Recommended applicability range:

- Oil density (API Gravity): 15 – 55 °API
- Temperature: 70 – 295 °F
- Gas-oil ratio: 50 – 3500 SCF/STB

A2.3.3. Undersaturated Oil Viscosity

Beal

The Beal correlation (1946) is one of the earliest and most well-known methods for estimating undersaturated oil viscosity. It is based on empirical data from North American crude oils and uses a power-law relationship linking viscosity at bubble-point pressure to viscosity at higher pressures. The formula accounts for the effects of pressure, temperature, and oil density, but does not explicitly include gas-oil ratio. Due to its simplicity and age, the correlation is not suitable for oils with unusual properties.
Recommended applicability range:

- Oil density (API Gravity): 15 – 45 °API
- Temperature: 100 – 220 °F
- Viscosity: 0.5 – 50 cP
- Pressure: P_b – 5000 psi

Beggs & Robinson

The Beggs & Robinson correlation (1975) was developed based on a large dataset of laboratory measurements for North American crude oils. It estimates the increase in oil viscosity at pressures above the bubble point. The method accounts for the effects of pressure, saturated oil properties, and temperature. Due to its simplicity and satisfactory accuracy for most oil types, this correlation has become widely used in petroleum engineering.
Recommended applicability range:

- Oil density (API Gravity): 16 – 58 °API
- Temperature: 70 – 295 °F
- Gas-oil ratio: 20 – 2100 SCF/STB
- Pressure: P_b – 8000 psi

Bergman

The Bergman correlation (2004) is designed to calculate the viscosity of undersaturated oil at pressures above the bubble point, particularly for heavy and bituminous fluids (5–25 °API). It employs an exponential relationship with pressure difference and includes a correction factor that accounts for gas-oil ratio and saturated oil viscosity. The model demonstrates good accuracy for high-viscosity oils and is recommended for use in "cold" reservoirs with typical formation conditions.
Recommended applicability range:

- Oil density (API Gravity): 10 – 40 °API

- Temperature: 100 – 300 °F
- Gas-oil ratio: 20 – 1500 SCF/STB
- Pressure: P_b – 5000 psi

De Ghetto

The De Ghetto correlation was developed to predict the viscosity of undersaturated oil, with a particular focus on heavy and bituminous crudes. The method provides separate calculation approaches for light and heavy fluids, ensuring high accuracy across a broad range of conditions.
Recommended applicability range:

- Oil density (API Gravity): 10 – 45 °API
- Temperature: 100 – 250 °F
- Gas-oil ratio: 50 – 2500 SCF/STB
- Pressure: P_b – 8000 psi

De Ghetto Agip

The De Ghetto correlation, developed by Agip, is designed to predict oil viscosity at pressures above the bubble point. It accounts for overpressure, saturated oil viscosity, and gas-oil ratio, delivering high accuracy for medium to heavy crudes (10–35 °API).
Recommended applicability range:

- Oil density (API Gravity): 10 – 35 °API
- Gas-oil ratio: 50 – 1500 SCF/STB
- Pressure: P_b – 8000 psi

Petrosky

The Petrosky correlation was specifically developed for Gulf of Mexico crude oils. It demonstrates good accuracy in predicting undersaturated oil viscosity under high-pressure conditions. The method is based on a modification of the classical Beal approach, incorporating regional fluid characteristics. The formula employs a power-law relationship linking viscosity at bubble point pressure to viscosity at higher pressures.
Recommended applicability range:

- Oil density (API Gravity): 16 – 45 °API
- Gas-oil ratio: 100 – 3500 SCF/STB
- Viscosity: 0.5 – 50 cP
- Pressure: P_b – 10,000 psi

Shilov

The Shilov correlation was developed to address modern field development conditions, particularly considering the characteristics of Russian crude oils. It is based on machine learning and the analysis of an extensive PVT database. The method delivers high accuracy for oils with anomalous properties and under high-pressure conditions. It accounts for thermobaric conditions, oil composition, and gas-oil ratio.

Recommended applicability range:

- Oil density (API Gravity): 12 – 45 °API
- Gas-oil ratio: 50 – 2500 SCF/STB
- Temperature: 100 – 350 °F
- Pressure: P_b – 10,000 psi

Gimatutdinov

The Gimatutdinov correlation was developed based on studies of oil fields in the former USSR. It is widely used in field development practices across CIS countries. The method incorporates the effect of pressure above the bubble point on oil viscosity through a logarithmic relationship. A distinctive feature of this correlation is its adaptation to the conditions of Western Siberia and other traditional oil-producing regions of the USSR/Russia.

Recommended applicability range:

- Oil density (API Gravity): 18 – 40 °API
- Gas-oil ratio: 200 – 4500 SCF/STB
- Temperature: 65 – 250 °F
- Pressure: P_b – 6,000 psi

Mishchenko

The Mishchenko correlation was developed to estimate oil viscosity under high-pressure conditions typical of deep reservoirs. The method is based on a modified exponential approach that incorporates thermodynamic parameters. A key feature of this correlation is its high accuracy for oils with elevated dissolved gas content and under abnormal reservoir conditions.

Recommended applicability range:

- Oil density (API Gravity): 15 – 48 °API
- Gas-oil ratio: 100 – 3000 SCF/STB
- Temperature: 140 – 400 °F

- Pressure: < 12,000 psi

Chu & Connally

The Chu & Connally correlation (1959) is one of the earliest and most widely used models for estimating oil viscosity at pressures above the bubble point. It is based on experimental data from U.S. oilfields and uses a power-law relationship to account for the effect of pressure on viscosity. The method is especially popular due to its simplicity and reliability under standard reservoir conditions.
Recommended applicability range:

- Oil density (API Gravity): 20 – 45 °API
- Gas-oil ratio: 50 – 1500 SCF/STB
- Temperature: 100 – 250 °F
- Pressure: < 5000 psi

Standing

Standing (1947) proposed one of the earliest practical correlations for estimating changes in oil viscosity at pressures above the bubble point. The method is based on data from California oilfields and uses a linear relationship between the logarithm of viscosity and pressure. Although considered outdated, this correlation is still used for preliminary calculations due to its simplicity.
Recommended applicability range:

- Oil density (API Gravity): 15 – 45 °API
- Gas-oil ratio: 90 – 1500 SCF/STB
- Temperature: 100 – 250 °F
- Pressure: < 5000 psi

Kartoatmodjo & Schmidt

The Kartoatmodjo & Schmidt (1991) correlation was developed to predict the viscosity of undersaturated oil with high accuracy, especially for heavy and bituminous crudes. It is based on an extensive database of more than 1,500 analyzed samples. The correlation accounts for the effects of pressure, temperature, gas-oil ratio, and oil density.
Recommended applicability range:

- Oil density (API Gravity): 15 – 40 °API
- Temperature: 100 – 250 °F
- Gas-oil ratio: 20 – 2500 SCF/STB
- Pressure: P_b – 5000 psi

Khan

The Khan correlation was developed to predict the viscosity of undersaturated oil, with particular emphasis on accounting for the effects of pressure, temperature, and fluid composition. Unlike many other methods, this correlation explicitly incorporates temperature dependence, making it especially useful in wide temperature range conditions. The formula is based on data from Pakistani oil fields but has shown good accuracy for other regions as well.

Recommended applicability range:

- Oil density (API Gravity): 15 – 45 °API
- Temperature: 100 – 300 °F
- Gas-oil ratio: 100 – 2500 SCF/STB
- Viscosity: 0.5 – 50 cP
- Pressure: P_b – 10,000 psi

Glaso

The Glaso correlation (1980) is an advanced method for calculating oil viscosity at pressures above the bubble point. It was developed based on an extensive database from North Sea oil fields. A key feature of this method is the use of a logarithmic relationship that captures the nonlinear behavior of viscosity as pressure increases.

Recommended applicability range:

- Oil density (API Gravity): 18 – 52 °API
- Temperature: 100 – 300 °F
- Gas-oil ratio: 100 – 3000 SCF/STB
- Pressure: Pb – 8000 psi

Vazquez & Beggs

The Vazquez & Beggs correlation is designed to estimate oil viscosity in the undersaturated region. It accounts for the effects of pressure, temperature, and oil properties using a power-law relationship based on extensive laboratory data. The formula relates oil viscosity at the bubble point pressure to its value at higher pressures. It is most suitable for light and medium oils (API > 20°), where the correlation provides the highest accuracy.

Recommended applicability range:

- Oil density (API Gravity): 15 – 50 °API
- Temperature: 100 – 300 °F
- Viscosity: 0.5 – 50 cP

- Pressure: Pb – 10000 psi

GAS

A3.1. Gas Compressibility Factor (Z-factor)

Dranchuk

The Dranchuk correlation (1975) is one of the most accurate analytical models for calculating the compressibility factor (Z-factor) of natural gases. The method is based on a modification of the Starling-Carnahan equation of state. It delivers high accuracy across a wide range of reduced pressures and temperatures. A notable feature is the use of a large number of constants, calibrated to match the Standing-Katz generalized chart.

Recommended applicability range:

- Reduced pressure: 0.2 – 30
- Reduced temperature: 1.05 – 3
- CO_2 content: < 15%
- H_2S content: < 10%
- N_2 content: < 20%

Papay

The Papay correlation (1985) is one of the simplest and most convenient methods for quick estimation of the gas compressibility factor (Z-factor). It was developed based on data from European gas fields. The model performs especially well for typical natural gases under moderate pressures and temperatures. The formula expresses the compressibility factor as a function of reduced pressure and temperature.

Recommended applicability range:

- Reduced pressure: 0.2 – 15
- Reduced temperature: 1.05 – 3
- CO_2 content: < 5%
- H_2S content: < 5%

Standing

The Standing correlation for gas compressibility factor (Z-factor) is one of the earliest practical methods developed for engineering calculations. The model is based on the principle of corresponding states. It uses reduced pressure and temperature and demonstrates good accuracy for standard natural gases with moderate non-hydrocarbon content. The method is especially useful for quick estimates due to its simplicity. However, the author notes the unreliability of the correlation outside the

recommended applicability range—particularly for reduced temperature.
Recommended applicability range:

- Reduced pressure: 0.2 – 15
- Reduced temperature: 0.92 – 2.4
- CO_2 content: < 10%
- H_2S content: < 5%

Redlich & Kwong

The Redlich & Kwong correlation (1949) is a cubic equation of state widely used to calculate the compressibility factor (Z-factor) of natural and process gases. As one of the first practical modifications of the Van der Waals equation, it combines relative simplicity with acceptable accuracy. The method is particularly useful for preliminary engineering calculations.
Recommended applicability range:

- Reduced pressure: 0.2 – 10
- Reduced temperature: 0.7 – 5 (optimal accuracy for 1 – 2)
- CO_2 content: < 20%

Hall & Yarborough

The Hall & Yarborough correlation (1973) is an analytical approximation of the Standing-Katz chart, specifically developed for calculating the compressibility factor (Z-factor) of natural gases. The method is based on the Starling-Carnahan equation of state and provides high accuracy without requiring iterative calculations. A key advantage is the use of an explicit formulation, making it computationally efficient.
Recommended applicability range:

- Reduced pressure: 0.2 – 20
- Reduced temperature: 1.2 – 3 (optimal accuracy for 1.4 – 2.8)
- CO_2 content: < 15%
- H_2S content: < 10%

Beggs & Brill

The Beggs & Brill correlation (1973) offers a convenient analytical approximation of the classic Standing-Katz chart for calculating the gas compressibility factor (Z-factor). The model combines good accuracy with computational simplicity and is especially popular in gas pipeline flow modeling. For reduced temperatures below 1.5, it is recommended to use an alternative method.
Recommended applicability range:

- Reduced pressure: 0.2 – 15
- Reduced temperature: 1.2 – 3
- Gas specific gravity (air = 1): 0.55 – 0.9
- CO_2 content: < 5%

A3.2. Viscosity

Carr

The classical Carr correlation provides an estimate of natural gas viscosity at atmospheric and reservoir conditions. The method includes two steps:

1. Calculation of viscosity at atmospheric pressure.
2. Correction for reservoir pressure and temperature.
   This approach is simple and reliable but may show deviations when hydrogen sulfide (H_2S) is present.

Recommended applicability range:

- Gas specific gravity (air = 1): 0.55 – 1.55
- Temperature: 100 – 400 °F
- Pressure: < 10,000 psi

Lee

The Lee correlation is one of the most widely used methods for calculating natural gas viscosity. It combines ease of use with good accuracy across a broad range of conditions. The formula accounts for the effects of temperature, gas density, and molecular weight through dimensionless parameters. It is well-suited for gases containing a low proportion of non-hydrocarbon components.
Recommended applicability range:

- Gas specific gravity (air = 1): 0.55 – 1.5
- Temperature: 100 – 340 °F
- Methane content (CH_4): > 70%
- Pressure: 100 – 8000 psi

Dean & Stiel

The Dean & Stiel method is designed for calculating gas viscosity using reduced parameters and is particularly accurate at high pressures and for non-standard gas compositions (e.g., gases containing H_2S and CO_2). The method is based on the principle of corresponding states.
Recommended applicability range:

- Reduced pressure: 0.1 – 15
- Reduced temperature: 1 – 3
- Gas specific gravity (air = 1): 0.5 – 2
- Gas composition: no limitations

A3.3. Pseudocritical Pressure and Temperature of Pure Hydrocarbon Gas

A3.3.1. Dry Gas

Brown

The Brown correlation is a classical method for estimating pseudocritical pressure and temperature. The model is widely used in the oil and gas industry due to its simplicity and acceptable accuracy under standard conditions. The correlation is applicable only for calculating properties of dry gas.
Recommended applicability range:

- Gas specific gravity (air = 1): 0.55 – 1
- C_7^+ content: < 1%

Dùn & Oriji

The Dùn & Oriji correlation was developed for more accurate calculation of the pseudocritical pressure of dry natural gases, based on modern datasets. The method is derived from statistical analysis of an extensive PVT database from African and Middle Eastern fields. The correlation does not account for the influence of heavy hydrocarbons.
Recommended applicability range:

- Gas specific gravity (air = 1): 0.55 – 0.8

Golan & Whitson

The Golan & Whitson method offers an improved approach for determining the pseudocritical pressure and temperature of dry natural gases. The correlation is based on a modification of the classic Standing-Katz method, incorporating the molecular weight of the gas. It shows better accuracy compared to traditional methods when applied to gases containing minor non-hydrocarbon impurities.
Recommended applicability range:

- Gas specific gravity (air = 1): 0.55 – 0.8

Thomas, Hankinson & Phillips

The Thomas, Hankinson & Phillips correlation estimates pseudocritical pressure and temperature values for dry natural gases. It is suitable for typical natural gases

without significant concentrations of non-hydrocarbon components. It is not applicable to gases with a specific gravity (air = 1) greater than 0.8.
Recommended applicability range:

- Gas specific gravity (air = 1): 0.55 – 0.8
- C_4+ content: > 90%

Joshi

The Joshi correlation offers a modernized approach to calculating pseudocritical pressure and temperature for dry and slightly sour gases. The method is based on a comprehensive global dataset. Its key advantage is high accuracy for gases with atypical compositions, without requiring complex corrections.
Recommended applicability range:

- Gas specific gravity (air = 1): 0.55 – 0.8

Lee & Wattenbarger

The Lee & Wattenbarger correlation was developed for accurate calculation of pseudocritical pressure and temperature for dry natural gases. The method is a modification of classical approaches, incorporating gas thermodynamics. It is based on research from reservoirs around the world. A key feature is the use of separate calculation formulas for different gas specific gravity ranges.
Recommended applicability range:

- Gas specific gravity (air = 1): 0.55 – 1.1

Golan & Whitson

The Golan & Whitson correlation is designed to calculate the pseudocritical pressure and temperature of wet hydrocarbon gases containing significant amounts of heavy fractions. The method is based on gas mixing rules, accounting for the influence of molecular weight and gas composition, which ensures high accuracy for gas-condensate systems.
Recommended applicability range:

- Gas specific gravity (air = 1): 0.6 – 1.2
- C_7^+ content: 1 – 20%

A3.4. Pseudocritical Pressure and Temperature of Non-Hydrocarbon Impurities

Carr

The Carr correlation allows correction of the pseudocritical pressure and temperature of natural gas in the presence of non-hydrocarbon impurities. The method is especially useful for fields with high concentrations of acid gases, where standard

methods produce significant errors.
Recommended applicability range:

- Gas specific gravity (air = 1): 0.55 – 1.2
- CO_2 content: < 20%
- H_2S content: < 25%
- N_2 content: < 5%

Piper & McCain

The Piper & McCain correlation is an advanced method for determining pseudocritical properties of gas-condensate mixtures containing non-hydrocarbon components. It was developed based on an extensive database from North Sea fields. The model provides high accuracy for complex multicomponent systems.
Recommended applicability range:

- Gas specific gravity (air = 1): 0.55 – 1.2
- CO_2 content: < 20%
- H_2S content: < 30%
- N_2 content: < 10%

Wichert & Aziz

The Wichert & Aziz correlation is a fundamental method for adjusting pseudocritical properties of natural gases with elevated levels of acid gases. The method accounts for the non-ideal behavior of such mixtures and ensures accuracy in the calculation of the gas compressibility factor. It is not applicable to gases with a high content of heavy hydrocarbons (C_7^+ > 5%).
Recommended applicability range:

- Gas specific gravity (air = 1): 0.55 – 1.0
- CO_2 content: < 40%
- H_2S content: < 40%

A3.5. Surface Tension

A3.5.1. Gas-Water

Sutton

The Sutton correlation is a modern method for calculating interfacial tension between natural gas and water, accounting for the effects of pressure, temperature, and water salinity. Unlike classical approaches, this correlation was specifically developed for high-pressure and wide-temperature conditions, making it especially useful for deep-

water fields and unconventional reservoirs.
Recommended applicability range:

- CO_2 content: < 15%
- Water salinity: 0 – 300,000 ppm
- Temperature: 100 – 400 °F
- Pressure: < 30,000 psi (optimal: 500 – 15,000 psi)

A3.5.2. Gas-Oil

Abdul-Majid

The Abdul-Majid correlation is a specialized method for calculating interfacial tension between oil and natural gas, taking into account oil density, temperature, pressure, and gas properties. The method is based on experimental data from Middle Eastern oils. It demonstrates particular accuracy for light and medium oils under high-pressure conditions.
Recommended applicability range:

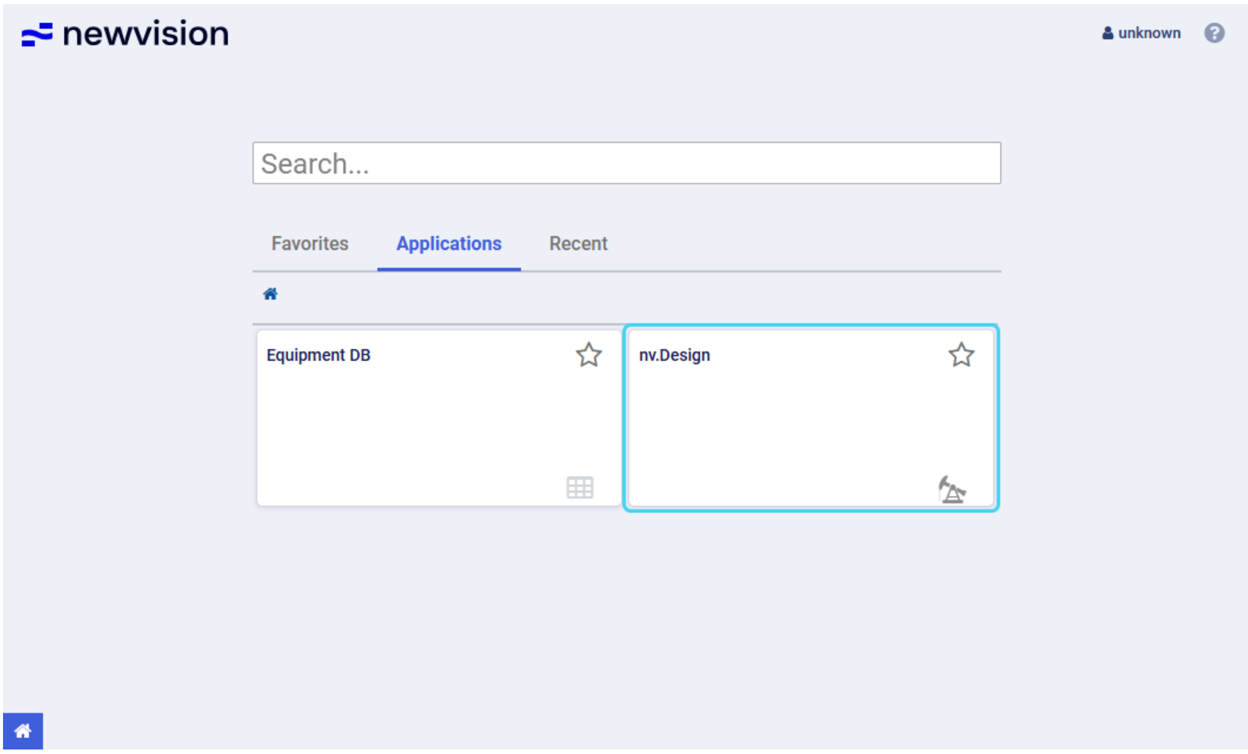
- Oil density (API Gravity): 25 – 45 °API
- Gas–oil ratio: 200 – 2500 SCF/STB
- Temperature: 100 – 300 °F
- Pressure: < 10,000 psi (optimal: 1,000 – 8,000 psi)

B1. Creating Project and Adding Well Data

1. Log in to the **newvision** system by entering your login and password.

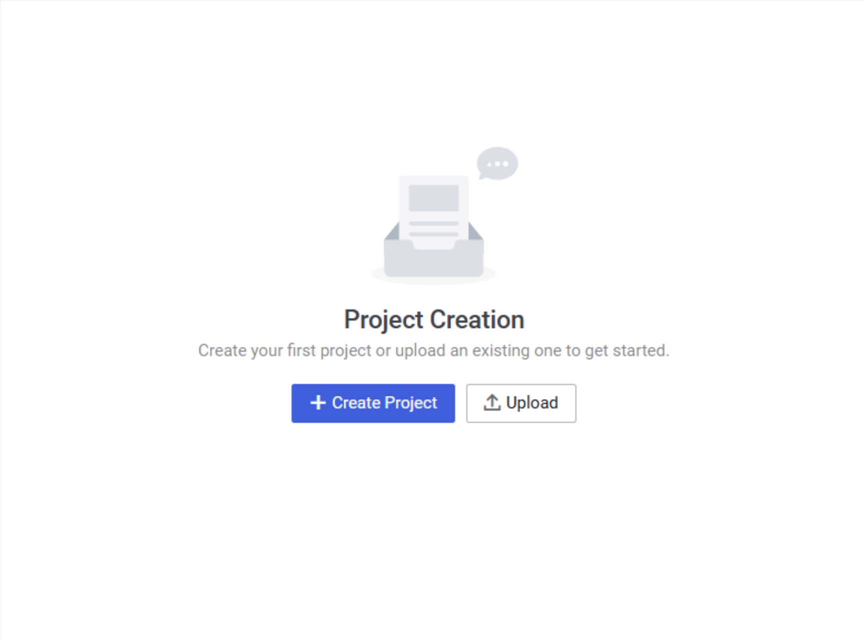
   The home page opens.

2. On the home page, click the **nv.design** module tile.



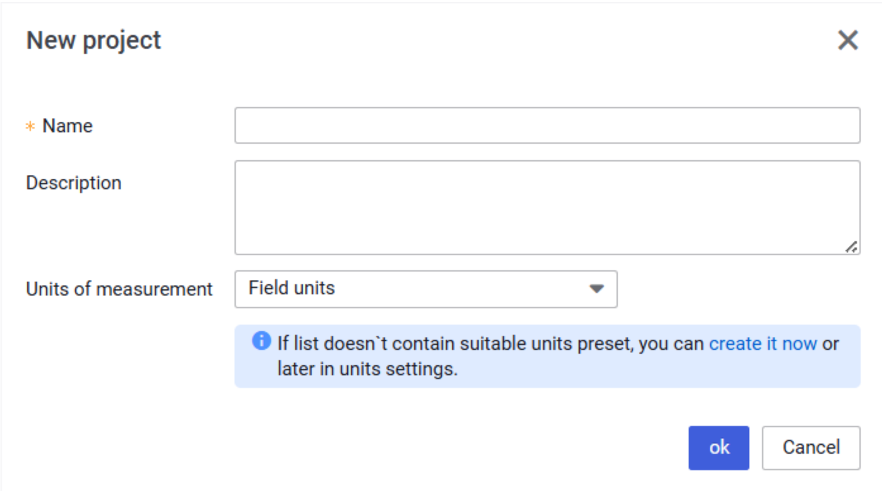
   The **Project Creation** window opens.

3. In the **Project Creation** window, click **Create Project (+)**.



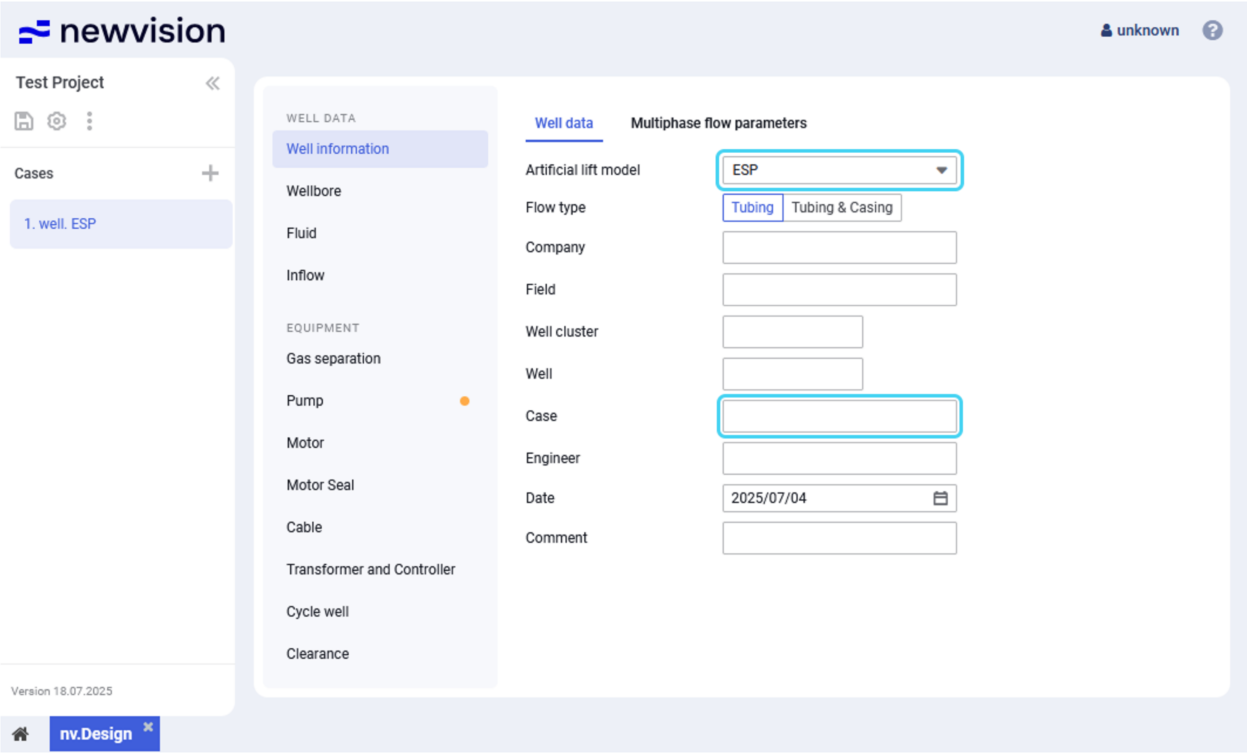
The **New project** window opens.

4. In the **New project** window, fill in the **Name** field, select a measurement system from the **Units of measurement** list or create a custom set of units, and then click **ok**.

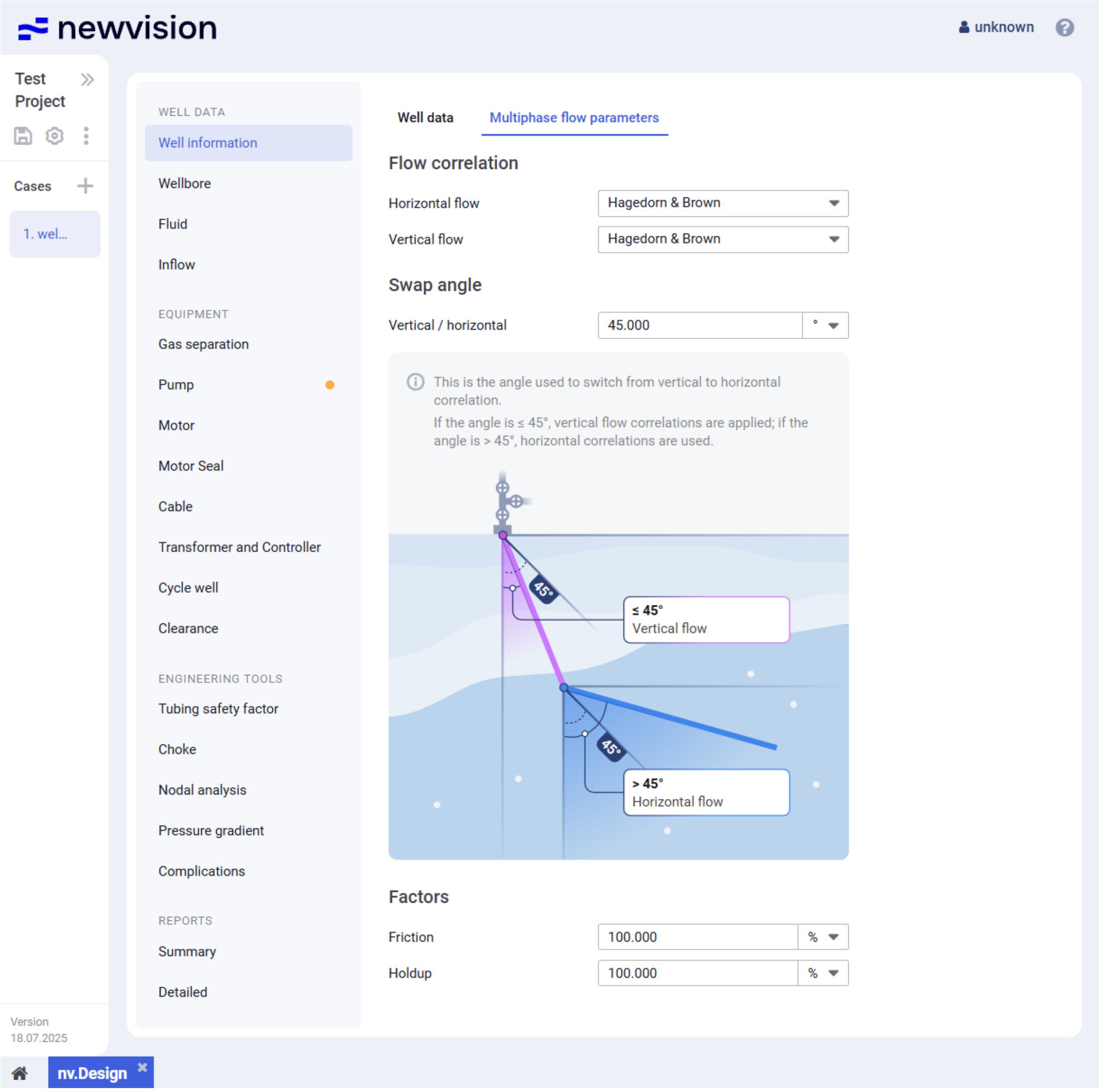


The created project opens with a default case created automatically.

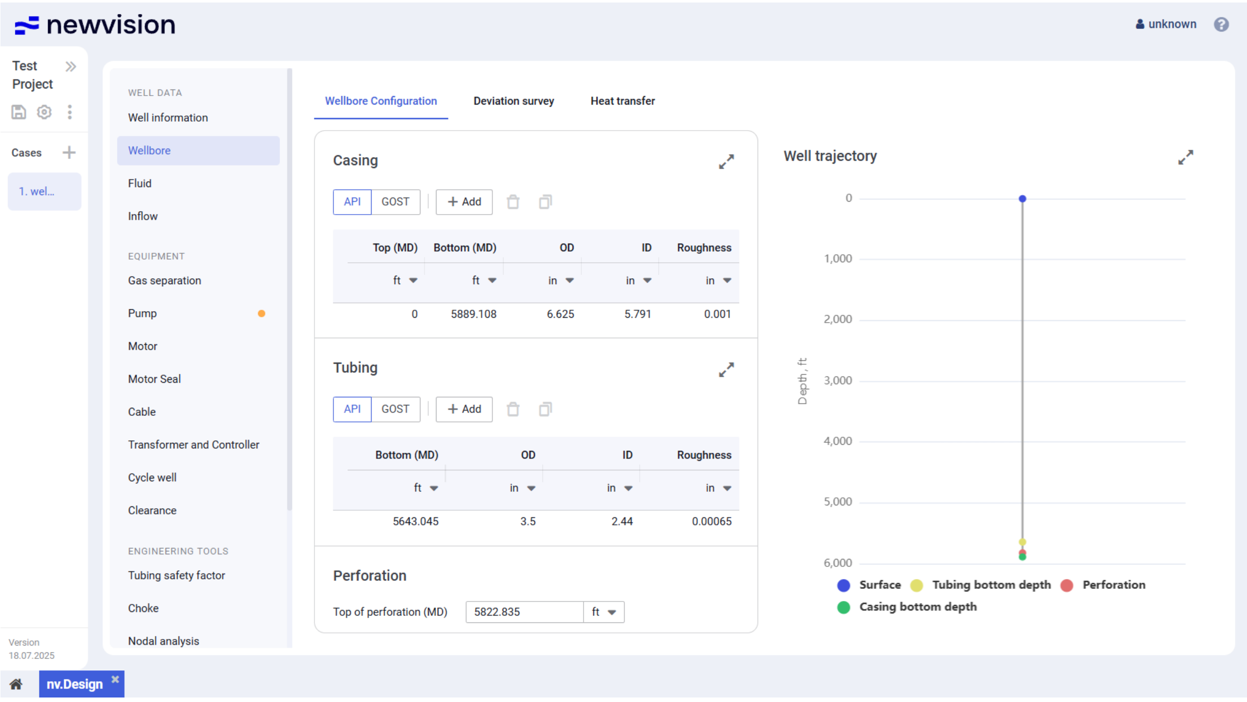
5. In the **Well information** section, on the **Well data** tab, from the **Artificial lift model** list, select **ESP**, and then, in the **Case** field, enter a name for the new case.



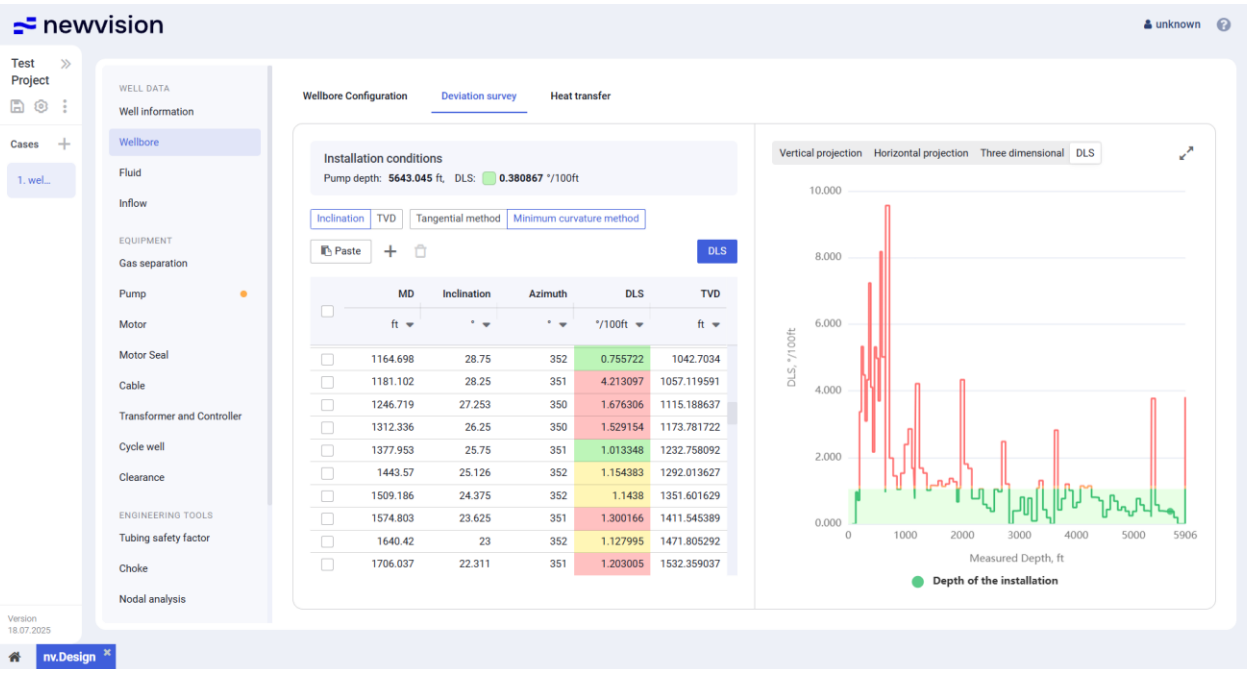
In the **Well information** section, on the **Multiphase flow parameters** tab, select the horizontal and vertical flow correlations, and, if needed, change the transition angle and/or friction and holdup factors. For details, see **Error! Reference source not found.**.



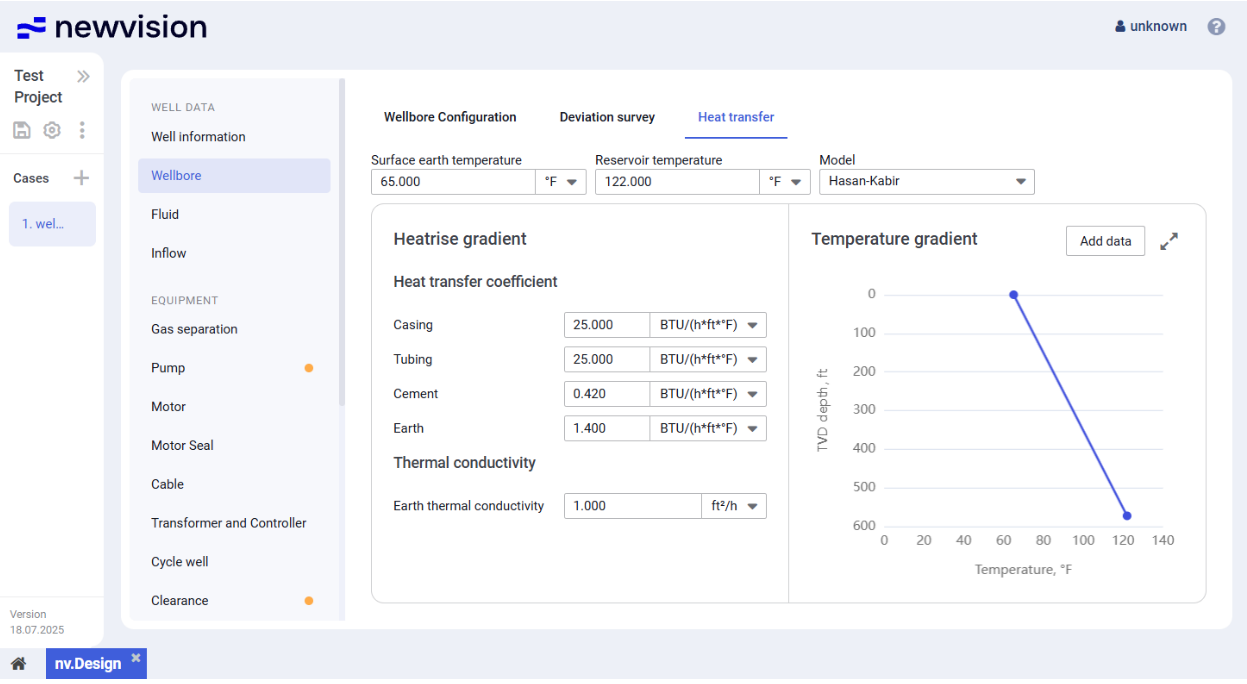
6. In the **Wellbore** section, on the **Wellbore configuration** tab, [configure the casing and tubing data]() and fill in the **Top of perforation** field.



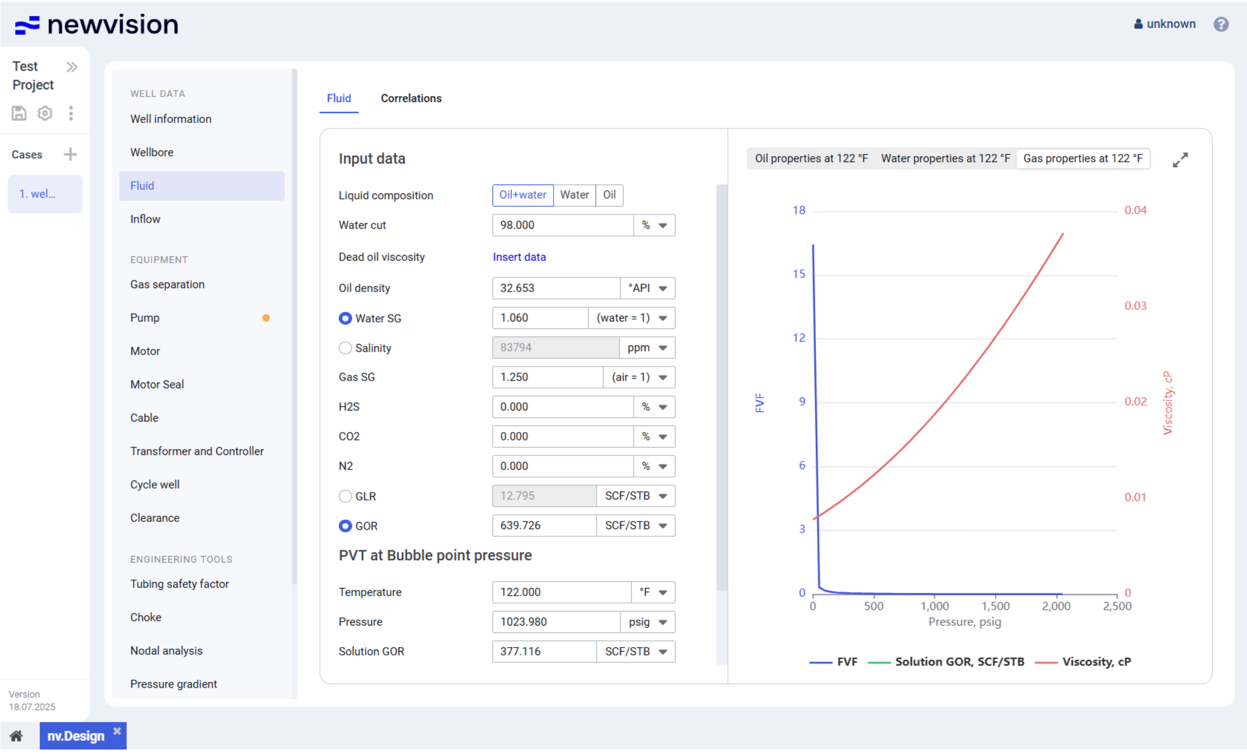
7. In the **Wellbore** section, on the **Deviation survey** tab, [configure maximum allowable dogleg severity]() and [deviation survey parameters]().



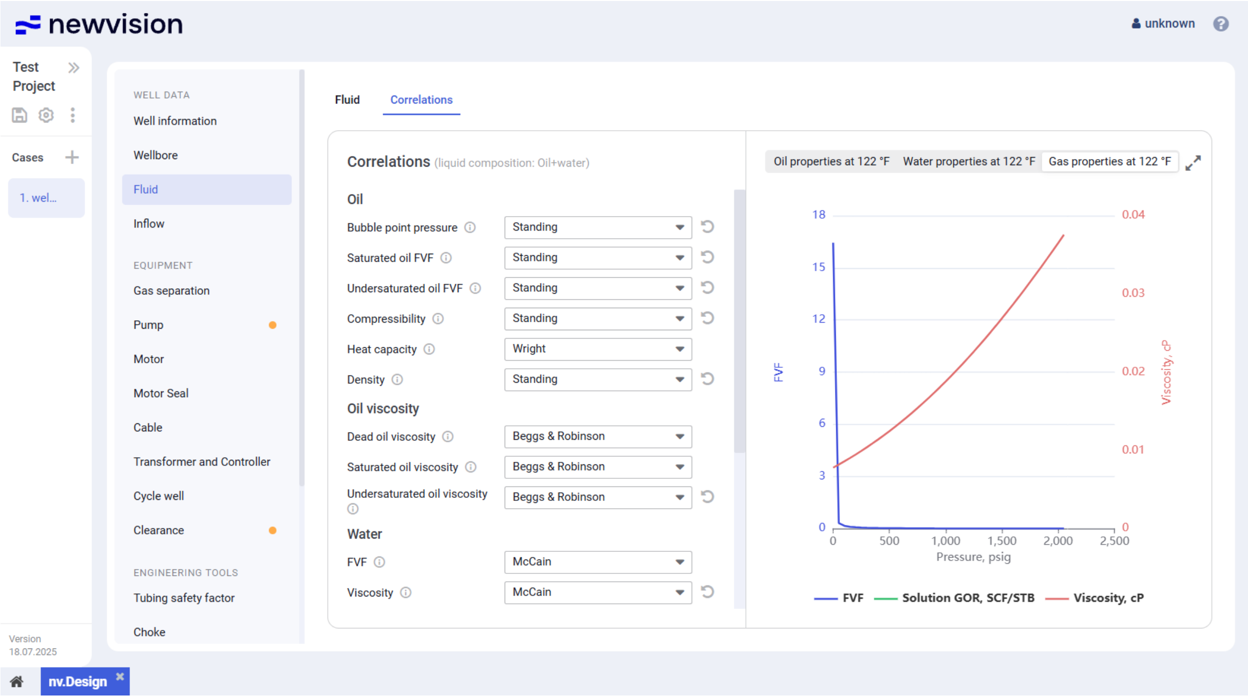
8. In the **Wellbore** section, on the **Heat transfer** tab, configure the temperature parameters and add well test data for building the well temperature profile.



9. In the **Fluid** section, configure the well fluid PVT properties and correlations used for their calculation. For details, see Configuring Fluid PVT Properties.



10. In the **Fluid** section, on the **Correlations** tab, select desired correlations from the corresponding lists. For details, see Appendix A: PVT Correlations.



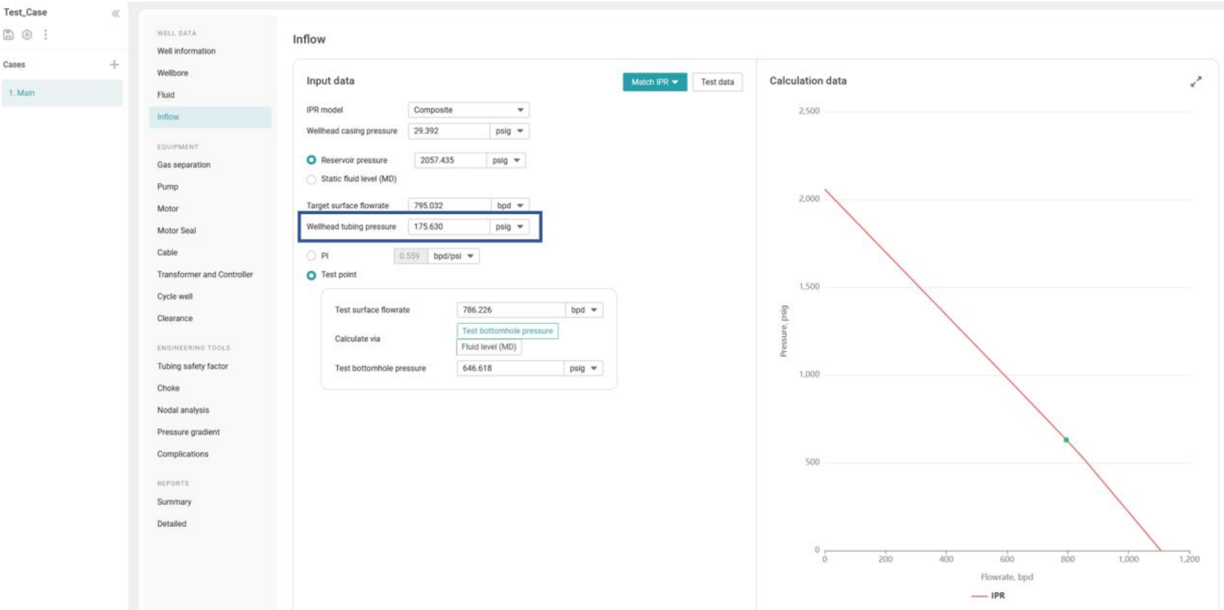
B2. Configuring Equipment

After adding general well data, proceed to equipment design:

1. In the **Pump** section, in the **Calculation parameters** pane, configure the calculation target parameters: enable two of the three available parameter groups: **Well productivity**, **Stages**, and **Pump frequency**. For details, see Pump.
2. In the **Pump** section, in the **Pump selection** pane, click **Add (+)** and select the desired model for the first pump section.

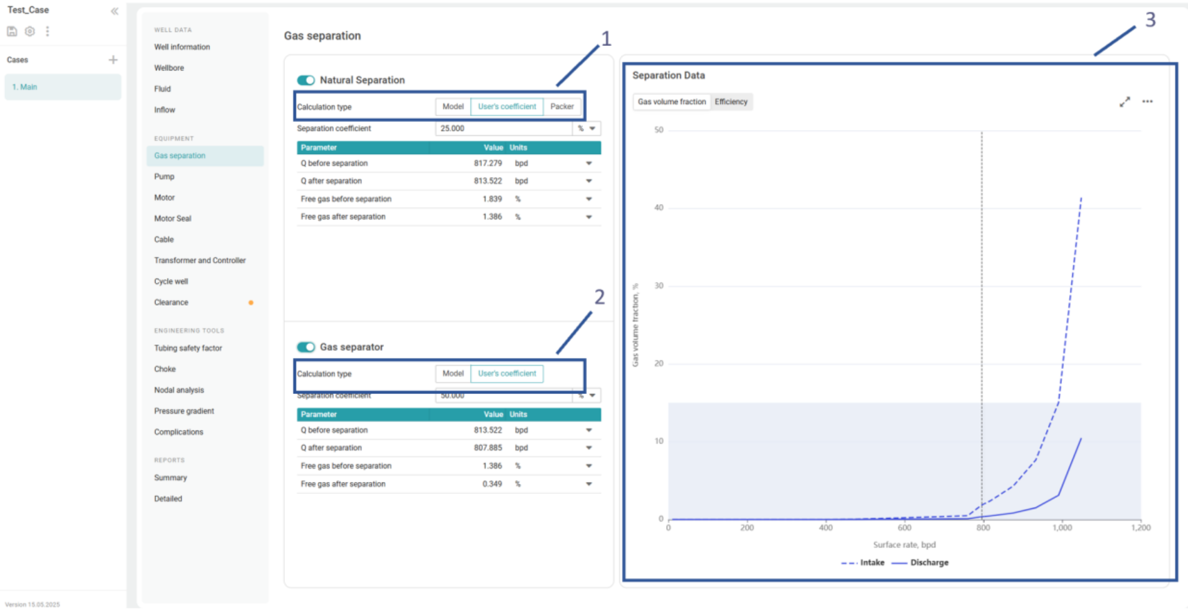
   Note

   You can add up to three pump sections in the same way.
3. Go back to the **Inflow** section, and enter the target value for the **Wellhead tubing pressure** parameter.

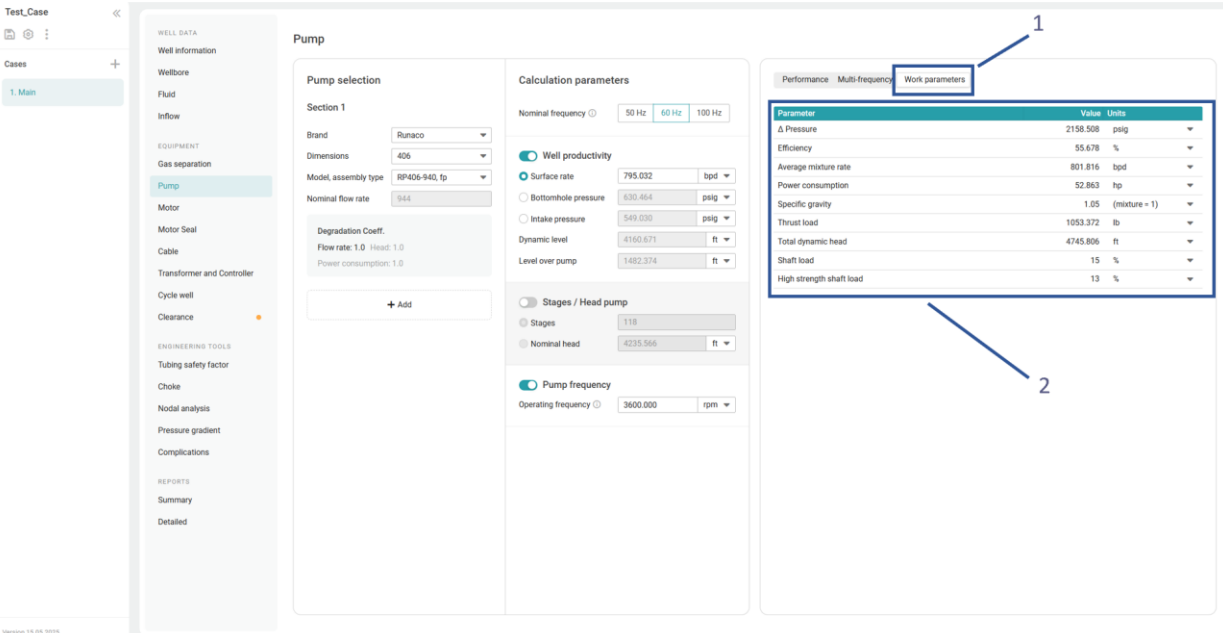


4. In the **Gas separation** section, configure the well natural, and/or mechanical separation parameters. The applied dynamic performance will closely reflect

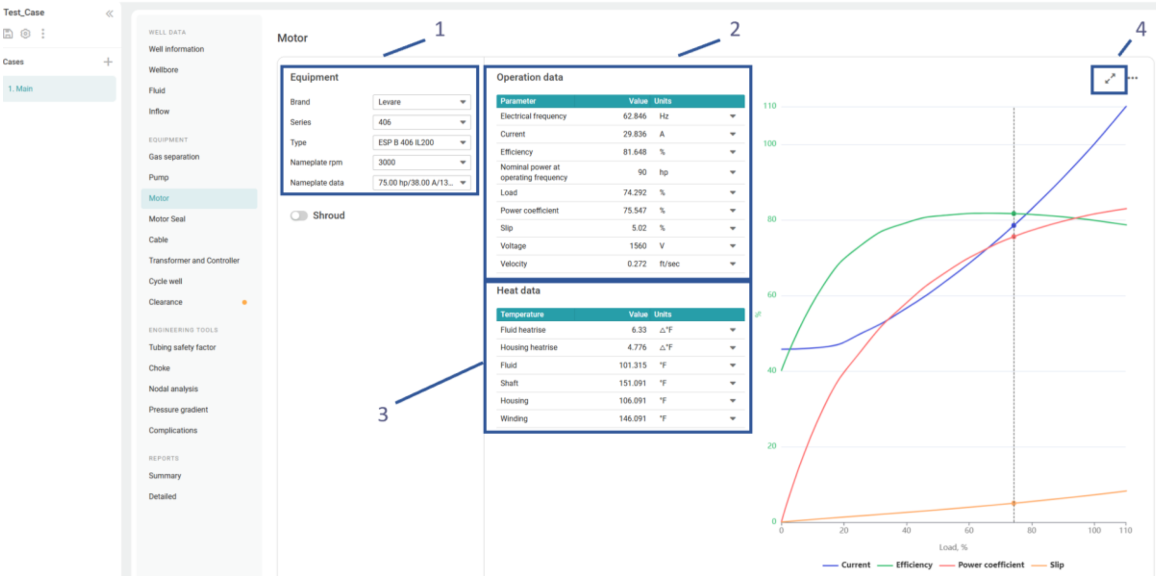
realistic conditions, taking into account variations in the separation coefficient depending on the production rate at the pump intake.



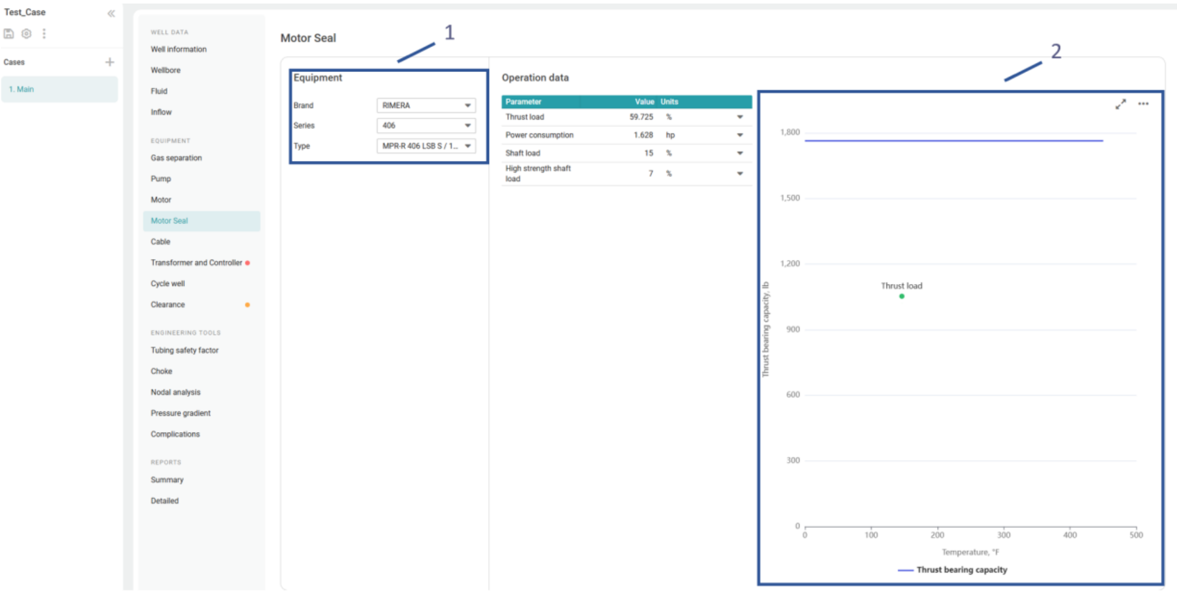
5. *(Optional)* Go back to the **Pump** section, in the upper-right corner of the section, click **Pump derating factors**, and then configure the flow rate, and power consumption derating factors for the pump sections. For details, see [Configuring Pump Parameters](#).
6. In the right part of the **Pump** section, view the calculation results presented as curves (**Pump performance** and **Multi-frequency** tabs) and a table (**Calculation data** tab).



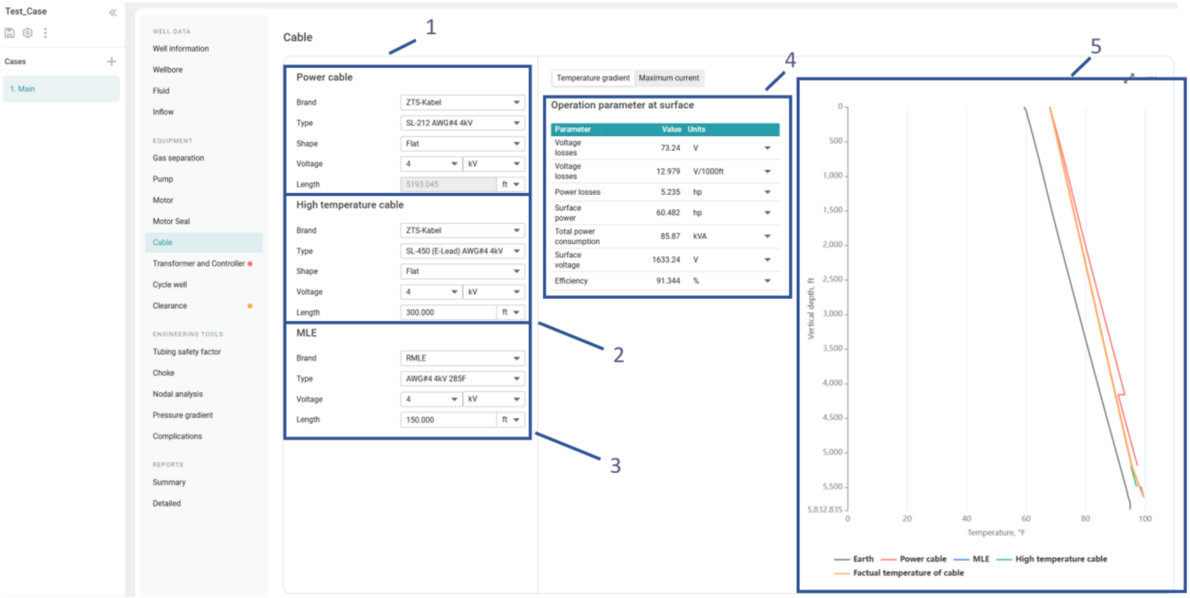
7. In the **Motor** section, in its left part, select a model of the motor that best suits the current parameters and, if needed, enable the **Shroud** option and specify the shroud inner and outer diameters. For details, see Motor.

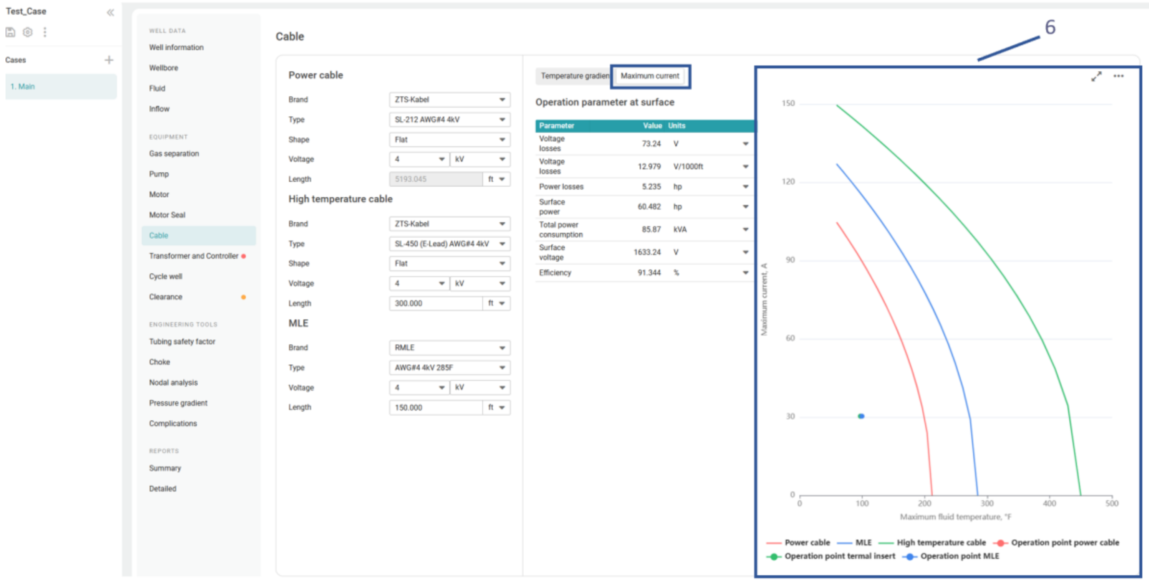


8. In the **Motor Seal** section, in its left part, select a model of the motor seal. For details, see Motor Seal.

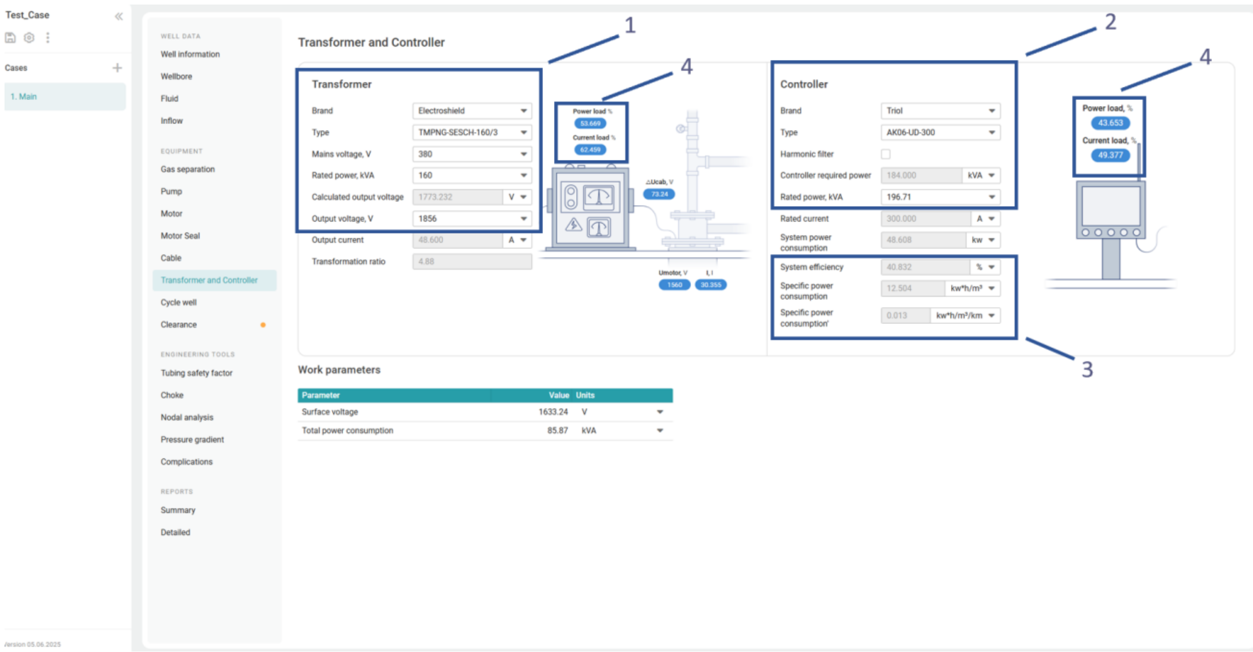


9. In the **Cable** section, select a power cable and, if needed, a high-temperature cable and a motor lead extension (MLE). For details, see Cable.



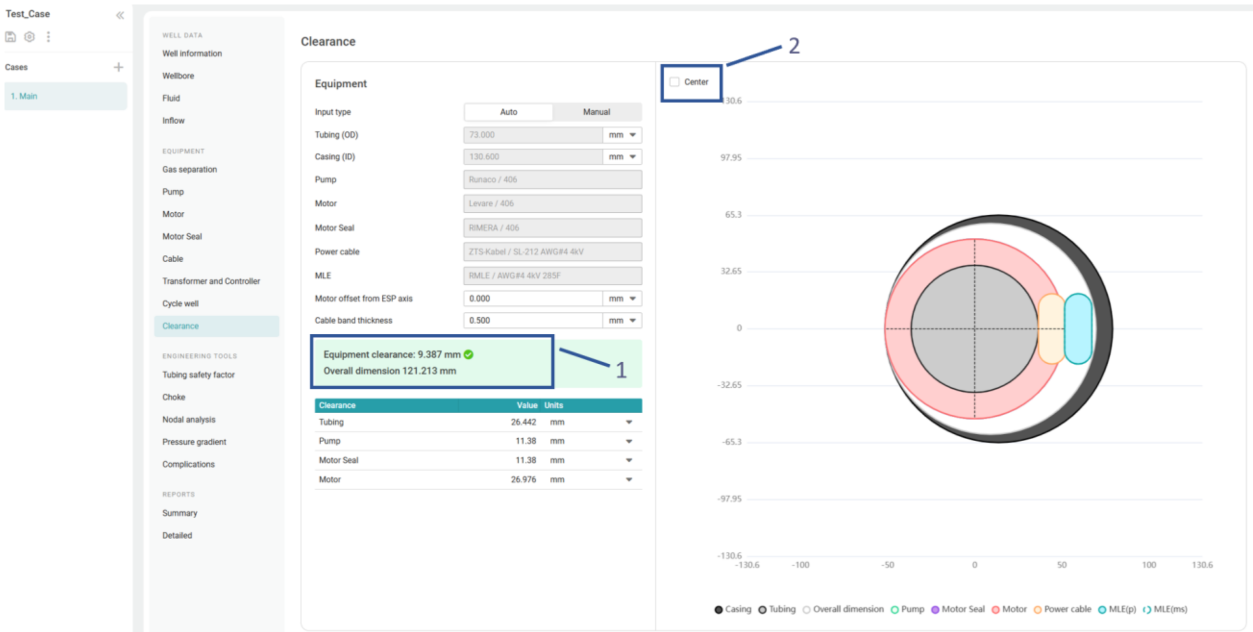


10. In the **Transformer and Controller** section, select the desired equipment models in the corresponding panes. For details, see [Transformer and Controller](#).



11. In the **Clearance** section, where equipment dimension data is automatically imported from other sections. The system calculates the maximum equipment size and minimum clearance—both critical for defining operating conditions (1).

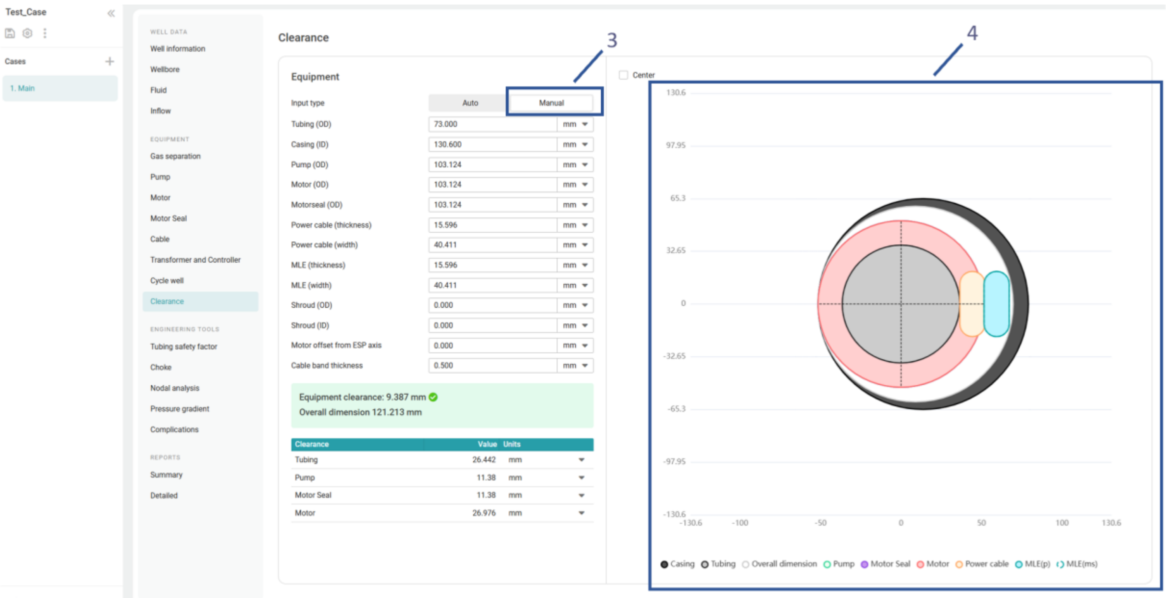
12. A useful feature allows alignment of the motor offset relative to other downhole equipment and accessories (2). Assembly alignment can also be adjusted to match the ESP and production string axes.



13. Manual input of equipment dimensions enables a quick check to determine whether clearance values fall within acceptable limits, even before detailed

calculations are performed (3).

On the right, a simplified ESP layout inside the well is displayed (4).

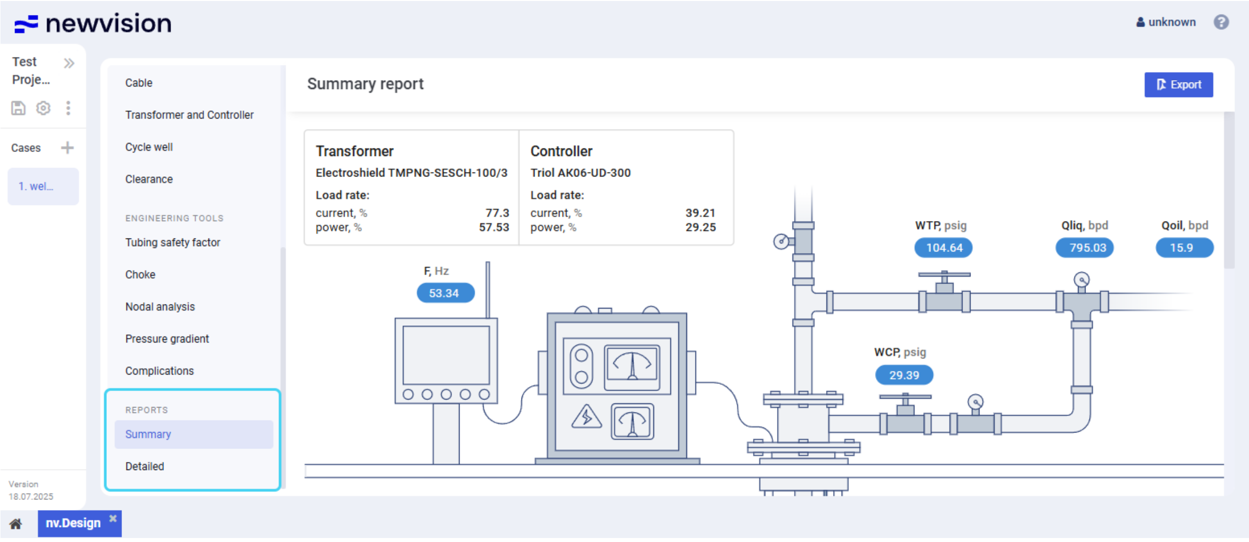


B3. Generating Reports

After all the well design parameters are configured, the system automatically generates the following reports:

- **Summary report**: Provides a simplified layout of the well with summary data on the well and production equipment parameters. For details, see Summary.
- **Detailed report**: Accumulates the input data and calculation results from all the module sections. You can customize the report by showing or hiding specific report sections. For details, see Detailed.

To open a report, in the left part of the module working area, click the desired report name at the bottom of the section list.



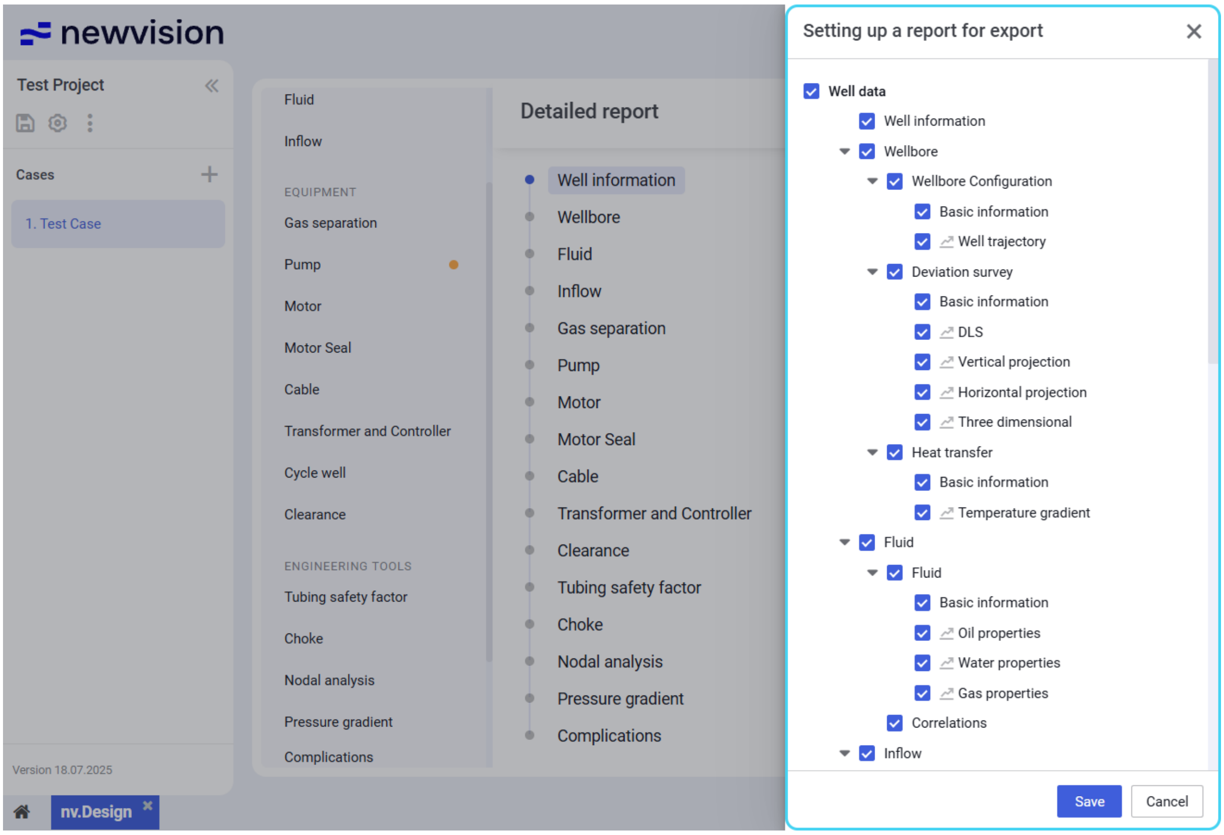
To export or print a report, in the upper-right corner of the report, click **Export ( )**, and then, in the standard browser window, select the desired action.

The **Detailed** report can also be exported to XLSX. To do this, in the upper-right corner of the report, click **Download ( )**.

To configure the **Detailed** report structure, in the upper-right corner of the report, click **Customize ( )**, and then, in the window that appears, select and/or clear check boxes of the sections that you want to show or hide in the report.

Note

Changes in the report configuration affect only the PDF export. Reports exported to XLSX contain all sections, including those that were hidden.


newvision
Test Project
Cases
1. Test Case
Version 18.07.2025
nv.Design
Fluid
Inflow
EQUIPMENT
Gas separation
Pump
Motor
Motor Seal
Cable
Transformer and Controller
Cycle well
Clearance
ENGINEERING TOOLS
Tubing safety factor
Choke
Nodal analysis
Pressure gradient
Complications
Detailed report
Well information
Wellbore
Fluid
Inflow
Gas separation
Pump
Motor
Motor Seal
Cable
Transformer and Controller
Clearance
Tubing safety factor
Choke
Nodal analysis
Pressure gradient
Complications
Setting up a report for export
Well data
Well information
Wellbore
Wellbore Configuration
Basic information
Well trajectory
Deviation survey
Basic information
DLS
Vertical projection
Horizontal projection
Three dimensional
Heat transfer
Basic information
Temperature gradient
Fluid
Fluid
Basic information
Oil properties
Water properties
Gas properties
Correlations
Inflow
Save
Cancel