5.1 Unit Procedure

5.1.1 What is a Unit Procedure?

The concept of a unit procedure is key in understanding how to model your process using Pro-Designer. The intelligent behavior of unit procedures under continuous and/or intermittent (batch, or semi-continuous) operation is what distinguishes Pro-Designer from any other simulation tool. As you will see, unit procedures have somewhat of a 'dual personality' behaving one way when their operating mode is set to continuous and another way when their operating mode is set to batch.

A unit procedure in Pro-Designer is defined as a modeled sequence of actions (called operations) taking place within the same main piece of equipment.

5.1.1.1 Unit Procedures in a Batch Recipe

When modeling a batch recipe, you may think of a (batch) unit procedure as simply a set of sequential operations (like charge A, charge B, heat, stir, react, transfer out). Since a single unit procedure is represented by a single icon in a flowsheet of Pro-Designer, you can lump as many or as few operations within a single unit procedure. If you use a single piece of equipment (some kind of vessel most likely) over and over during the execution of a recipe from beginning to end, you could – in principle – represent everything that takes place inside that vessel as a single unit procedure. There's no limit to the number of operations that can be included in a unit procedure. However, you will find it easier and more natural to break down this long set of operations into smaller sets and therefore, represent them on the flowsheet with several icons, each identifying a distinct unit procedure. Where should somebody break the sequence of actions in order to end a unit procedure and start the definition of another is more or less up to the user. Usually, it should be determined by one of two factors:

(a) A conceptual step has been completed (e.g. substrate preparation, or fermentation, etc.), or

(b) The entire contents of the vessel (or whatever else the main equipment might be) are transferred out (i.e. the equipment is being emptied).

When any of the two above conditions are encountered, it is usually is a good idea to end your current unit procedure and start another.

Every unit procedure is carried out in some kind of main equipment (Reactor, Fermentor, Diafilter, Nutche filter, etc.). Clearly, two or more unit procedures can be assigned to take place in the same vessel (you must make sure though, that they are scheduled carefully so that their equipment occupation times during a full recipe execution do not overlap). The types of operations that can be included in a unit procedure depend on the type of equipment the unit procedure is carried out (Reactor, Diafilter etc.) and the operating mode of the unit procedure (batch or continuous).

5.1.1.2 Unit Procedures in a Continuous Flowsheet

When modeling a continuous flowsheet (e.g. a wastewater treatment plant), you may think of a (continuous) unit procedure as simply a single unit operation: an aeration basin simply represents a basin that receives flow continuously, processes (reacts) continuously and outputs flow continuously as well. In essence, unit procedures in a continuous mode are simply an operation sequence with one and only one member. Since that operation is 'on' all the time, there is no idle time (or free time) for the equipment associated with that unit procedure to carry out any other operations. Clearly, a continuous unit procedure cannot share its equipment with any other unit procedure in the same flowsheet.

5.1.1.3 Common Features

As mentioned above each unit procedure is represented on the flowsheet by an icon. The icon's appearance depends of the type of unit procedure started and most importantly the type of equipment that the unit procedure is going to be carried out. There will be one or more input streams attached to the unit procedure as well as one or more output streams leaving the unit procedure. The input streams connect upon the unit procedure's input ports. Only one stream per port is allowed. Similarly, all streams leaving the unit procedure must start from an output port. Any one of the operations in the unit procedure list can access any of the input and/or output streams (provided its model permits it). However, a stream can only be used by an operation in a unit procedure only once. In other words, no two operations can share an input stream or an output stream. Every unit procedure must be assigned a main piece of equipment that hosts the procedure. However, as mentioned in the previous section, in the case of batch procedures, several unit procedures can be defined to use the same host equipment. Under every unit procedure's icon you can see two labels. The first displays the name of the unit procedure and then the name of the host equipment. The second label (shown under the first) represents a short description of the unit procedure. Finally, the cosmetic appearance of the procedure's icon (including its labels) is determined by its drawing style. The drawing style of a procedure's icon dictates features like the color of the icon, the type of fonts used for the labels, the appearance or not of each of the labels, etc.

5.1.2 Operating Mode

A unit procedure in Pro-Designer can be set in:

- Batch (or Semi-Continuous) Operating Mode
- Continuous Operating Mode

You can set the operating mode of a unit procedure by selecting the Operating Mode… menu option from the procedure's context menu. Then the following dialog (Fig. 5.1)

- **If you set the unit procedure's operating mode as continuous**
  Then this unit procedure will no longer show in any Gantt charts (since it is 'on' all the time and the equipment is busy all the time, there are no scheduling issues to be dealt with).

- **If you set the unit procedure's operating mode as batch**
  Then from this dialog you also have a chance to set the number of cycles per batch for this unit procedure. The number of cycles per batch determines the number of times that the operation sequence in this unit procedure will be repeated while processing quantity that amounts to a single batch. For more information on number of cycles per batch, cycle time, and other related terminology please see Scheduling Definitions section in Chapter 6 . Finally, when a unit procedure is operating in batch mode and there are more than one pieces of equipment associated with it, you can specify whether you wish to stagger the operation of the equipment or simply let them operate in parallel (default). Staggering can help eliminate equipment bottlenecks (Chapter 9).

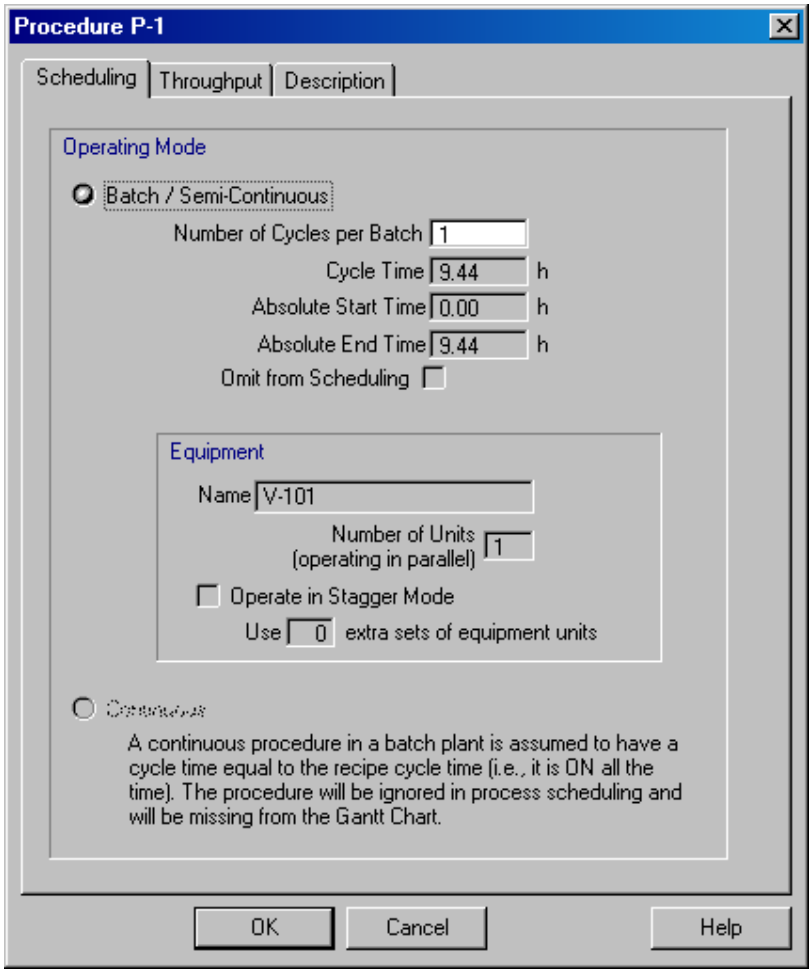


Figure 5.1: Setting the operating mode of a unit procedure.

You should set the operating mode of a unit procedure to **<u>continuous</u>** if:

(a) The equipment hosting this unit procedure is 'on' all the time (i.e. there is no down time)
(b) There is only one operation being carried out, or
(c) The operation being carried out is not cyclical in nature (i.e., all physico-chemical transformations are in steady-state and do not change in time).

You should set the operating mode of a unit procedure to **batch (semi-continuous)** if:
(a) The equipment hosting this unit procedure is 'on' some time and 'off' some time (i.e. there's some down time)
(b) There is more than one operation taking place; each operation has its own schedule (start time, duration), or
(c) The operations participating in the unit procedure are cyclical in nature (i.e. a non-steady behavior is observed that repeats itself cyclically in time). For example, consider a chromatography unit procedure: the column must be loaded with solution and then the loading operation must be followed by one or more wash or elution steps (operations). The when the next batch arrives this sequence repeats itself all over again.

Finally the option for "Omit from Scheduling" is there in case the user wishes to overwrite the default behavior of Pro-Designer regarding which unit procedures are included into the scheduling (and resource tracking). By default Pro-Designer considers all batch mode procedures as part of its scheduling and resource tracking. However, If there's a specific unit procedure (e.g. some mixing step) that you want to be ignored from scheduling and not appear in Gantt charts etc., you can check the option in this box and thus hide it from all further involvement with scheduling issues.

The Holdup Time

When a batch unit procedure (like chromatography, batch filtration, batch distillation, etc.) is set to operate in a continuous process, Pro-Designer needs to infer the amount of material that gets processed per cycle. In other words, the implicit assumption is that, in order for this unit procedure to function cyclically in an otherwise continuous environment, there must be a tank that accumulates material for a certain time (at least while the procedure is in progress) and then feeds the next cycle of the unit procedure. This time we call holdup time. Obviously, this time must be at least as long as the cycle of the unit procedure (but it could be longer). For unit procedures whose cycle time is set directly by the user (in other words, the cycle times of all contained operations have process times, setup times and turnaround times directly set by the user), the holdup time is assumed to be equal to the cycle time of the unit procedure. In that case, the user does not need to supply the procedure's holdup time (and it will not be editable in the procedure's operating mode dialog). However, at least one component making up the procedure's cycle time is calculated by the system (as is the case for chromatography columns) then the user must directly set the holdup time (the field is editable).

NOTES:

a. For unit procedures that are truly cyclical (e.g., chromatography), the continuous mode of operation option is not available.

b. For unit procedures that are continuous in nature (e.g., pumps, disk-stack centrifuges, etc.), the batch / semi-continuous mode of operation option represents interrupted continuous operation.

5.1.3 Operations in a Unit Procedure

As discussed at the beginning of this chapter, unit procedures in batch mode contain a sequence of operations. Most unit procedures contain already an operation by the time

they are first created. For instance, when you insert a Microfiltration (batch) unit procedure, it already contains a 'Concentration' operation; when you insert a Continuous Stoichiometric Reaction unit procedure in a CSTR, it already contains a 'React' operation. You can, of course, add more operations later. Some unit procedures contain no operations when they are first created. These are the Vessel Unit procedures (in a Reactor, in a Fermentor, in a Seed Fermentor and in an Air-Lift Fermentor) and they do nothing by themselves. They are considered a 'general purpose' unit procedure and as such it does not already contain any pre-determined operations. You must visit their Add/Remove Operations interface and add operations to them, in order to accomplish your goals in that unit procedure. Operations can be added/removed/re-ordered in a unit procedure by right-clicking on the unit procedure's icon and then selecting the **Add / Remove Operations …** option. Remember that a unit procedure has a dual behavior depending upon its operating mode. If it is a continuously operated procedure (i.e. no cyclical operation(s) occur(s) in it but all the physico-chemical transformations happen in a manner that does not change in time e.g. a CSTR reaction, or pumping) then one and only one operation can be carried out by this unit procedure and the **Add/Remove Operations …** option is not available. Therefore, if a unit procedure is set into continuous mode, you cannot add/remove operations to it.

Tip

As a shortcut, you can access the **Add/Remove Operations …** option of a unit procedure in batch operating mode by double clicking on its icon. Double clicking on a procedure's icon when it is in continuous mode, will bring up the i/o simulation dialog of the (only) operation in it.

Note that you can add as many operations as you wish in the operation list of a batch unit procedure. However, the types of operations available depend on the specific type of unit procedure you are editing. For example, for a Microfiltration unit procedure the available options for operations are:

- CIP (Clean-in-Place)
- Charge
- Concentrate (batch)
- Concentrate (feed-and-bleed)
- Hold
- SIP (Steam-in-Place)
- Transfer-in
- Transfer-out

On the other hand, for a general purpose Vessel unit procedure the available options for operations are:

- Agitate
- Charge
- CIP (Clean-in-Place)
- Cool
- Crystallize
- Distill
- Evacuate
- Extract
- Phase Split
- Ferment (Kinetic)

- Ferment (Stoichiometric)
- Gas Sweep
- Heat
- Hold
- Pressurize
- Pull In
- Pull Out
- Purge / Inert
- React (Equilibrium / Kinetic / Stoichiometric)
- SIP (Steam-in-Place)
- Split (Component Flow)
- Transfer In
- Transfer Out
- Vaporize / Concentrate
- Vent

Tip

From the same **Add/Remove Operations…** dialog, you can also re-arrange the order of existing operations in a unit procedure.

NOTES:

a. Since each of the operations in the unit procedure list is individually scheduled, it is possible that the order in the operation sequence and the (possibly computed) start time operations are in conflict. If that is the case, Pro-Designer will notify you about the violation. It is important to understand that for M&E balances, the system treats the operations as happening in the sequence as implied by the operation order shown in the **Add / Remove Operations …** dialog.

b. The scheduling settings of each operation entered in a unit procedure list are set to default values as follows: For the first operation, it is assumed that its starting time will be determined using a time shift (set by default to 0.0) with respect to the beginning of the batch. In other words, we assume that the first operation of this unit procedure (and hence the procedure itself) will be started at the beginning of the batch. For every subsequent operation, its default settings are such that schedule the operation to start as soon as the previous operation is ended. In other words, it uses as reference time the end of the previous operation and as time shift 0.0. All of these settings of course, can be changed. Simply visit the scheduling tab of each operation in the list and modify according to your actual.

c. You can schedule two operations in a unit procedure to be starting at the same time (synchronize their start times). However, the simulation models will still execute the operation models in sequence. It is impossible to take into account the fact that two or more operations actually take place at the same time and alter the simulation results. Therefore, for M&E balance calculations, the outcome depends solely on the order that the operations appear in the unit procedure list. Synchronizing two or more operations to take place at the same time during a procedure will only affect the tracking of any resources associated with those operations.

5.1.4 Icon

Each unit procedure is depicted on the screen by an icon. The actual pictorial used is dependent upon the type of unit procedure and most importantly the type of equipment that this procedure will be allowed to be carried out (e.g. Stirred Jacket Vessel, Microfilter, etc). But, you may ask, what about the equipment itself ? Does each icon also represent a physical piece of equipment, too? Even though that can be the case, each icon does not necessarily correspond to a single piece of equipment. Stream mixers, for example, do not correspond to any physical piece of equipment. In other cases, a depicted unit procedure takes place into a piece of equipment that happens to be used by another procedure (i.e., both procedures are hosted by the same equipment — this is very common in batch processes). If such is the case, multiple icons, appearing in different places in the flowsheet, represent the same physical piece of equipment, but different operations that take place at different times during the execution of recipe. For example, imagine a vessel that is being used by two distinct reaction procedures of a long recipe.

Furthermore, even though a single pictorial icon is always used for a unit procedure, it may represent the existence of multiple pieces of equipment (operating in parallel) that are needed to carry out the unit procedure's operation list. This will be the case if there is no single piece of equipment large enough to accomplish the required physico-chemical transformation(s). In that case, we have to employ several equipment units operating in parallel. For example, suppose you request the presence of a filtration unit procedure that is expected remove solid particles from a solvent. However, what if the required filtration area to accomplish the necessary removal is larger than the largest available (commercially) filter? In that case, the system will decide to use a set of equipment units (filters) operating in parallel (reported on the Equipment Data… dialog of the unit procedure as 'Number of Units'). Each filter will have, of course, a filtration area less than the maximum. Therefore:

An icon simply represents a single unit procedure and may correspond to none, one or several pieces of equipment operating in parallel.

Notice that under each icon, Pro-Designer displays two strings (labels):

- The first label depicts the name of the unit procedure and then the name of the process equipment used to carry out the unit procedure (the two names are divided by default by a '/', but the user can specify a different delimiter that separates the two names)

- The second label is simply a string that describes the operation taking place.

Unit procedure icons allow streams to transfer material in and out of the operations. The streams are attached to the procedure's icon at special connection points called ports (see next).

5.1.5 Ports

Each icon can have several ports. A port is simply a connection point that can be used by an incoming or an outgoing stream. Input ports are those used as ending points of streams with flow into the unit procedure and output ports are touch points for streams that represent material leaving the unit procedure. Since there are two types of flows (bulk and discrete) there are also two types of ports: bulk flow ports and discrete flow ports. Only bulk streams can use bulk flow ports and only discrete stream can use discrete flow ports. In fact, Pro-Designer decides the nature of a stream based on which ports you chose to use as input and/or output. Notice how Pro-Designer displays bulk flow ports differently from discrete flow ports:

Bulk Flow Ports:
Discrete Flow Ports:

Each port can anchor only one stream. Ports that already have a stream hooked on, are considered "busy" by the system, and unavailable as ending points of input streams or starting points for output/intermediate streams.

The location of each port can be easily recognized, since the cursor changes as soon as the mouse is over a port:

Input/Output
Bulk Flow Port Cursor

Input/Output
Discrete Flow Port
Cursor

Output ports serve as starting points for intermediate and output streams, and input ports serve as ending points of intermediate and input streams.

From all input ports, one of them is special and is considered as the default input port. The default input port has a very special property: it allows the material of the stream attached to it, to be automatically forwarded into the unit procedure's equipment (i.e., without the user having to define a special transfer-in or charge operation). However, this is only allowed to happen if the unit procedure itself doesn't have any material transfer-in operations in its operation list. This behavior presents a very convenient way to transfer material into a unit procedure without having to worry about their timing (scheduling). However, notice that if you decide you would like to take advantage of the automatic loading of material into a unit procedure using the default input port, you cannot include other transfer-in or charge operations in the unit procedure's operation list. In other words, you must either completely disregard the timing (scheduling) of all material being loaded into a unit procedure, or schedule all of it (by introducing transfer-in and charge operations at appropriate order in the operation sequence). Notice how Pro-Designer displays the default input port with a hollow arrow whereas all other ports are displayed with a solid arrow:

Regular Input Port

Default Input Port

The default output port is a similar concept applied to output ports of a procedure's icon. The default output port is a designated output port that automatically transfers out any material existing in the equipment after the conclusion of the last operation in the unit procedure's operation list. Note that again, this is a convenient way to remove material from a piece of equipment without having to worry about the timing (scheduling) of the removal operation. However, this behavior will only be allowed if no other transfer out operations exist in the operation list of the unit procedure. In other words, the user must decide to either schedule all or none of the material transfer out of the equipment during a procedure's execution. Again, Pro-Designer displays the default output port as a hollow arrow as opposed to filled arrow used for all the other regular output ports.

Regular Output Port 

Default Output Port 

5.1.6 Labels

Each unit procedure icon is accompanied by two labels:

- The Name Label and
- The Description Label

The description label, simply displays a string that is supposed to describe what is being accomplished by the unit procedure (e.g. Bacterial Fermentation).

The name label reports the name of the unit procedure and the name of the equipment that is used to carry out the procedure. The two names (unit procedure name and equipment name) are separated by a '/'. The separation delimiter is part of a procedure's style and can be changed by the user to any string. By default, Pro-Designer makes up a name for a unit procedure by combining a prefix (typically a P-) and a number starting from 1. For example, the first unit procedure will be named P-1. The next unit procedure will be called P-2, and so forth. The equipment tag names are made up in a similar way, except the prefix depends on the type of equipment being employed. For example, for vessels will be 'V- but for microfilters will be 'MF-'. Note that V-101 will be used for the first stirred vessel w/ jacket employed by the first such unit procedure and V-102 will be used for he second vessel. All unit procedure names must be unique amongst unit procedures and all equipment tags must be unique amongst equipment tags. Both the name and the equipment tag name are user-editable and can be hidden (if desired). This can also be accomplished by editing the style of the unit procedure's icon.

If you do not like the name chosen for you, you can edit it:

To edit the name of a unit procedure

1. Bring up the unit procedure's context menu for the procedure whose name you want to edit (i.e., right-click over the procedure's icon).
2. Select **Edit Labels....**
3. In the dialog window that comes up, type in the new name for the procedure and click **OK**.

To edit the equipment name of a unit procedure

1. Bring up the unit procedure's context menu for any procedure hosted by the equipment whose name you want to edit.
2. Select **Edit Labels....**
3. In the dialog window that comes up, type in the new name for the equipment and click **OK**.

Note that if the equipment sharing is used, you may change the name of the equipment by starting from any of the unit procedures carried out inside that equipment.

To edit the description of a unit procedure

1. Bring up the unit procedure's context menu for the procedure whose name you want to edit (i.e., right-click over the procedure's icon).
2. Select **Edit Labels....**
3. In the dialog window that comes up, type in the description for the unit procedure and click **OK**. Descriptions need not be unique and any string up to 31 characters is acceptable.

The fonts and colors used by the system to display the tag names and descriptions of new unit procedure is specified based on default style for unit procedure icons that are kept for each design case. To modify the default style for a procedure icon, select **Preferences/Default Styles/Procedure Icons …** option from the flowsheet's context menu. Then select the "Name Tag" and "Description Tag" tabs and edit the style properties affecting the appearance of name labels and description labels. Any changes made in the default style of procedure icons will affect all procedure icons (present and future) that do not have their styles overwritten by the user. If you wish to overwrite the default style for a selected number of procedure icons (e.g. in order to make them stand out), you may overwrite the default style just for these procedures.

5.1.7 Style

The style of a unit procedure icon is a collection of attributes that determine the visual appearance of the icon and its labels. Icons of unit procedures are monochrome. They are drawn using a default color that is part of the default style for a procedure. Furthermore, the labels are drawn using a font and text color that is also part of the default style of a procedure. In detail, the style of a unit procedure is comprised of the following attributes:

For the Icon itself:

- Color

For the Name Label:

- Text font
- Text color
- Text background (opaque or transparent)
- Visibility of the unit procedure name (on / off)
- Visibility of the equipment name (on / off)
- Delimiter (separator) used between names
- Frame visibility on/off
- Frame line attributes (thickness, color, style)

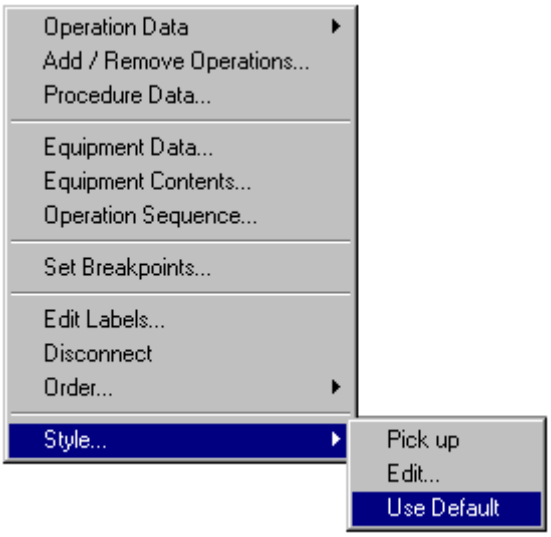
For the Description Label:

- Text font
- Text color
- Text background (opaque or transparent)
- Visibility of the description label (on / off)
- Frame visibility on/off
- Frame line attributes (thickness, color, style)

Every procedure icon when it is first drawn it uses a default style for a unit procedure icon. However, you may overwrite the style of any unit procedure(s) icon as follows:

To edit the style of a unit procedure's icon...

1. Bring up the context-menu of the procedure (by right clicking on the icon of the procedure) that you wish to modify its style and select **Style.**



2. Then the following menu appears**:**
   If you select **Use Default**, then the selected unit procedure(s) will be forced to follow the style set as the default style of unit procedures. To find out how to edit the default style of unit procedures see the section below ("Editing the Default Style of Unit Procedures"). If you select the **Edit...** option you are presented with the style-editing dialog.
3. Make any choices that you wish to apply in the selected unit procedure's style and click **OK** (for more details, see Defining the Style of a Unit Procedure).

Tip

If you like the style of an existing procedure icon and you want to apply it to several others, you can use the **Style/Pickup** and **Style/Apply** commands either the procedure's context menu or visual objects toolbar. Select the procedure whose style you wish to copy and then click on the **Style/Pickup** button of the visual object toolbar (or select **Style/Pickup** from its context menu). Then select all the procedures that you wish to use that style and then click on the **Style/Apply** button of the visual object toolbar (or select **Style/Apply** from any selected procedure's context menu). It's that simple. All the selected procedures are now displayed using your choice style.

Editing the Default Style of Unit Procedure Icons

Every unit procedure that is inserted into a design case must be provided with a style (default style). The characteristics of the default style can be edited for each design case file. Note that the changes will stay saved with the saved design case file and the next design case will be equipped with the defaults that your "Pro-Designer" software has built-in.

To edit the default style of unit procedures...

1. From either the **Edit / Flowsheet Options / Preferences / Default Styles...** submenu of the main menu or the context menu of the flowsheet select **Unit procedure Icons.**

2. From the dialog that pops up make your selections for all style attributes and click **OK**.

NOTE: Modifying the default style of a unit procedure will affect the appearance of all existing unit procedures that follow the default style. If you wish to have some step icons maintain their current style, you must explicitly visit them and use the **Style / Edit...** option to set their styles yourself. After you set the style of an object, changing the default style will not affect the appearance of that object.

Editing the Style of a Unit Procedure

Whether you are modifying the style of a particular unit procedure in the flowsheet or the default style of all unit procedures, the Unit procedure Style dialog described here (see Figure 5.2) allows you to edit the following style characteristics:

For the Icon itself:
- Color

For the Name Label:
- Text font
- Text color
- Text background (opaque or transparent)
- Visibility of the unit procedure name (on / off)
- Visibility of the equipment name (on / off)
- Delimiter (separator) used between names
- Frame visibility on/off
- Frame line attributes (thickness, color, style)

For the Description Label:
- Text font
- Text color
- Text background (opaque or transparent)
- Visibility of the description label (on / off)
- Frame visibility on/off
- Frame line attributes (thickness, color, style)

For the Allocation Label:

- Text font
- Text background (opaque or transparent)
- Visibility of the description label (on / off)
- Frame visibility on/off
- Frame line attributes (thickness, color, style)

The dialog has seven tabs. The Icon tab, shown below, allows you to define the icon color of a unit procedure.

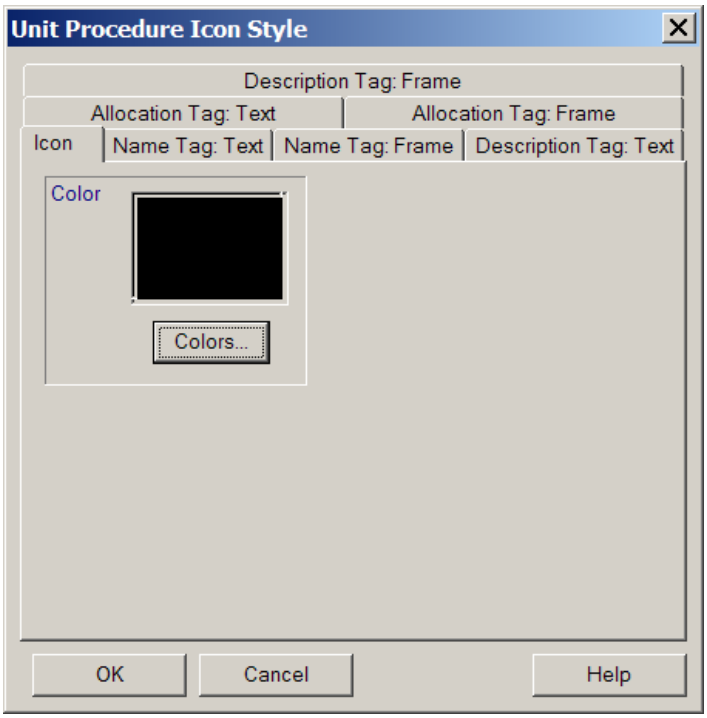


Figure 5.2: Dialog for editing the style of a unit procedure's icon.

To select another color, click on the **Colors…** button. Then the dialog of Figure 5.3 appears that allows the user to select a different color.

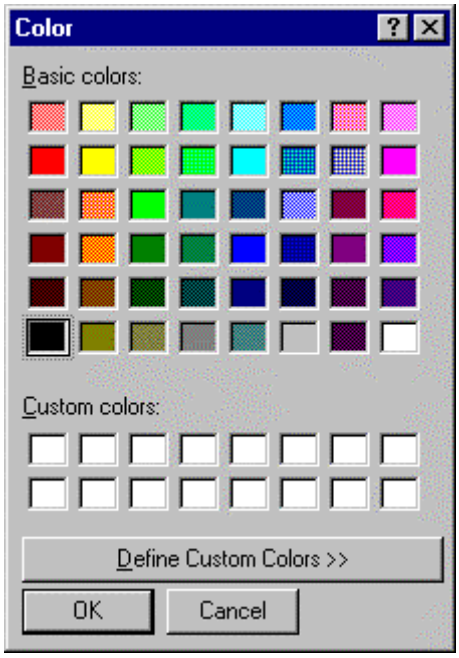


Figure 5.3: Dialog for selecting the color of a unit procedure icon.

The Name Tag (Text) tab shown below (Figure 5.4) allows you to define the characteristics of the name label. You can elect not to display either the name of the unit procedure or the name of the associated equipment or both. Also, you may choose any string that you wish (up to 12 characters) to be used as the dividor between the name of the unit procedure and the name of the equipment. By default, the dividing string is ‘ / ‘ (a forward slash preceded and followed by spaces).

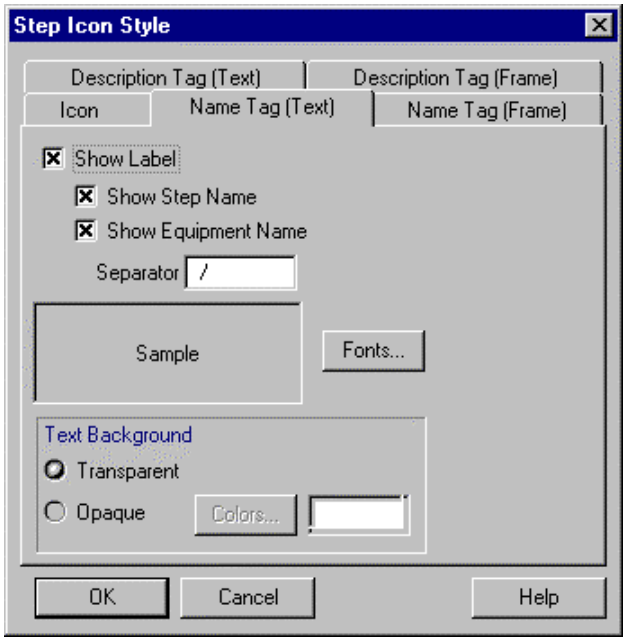


Figure 5.4: Dialog/Tab for editing the style of unit procedure labels.

5.1.8 Unit Procedure Types

In order to visually compose a recipe (in case of a batch process) or a flowsheet (in case of a continuous process) you must breakdown the overall processing scheme into unit procedures. Following is a list of all unit procedure types (categorized by group) currently supported by Pro-Designer. The actual list available depends on which member of the Pro-Designer family of software (EnviroPro or SuperPro) you own

Tip

A detailed description of the various unit procedures and their operation models is available in the on-line Help Facility. To access that information for a procedure, simply click on the unit procedure icon to highlight it, and then hit the F1 key.

5.2 Operations

5.2.1 What is an Operation?

An operation represents the simplest physicochemical transformation step that can be modeled by Pro-Designer. It can be simulating a very simple unit operation such as Charge or Mix or a more complicated unit operation such as distill or react. Operations cannot be added directly to the recipe or the flowsheet. Operations are added as elements of a unit procedure and unit procedures put together make up a recipe

Operations are added to unit procedures and not directly to the recipe.

Sometimes unit procedures can simply include only one operation. In that case, from a functional point of view, a unit procedure accomplishes exactly the same simulation goals as a single operation. In fact, for the case of continuous unit procedures this happens all the time. A continuous unit procedure (such as what you typically use to simulate a continuous process) contains one and only one operation. However, when modeling batch recipes, you can string several operations, one after the other, to make a single unit procedure (as long as all operations in a unit procedure are carried out in the same equipment). In order to add (or remove) an operation in (or from) a unit procedure, you must use the **Add / Remove Operations …** dialog.

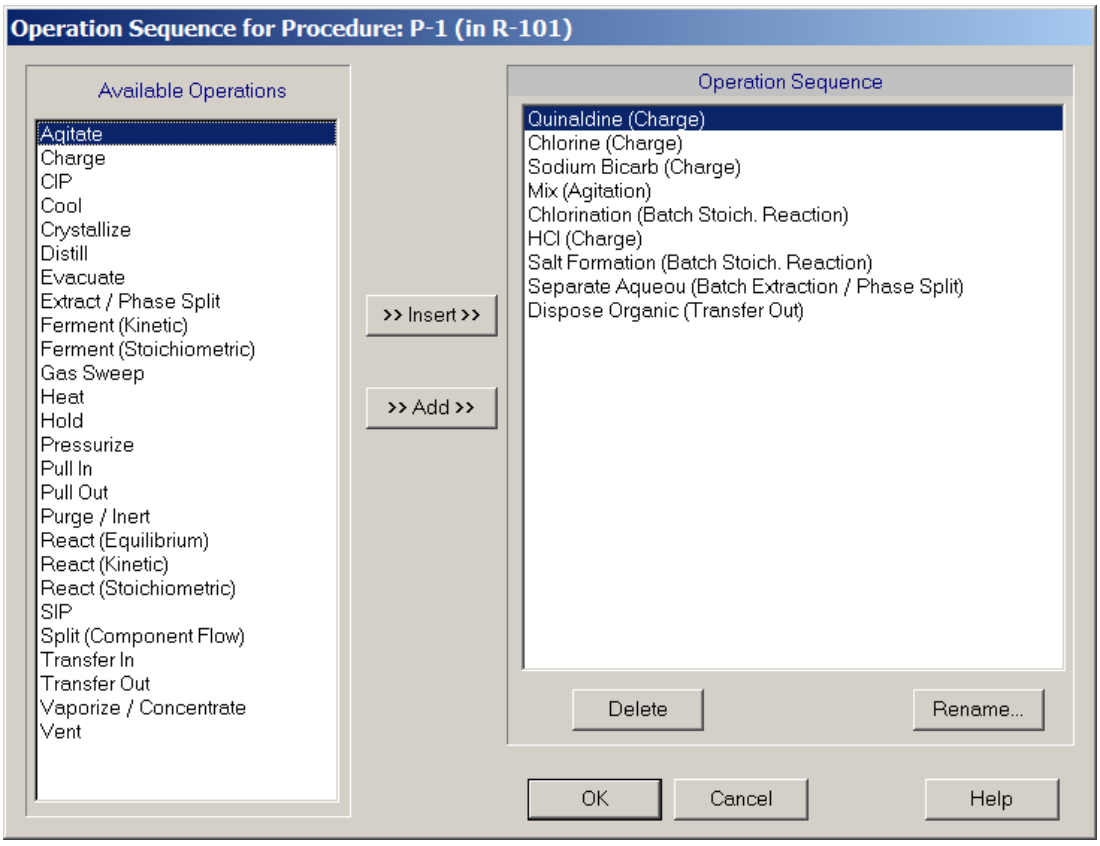


Fig. 5.5: The Add / Remove / Reorder Operations Dialog.

This dialog can be viewed by selecting the **Add/Remove Operations…** option of the procedure's context menu. Remember that this dialog is only available if the unit procedure is in batch (or semi-continuous) mode.

Even though there are many unit operation types available in Pro-Designer, only a subset of those is available whenever you are within the Add/Remove Operation dialog of a given unit procedure. The actual list available depends on the type of unit procedure and the type of equipment used to host the procedure.

5.2.2 The i/o Simulation Dialog

Once you have added operations to a unit procedure, you may access their i/o simulation dialog from the command menu of the procedure. Simply right-click on the unit procedure's icon and select the first option (**Operation Data…**). Then, a sublist will present the names of all operations (in sequence) that have been introduced in that unit procedure. Selecting any one name from that list will bring up the simulation dialog for that unit procedure. If the unit procedure contains a single operation alone, then you can invoke its i/o dialog by selecting **Operation Data …** from the procedure's context menu directly (no submenu exists). Furthermore, if the unit procedure is in continuous mode, double clicking on the procedure's icon will bring up the operation's i/o simulation dialog.

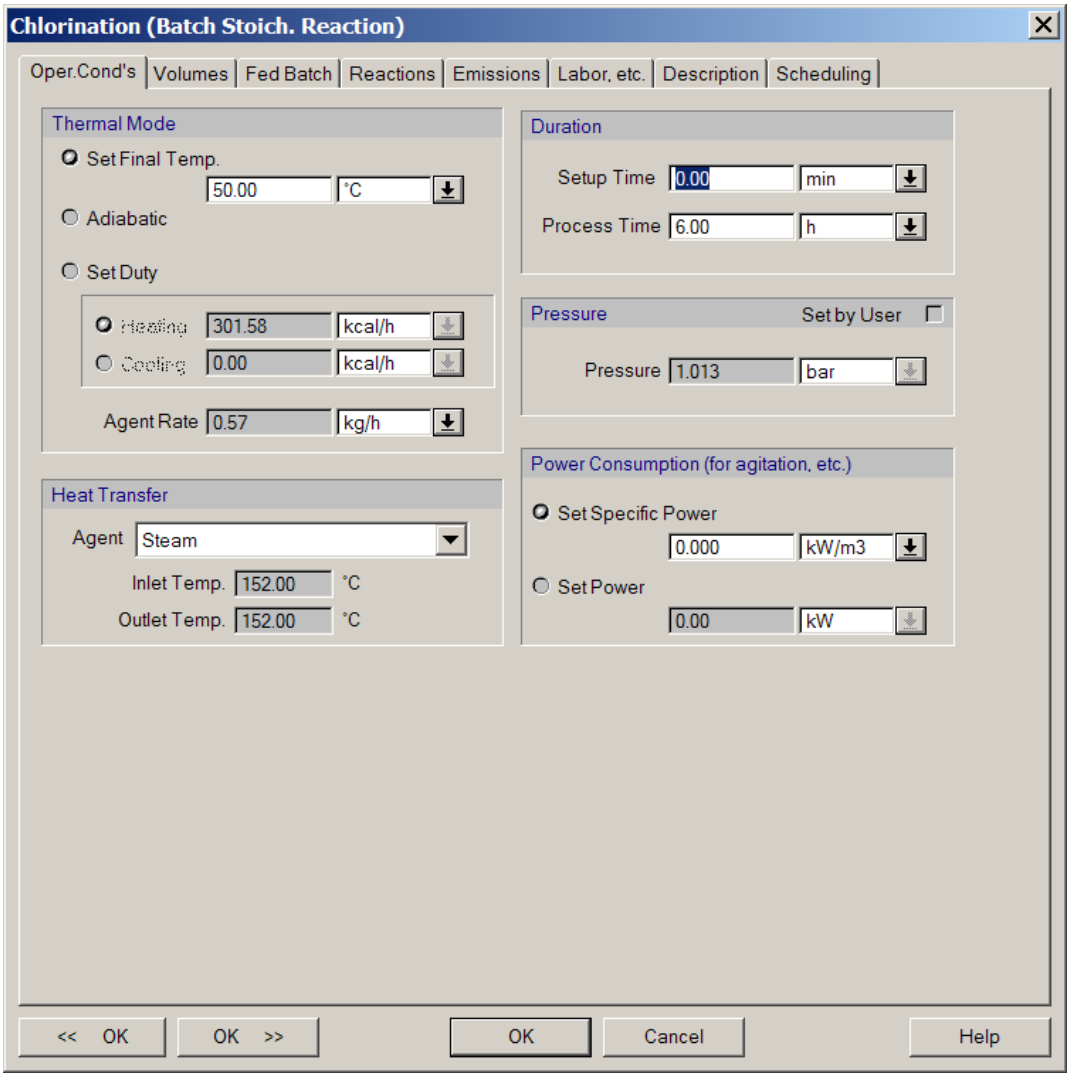


Fig. 5.6: A typical i/o simulation dialog for an operation.

The i/o dialog of an operation is made up from several tabs. Each tab presents a group of variables some required to be set by the user (inputs) and others calculated by the simulation engine (outputs). Sometimes a variable may be considered an input or an output depending on other operation-related or procedure-related (e.g. the operating mode), or even equipment-related settings (e.g. the sizing options). Most input variables come preset to default values.

All operation simulation dialogs will have an “Oper. Cond’s” (Operating Conditions) tab, a “Labor, etc.” tab, a “Description”, and a “Scheduling” tab (if the overall mode of operation is set to Batch). The contents of the “Oper.Cond’s” Tab depend on the type of the operation, but the contents of the other two tabs are standard for all. During editing of the simulation parameters for an operation, you can click on the **Help** button to jump into a help screen with more information about the variables being edited, their legal ranges and / or more explanations about possible choices available to you on that tab.

5.2.3 The Scheduling Tab

This dialog tab is common to all operation's i/o simulation data dialogs (when the plant's mode of operation is batch

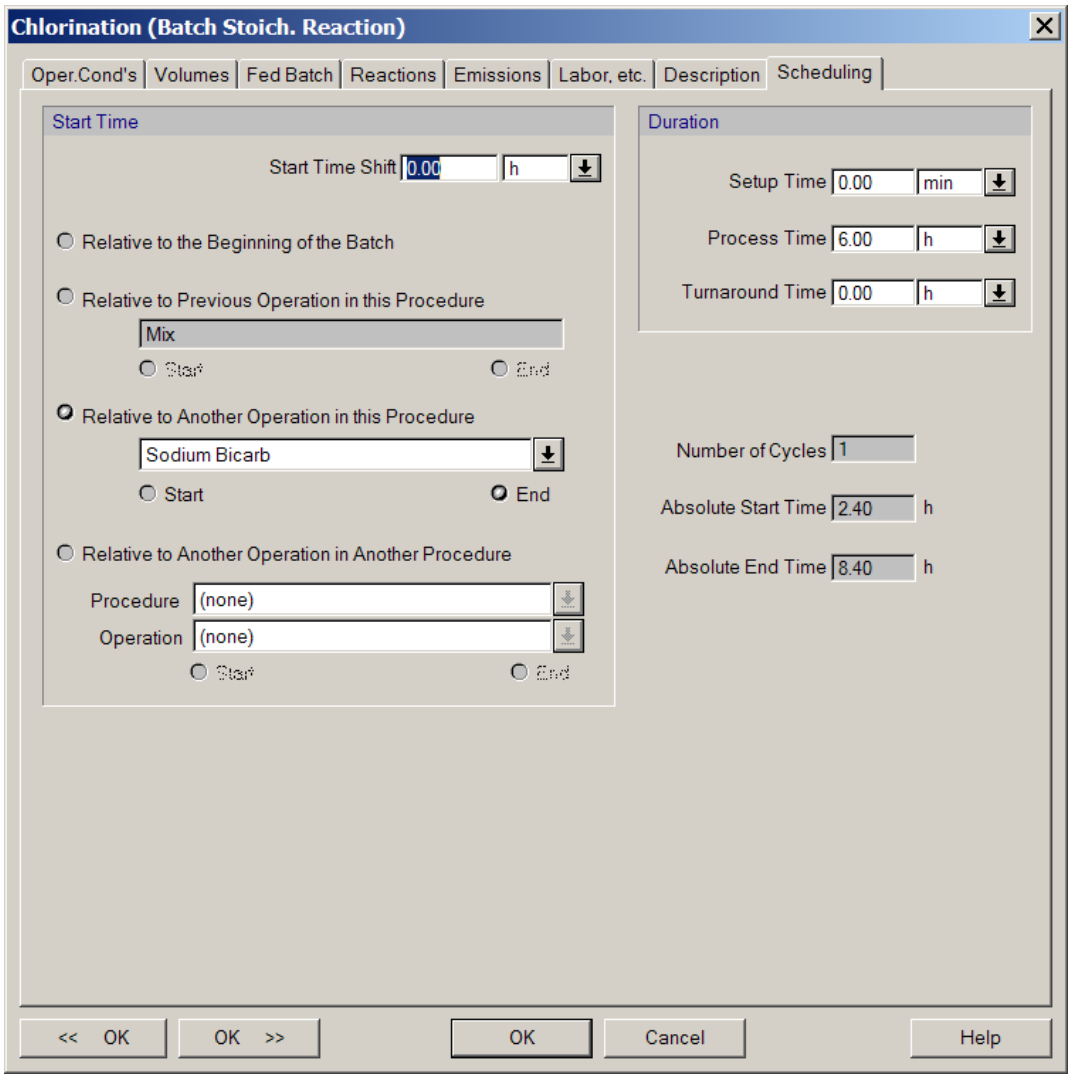


Fig. 5.7: The Scheduling tab of all operations.

From this dialog you can set:

- The **starting time** of the operation

  In order to specify the start time of the operation you must specify:

  a reference time point: it can be any of the following events:

  - the beginning of the batch,
  - the beginning or ending of the previous operation in the same procedure,
  - the beginning or ending of another operation in the same procedure
  - the beginning or ending of another operation in another procedure

a time shift from that time point (positive for later time, or negative for earlier time)

- The entire **duration** of the operation (per cycle)

  The entire duration of the operation is made up from three components:

  - the **setup time**
  - the **process time**
  - the **turnaround time**

For more information on the definition of the parameters that appear on this dialog, consult the chapter on Scheduling.

Tip

Setting the setup time, process time, turnaround time (and number of cycles for the procedure) may affect not only the outcome of the scheduling calculations (plant batch time, number of batches per year etc.) but also the simulation results (sizing of equipment etc.)

NOTES:

a. If the process time is calculated (i.e. it is an output of the simulation model), it is displayed grayed out (like the Absolute Start Time) and cannot be edited.

b. The dialog also displays (for viewing purposes only) the Absolute Start Time and the Absolute End Time of the operation. These time points are always with respect to the beginning of the entire batch (i.e. the beginning of the earliest scheduled unit procedure in this recipe). Note that if the unit procedure is set to execute in multiple cycles the Absolute Start Time coincides with the start time of the operation during the first cycle and the Absolute End Time is set from the ending time of the operation during the last cycle of the procedure.

c. The dialog displays as well the number of cycles set for the unit procedure (for viewing purposes only). To edit the number of cycles, please see Section 5.2.2).

5.2.4 The Labor, etc. Tab

This dialog tab is common to all operation's i/o simulation data:

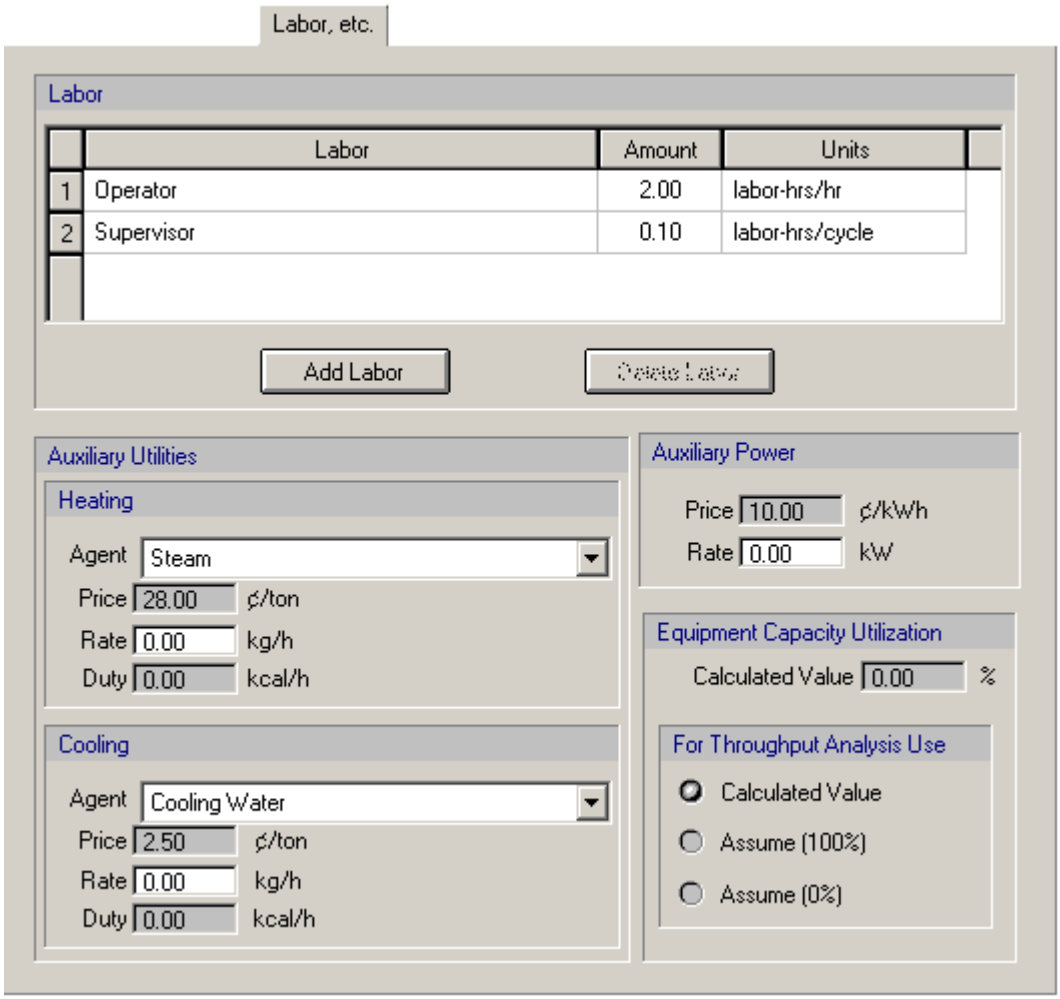


Fig. 5.7: The Labor, etc. tab of all operations.

From this tab you can set:

- The **labor requirements**
  The table at the top of this tab lets you define the labor hours per operation hour or (for batch procedures) per cycle needed to carry out the operation. Multiple labor types can be defined. Fractional values of labor requirements are meaningful in the sense that perhaps an operator needs to spend only a fraction of his/her time during the progress of this operation (while he/she is supervising the execution of another operation). In Chapter 7 it is explained how you can define new labor types in the databank and use them within an operation.

- Any **Auxiliary Utilities (Heating/Cooling/Power)**
  Auxiliary utilities are amounts of utilities that are not normally being calculated as part of the simulation model of the operation. If significant amounts are being consumed, then you should specify their rate of consumption in this dialog. Note that rates are required as amounts / h where h refers to operation hour (i.e. time

during which the operation is being carried out). When you specify an auxiliary heating, cooling, or power requirement for a specific operation, the resulting values are not used in heat balances. The values are only used in calculating the operating cost of the equipment associated with that unit procedure and for adding to the consumption levels of that resource). In Chapter 7 it is explained how you can define new heat transfer agent types in the databank and use them within an operation.

- How the **Equipment Capacity Utilization Factor** is to be calculated in the Throughput Analysis Report
  The equipment capacity utilization factor indicates how much of the available equipment capacity (e.g. volume) this operation is using up. This factor is employed heavily in the throughput analysis performed by Pro-Designer. Pro-Designer has its own logic for computing these factors for every type of operation. The user may allow the computed value to be used in the throughput analysis, or he/she may overwrite the computed value to either extreme: 100% (thus increasing the likelihood that the system will consider this operation and its equipment as potential bottlenecking candidates) or 0% (thus removing this equipment from the list of potential bottlenecking candidates). For more details see Chapter 9.

5.2.5 Default Input Data Values

Default values for most of the input data required for simulation the effects of each unit operation are already preset and displayed the first time you open the input/output simulation dialog of a each unit operation. These values reflect typical operation conditions in the biochemical / pharmaceutical / waste treatment process industries. Having such default values is very convenient, especially in cases where you are about to simulate an operation for which experimental data are not readily available (for your specific application). However, caution should be exercised when evaluating the outcome of a simulation (or an economic evaluation) that is based on such default values, without any knowledge of the range of the actual parameters during industrial operation.

Of course, you can always overwrite the default values with more relevant values that apply for the conditions of the particular operation you wish to simulate.

Pro-Designer requires that you visit each of the i/o simulation dialogs for all the each operation involved in a process before you can simulate the process (with the exception of any mixing operations, since they do not have an i/o simulation dialog.

5.3 Equipment

Every unit procedure must be carried out in a piece of equipment. However, there are a couple of notable exceptions to the above general rule:

1. Mixers, Splitters and Generic Boxes: Even though they have a piece of equipment associated with them, they estimate the equipment cost to 0.0. Since often times these unit procedures do not represent 'real' procedures of the recipe or they represent (in abstraction) another procedure with operations that Pro-Designer does not currently support (and therefore knows nothing about their equipment). You may, of course, overwrite this default behavior of Pro-Designer and specify a purchase cost model for the equipment associated with any of the above unit procedure and Pro-Designer will use it.

2. Far transportation procedures (by land, sea or air) do not have an associated piece of equipment. They do not display an equipment dialog. Any equipment related cost is assumed to be factored in the annual transportation costing model.

The name of the equipment associated with a unit procedure is displayed in the second half of its name tag (the first label shown under the unit procedure's icon). The equipment's purchase cost is calculated by the system, but if you wish, you may either overwrite it with your own estimate or define your own cost model.

It is possible for two or more unit procedures to share equipment (if they are used in batch mode and they are part of a batch operating plant). If that is the case, you must make sure that all unit procedures hosted by the same equipment, are scheduled in non-overlapping intervals. For more details, see next section.
All equipment-related data are accessed from the Equipment Data Dialog. To bring up the equipment data dialog, select Equipment Data… from the context menu of an procedure hosted by the equipment. The dialog has six tabs:

1. **Equipment Tab:** Allows you to specify sizing and equipment selection options.

2. **Purchase Cost Tab:** Allows you to specify how the equipment's purchase cost will be estimated.

3. **Adjustments Tab:** Allows you to set any adjustments that need to be made to the base purchase cost.

4. **Consumables Tab:** Allows you to specify whether the equipment makes use of any consumables and their usage specifications.

5. **Scheduling Tab:** Displays scheduling data (start time, occupation times etc.)

6. **Throughput Tab:** Displays data related to throughput analysis and debottlenecking such as equipment capacity utilization, if the equipment is a time bottleneck etc.

7. **Allocation Tab:** Lets you allocate the equipment to a databank site equipment or set its data according to a vendor equipment.

5.3.1 Selection and Sizing

This is done from the first tab (Equipment) of the equipment data dialog.

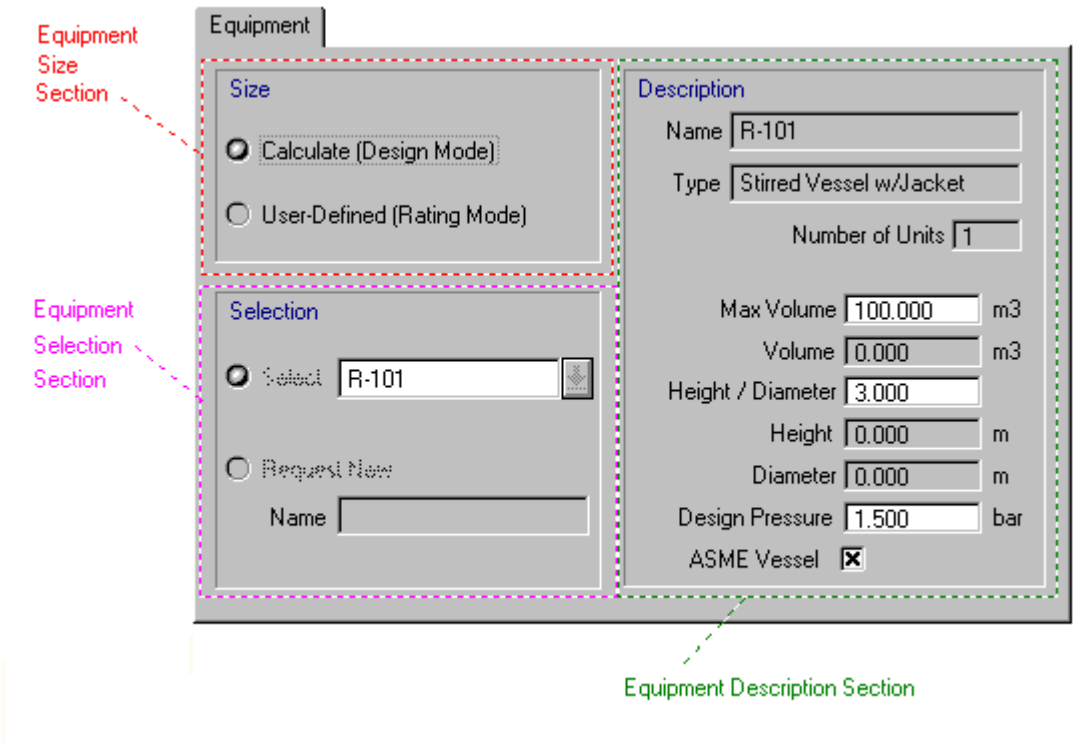


Figure 5.8: A typical Equipment tab.

Even though the actual contents of the equipment tab of each type of equipment varies depending on the type of the equipment, all equipment tabs share the following characteristics.

The equipment tab is always divided into three sections:

- The (Equipment) Size Section
- The (Equipment) Selection Section, and
- The (Equipment) Description Section.

Equipment Size Section

You have two options when it comes to sizing of the equipment:

- you can choose to have Pro-Designer calculate the size (based on performance specifications that will be described as part of the i/o simulation dialogs of the operations inside that unit procedure), or
- you may specify the size yourself

If you let Pro-Designer determine the size of the equipment, then we call this the ***Design Mode***, since the program will design (and size) the equipment required. Almost

always, there are physical limitations on the available size of processing equipment. For example, filters may not be available with filter area greater than 80 m2. When you are in design mode, you must specify the maximum available size for the equipment involved. If Pro-Designer determines that based on the performance specifications, a larger size is needed, it will employ more than one pieces of equipment (sized equally) with sizes that do not violate the maximum available size. It will assume that in order to carry out the procedure, you operate all pieces of equipment in-parallel.

If you specify the size yourself, then you must describe the equipment fully (including how many pieces, or the Number of Units). When you choose this option we say that the equipment is in ***Rating Mode***. In this mode, the performance of all operations in the equipment will be calculated based on the limitations imposed by the equipment involved. For instance, if you are restricted to use a piece of equipment that already exists, then you should set the equipment in rating mode and describe the size of your equipment. Or, you may not have the equipment itself, but, for some reason, you may force the system to use a piece of equipment with preset capacity (or size). Equipment allocated to sites or associated with vendor equipment (see Sections 5.3.6 and 5.3.7) are always in Rating Mode and their data cannot be edited since they are locked to those of the site or vendor equipment. By default, each unit procedure, when first created, is assumed to be in design mode and using its own, dedicated piece of equipment.

Equipment Selection Section

The equipment type is automatically determined for each unit procedure and cannot be changed by the user. For instance, a well-mixed equilibrium unit procedure is always carried out in a Stirred Vessel w/Jacket. A Diafiltration unit procedure is always assumed to be contained in a Diafilter. Furthermore, by default, it is also assumed that each unit procedure is carried out in its own (exclusive) equipment. That's why this section's choice is set to 'Select' and the equipment name is displayed in the drop-list box.

Example: Assume you have two batch reaction unit procedures required in your process. After you select the correct unit procedure option and click anywhere on the flowsheet, Pro-Designer inserts a new unit procedure (P-1). If you inspect its equipment data, you will see that the 'Select' option is on in the Equipment Selection Section and the name 'V-101' is displayed. It means that currently this unit procedure is using equipment V-101 (which was, in fact, created for that unit procedure) but you may opt to have this unit procedure share equipment with another procedure. For instance, say you have a second batch reaction unit procedure (P-2) which you wish to be carried out in the same vessel (V-101). All you have to do is visit the Equipment Data dialog of the second unit procedure. Notice that as claimed earlier, Pro-Designer automatically created another vessel (V-102) to host this second unit procedure. However, if you visit the 'Select' drop-list, and pick the "V-101" name appearing in the list and then click OK, the V-102 vessel is automatically eliminated from the recipe and now, both unit procedures, use the same vessel (V-101). Notice that the name V-101 appears in the second half of the name labels in both unit procedures.

The equipment tab can play an important role in scheduling, if the overall operating mode (for the process) is batch and the unit procedure is carried out in batch mode. In that case, you may elect to share equipment with another unit procedures that is also carried out in a piece of equipment of the same type. This can save money in terms of

capital cost (less total equipment for the entire process) but it introduces scheduling constraints, as you are no longer free to execute each unit procedure contained in the equipment at any time you wish. Obviously, no two procedures can have their procedure times overlap. This will trigger an equipment sharing constraint violation and will be reported by Pro-Designer.

5.3.2 Purchase Cost

In estimating the purchase cost of a piece of equipment used by a unit procedure, you have the following options (shown when you select the Purchase tab of the equipment data dialog – see Figure 5.9):

1. specify the purchase cost yourself, or
2. use the built-in cost model specific to this type of equipment, or
3. define the parameters of a power-law model that will determine the cost of the equipment

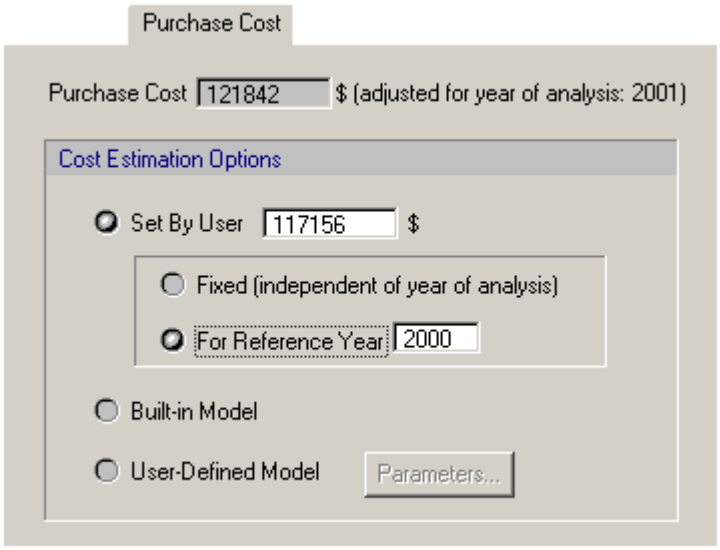


Figure 5.9: The Purchase Cost tab of the Equipment Data Dialog.

The user-specified cost can either be fixed and independent of the year of analysis for the design case or adjustable to inflation according to a reference year. This latter case is the one automatically selected if the equipment is allocated to a site equipment. In that case, the purchase cost will be set equal to that of the site equipment and will no longer be editable.

If you decide to specify your own model, then, the button labeled **Parameters…** gets activated. Clicking on the **Parameters…** button, presents you with another dialog that allows you to describe a power-law based model which will be used for the estimation of the purchase cost of that particular unit procedure's equipment. See the **User-Defined Equipment Purchase Cost Model** section below for more information on this topic.

NOTES:

a. The program by default uses its internal model to calculate equipment purchase cost.

b. If a procedure requires multiple pieces of equipment (of equal size) operating in parallel, then the purchase cost displayed is the cost of a single equipment item. The purchase cost of the step is that of a single piece times the number of equipment items required to carry out the operation.

c. You can also modify the material and installation factors through the Adjustments tab of the Equipment Data dialog.

5.3.3 User-Defined Purchase Cost Models

The user-defined cost model is of the following, power-law form:

$$PC = C_o\left(\frac{Q}{Q_o}\right)^a$$

Where Co is the base cost, Qo is the base capacity, and a is the exponent of the power law function. In cases where the capacity variable Q needs to span a wide range of values, the total range is broken down into several intervals and a set of parameters a, Co and Qo is supplied for each interval.

The specification of a user-defined cost model must also be accompanied by the calendar year for which the cost estimates of the model are accurate (cost reference year), in order for the program to be able to adjust for inflation.

Tip

A user-defined cost model will apply for that particular equipment that was defined and not for all pieces of equipment of the same type. If more such pieces of equipment exist in a design case and you wish to use the same user-defined power law purchase cost model, in order to avoid duplication of work, it is recommended to do the following: (a) create one such unit procedure, (b) define the purchase cost model as explained before, and (c) copy and paste that unit procedure as many times as required, to create additional unit procedures featuring the same purchase cost model for their associated equipment.

5.3.4 Cost Adjustments

The purchase cost tab determines how to calculate the purchase cost of a single piece of equipment (of the type used by the selected unit procedure). The Adjustments Tab of the equipment data dialog, lets you adjust the calculated cost based on the following considerations:

1. Standby Units

For pieces of equipment that can be critical for the operation of the process, you may choose to have one or more pieces standby (in case the regularly used pieces of

equipment go down for scheduled or un-scheduled maintenance). In this field you can specify how many additional pieces of equipment are required for that purpose.

2. Capital Cost Adjustments

Already Depreciated Portion
Oftentimes, a piece of equipment used has already been either fully or partially depreciated. Setting anything other than 0.0 in this field will affect the direct fixed capital total for the section that this equipment belongs. However, any purchase cost derivative adjustments will still use the full amount of the purchase cost as estimated by the Purchase Cost Tab.

Installation Cost
This factor is used to estimate installation cost for each piece of equipment by directly multiplying the purchase cost of the equipment.

Material Factor
The purchase cost as calculated by the options set by the Purchase Cost Tab, estimates the cost of equipment assuming a reference material of construction. For all other materials, the purchase cost is adjusted by multiplying with a material-specific factor. The list of eligible materials for every equipment type and the corresponding material factors can be found in the databanks.

3. Operating Cost Adjustments

Different variables may be used to calculate the facility dependent operating cost. To specify what type of calculations are to be performed chose **Section / Operating Cost /Facility (tab)** from the **Flowsheet** context menu. For each equipment you can specify these variables in the Adjustments Tab:

Usage Rate
Used to calculate facility dependent cost based on operating parameters. It represents the cost per equipment usage hour.

Availability Rate
Used to calculate facility dependent cost based on operating parameters. It represents the cost per (equipment availability) hour.

Maintenance Cost
Used to calculate facility dependent cost based on capital investment parameters. The maintenance cost is calculated by multiplying the maintenance cost factor with the purchase cost.

To access the construction material databanks, use the **Databanks/Construction Materials...** menu item from the main menu (or hit **F4** as a shortcut.) The dialog shown in Figure 5.10 appears. In the User databank, you can extend the list of available materials by clicking on the **Add Material…** button and filling in the material factors for all equipment types for which that material will be available. A material factor value of –1 (or any non-positive value) signifies that the material is not available for the construction of equipment of the corresponding type. A value of 1.0 signifies that this is the default material for which the purchase cost default built-in model applies.

For a selected material, the material factor in specific flowsheet equipment is initialized to the value found in the databank. However, you can edit that value for the flowsheet equipment without affecting the value saved in the databank. Similarly, changes made in the construction material databank do not affect existing design cases or other parts of the databank even if the edited materials are used for site or vendor equipment (see Sections 5.3.6 and 5.3.7 for details). Note, however, that you will not be able to delete from the User databank materials used for the construction of site or vendor equipment; the equipment will have to be removed first.

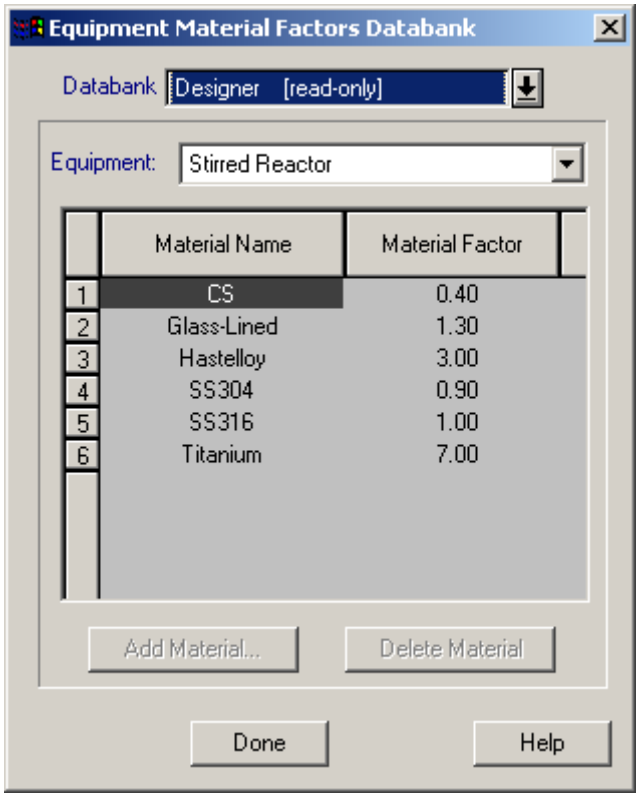


Figure 5.10: The construction material databank dialog.

5.3.5 Equipment Consumables

The Equipment Consumables Tab lets you register different consumables for use by the equipment. Some equipment require the use at least one consumable (for example filters require the use of membrane, disposable reactor skids require the use of disposable reactors). For these equipment you can select the specific consumable to be used by selecting one of the registered consumables of that Type from the Consumables Databank (see Chapter 16 for information on the consumables Databank). You can also specify the replacement frequency of the required consumable.

Figure 5.11 shows the dialog that comes up for the Microfilter Consumables Tab. The top part of the dialog refers to the usage of the required consumable which is of the

"Membrane" type. The user can select a specific membrane and specify its replacement frequency. The bottom part of the dialog refers to *"Other"* consumables. This is available in the consumables tab of all equipment dialogs. You can add any consumable registered in the user databank for usage by the equipment by clicking the **Add** button, or delete a consumable by selecting the consumable (clicking on the number column) and clicking the **Delete** button. Clicking on the Add button will present to you the Consumables Databank Interface, which is describe in Chapter16.

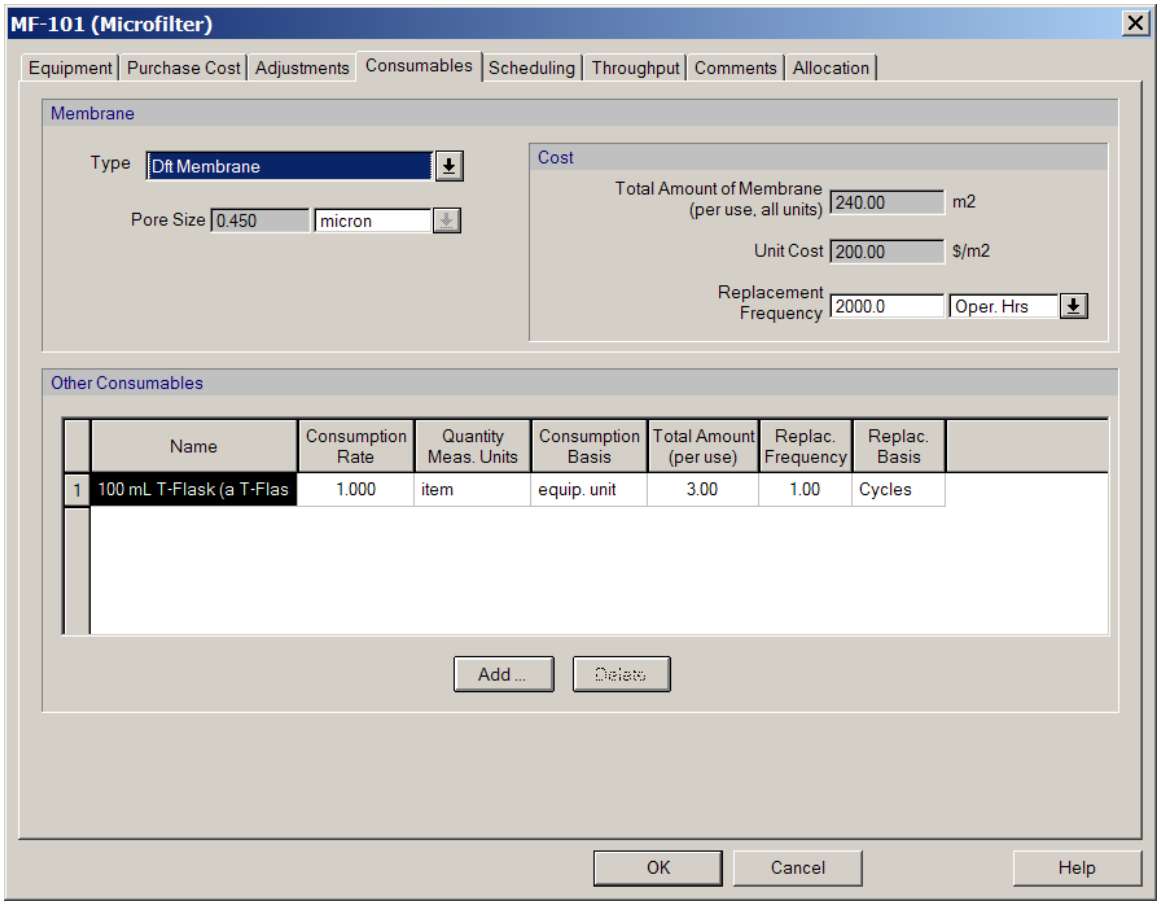


Figure 5.11: The Consumables Tab for a microfilter dialog.

To view the consumables that are currently being used in the present design case, select **Consumables…** from the Flowsheet context menu. This brings up the dialog in Figure 5.12.

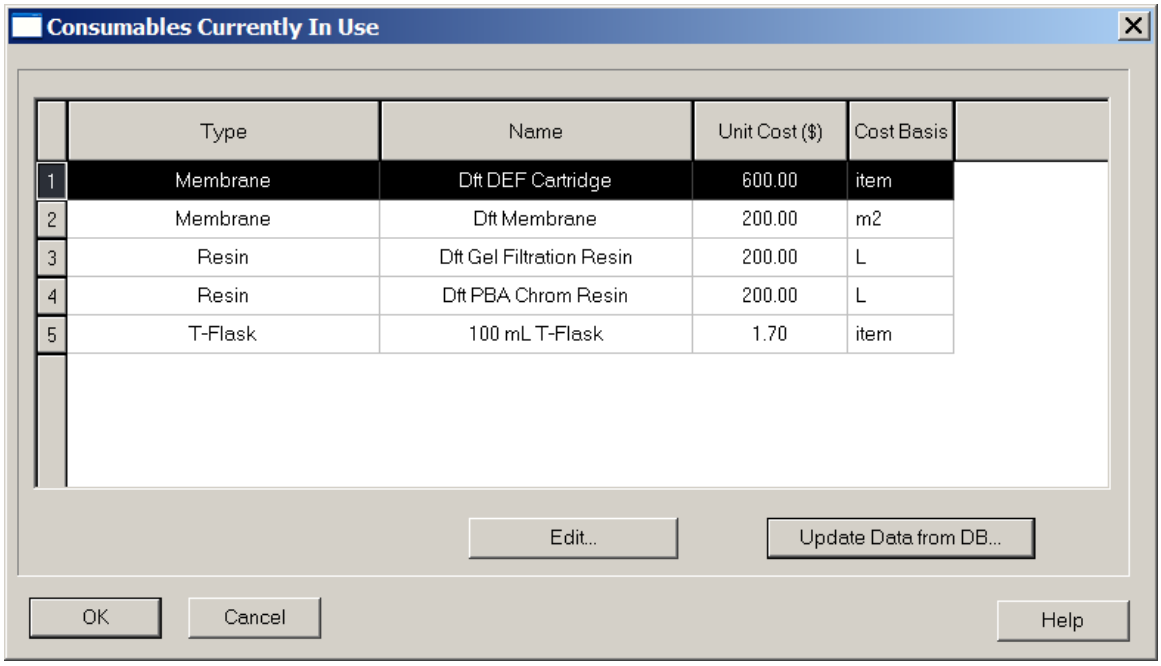


Figure 5.12: The Consumable Usage dialog.

5.3.6 Equipment Allocation

The Equipment Allocation Tab lets you define a site equipment where the flowsheet equipment is allocated to, or a vendor equipment according to which the flowsheet equipment is supposed to be constructed (see Section 5.3.6 and 5.3.7). By default, all flowsheet equipment are initialized as unallocated. If the section where this equipment belongs is allocated to a databank site, then the option to allocate the equipment to the databank is activated. The list of eligible site equipment for allocation includes all equipment of the same type as the flowsheet equipment that have been declared for this site in the databank. You can view the properties of all eligible site equipment by selecting one from the list and pressing the **View…** button or you can create a new site equipment by pressing the **Add New…** button.

Once a flowsheet equipment is allocated to a site equipment, its data are considered 'locked', a fact that is indicated by the green lock key icon displayed above the equipment's name. The equipment's sizing mode is set to Rating, all its specifications are set according to the site equipment and cannot be edited. Procedures that share the same flowsheet equipment will necessarily have to share the same allocated equipment (if any.) In other words, flowsheet equipment sharing implies site equipment sharing as well. Therefore, equipment sharing is not permitted among procedures belonging to sections allocated to different sites (see Section 5.4.)

When the 'Unallocated' option is selected you can set the equipment's data according to a databank vendor equipment. This signifies the intention to purchase and install in a site a piece of equipment following the specifications of a vendor equipment. As with the site equipment allocation case, the flowsheet equipment specifications (but not the economic data) are locked, a fact indicated by the red lock key icon displayed above the equipment's name.

You can select not to have any visual display of equipment allocation (the 'lock key' icons) by visiting the Preferences (Misc.) dialog accessed through the **Edit/Flowsheet Options/Preferences/Miscellaneous…** menu item. There you can set the corresponding flag on or off according to your preference.

5.3.7 Site Equipment

As indicated in the previous section, flowsheet equipment in design cases can be allocated to site equipment to denote that existing equipment are to be used to carry out a series of process tasks. The User databank lets you declare existing equipment in sites and subsequently use them in design cases. For obvious reasons, the provided User site equipment databank comes initially empty. To access the site equipment databank and add or modify site equipment, use the **Databanks/Equipment/In Sites...** menu item from the main menu (or hit **F7** as a shortcut.). See Chapter 16 (section on ***Equipment in Sites Databank***) for more information.

5.3.8 Vendor Equipment

Both the Designer and User databanks come equipped with a table where users can declare equipment available from vendors or manufacturers. Unlike site equipment items who are supposed to represent existing equipment, vendor equipment items are just a list of specifications based on which 'real' equipment can be constructed. Flowsheet equipment in design cases can have their data set according to a vendor equipment to signify in this way the intention to buy an equipment with given specs for the needs of the modeled process.

To access the vendor equipment databanks and add or modify vendor equipment, use the **Databanks/Equipment/Available from Vendors...** menu item from the main menu (or hit **F8** as a shortcut). See Chapter 16 (section on ***Vendor Equipment Databank***) for more information.

5.3.9 Equipment Vendors/Manufacturers

Both the Designer and User databanks come equipped with a table where users can declare equipment vendors and manufacturers. To access the vendor/manufacturer equipment databanks, use the **Databanks/Equipment/Vendors/Manufacturers...** menu item from the main menu (or hit **F9** as a shortcut).). See Chapter 16 (section on ***Vendor/Manufacturer Databank***) for more information.

5.3.10 Equipment Type Databank

The Designer databank contains a hierarchical list of all equipment types used in Pro-Designer. For every equipment type, the Designer databank holds a list of specifications that are necessary for the characterization of equipment inside a design case and match exactly the properties of that equipment in Rating Mode. The User databank has a similar table where user-defined specifications per equipment type can be deposited. To view and edit the list of specifications for every equipment type, use

the **Databanks/ Equipment/Types...** menu item from the main menu (or hit **F10** as a shortcut). See Chapter 16 (section on ***Equipment Type Databank***) for more information.

5.3.11 Equipment Specification Variables

In Pro-Designer every equipment (whether in a design case or the databank) is characterized by a set of specification variables. The Designer databank contains all specification variables that are needed for the basic characterization of all equipment types. In the User databank, you can store in a similar table additional specification variables that could become part of the basic description for some equipment type (see Section 5.3.9) or used as extra variables for the description of a particular site or vendor equipment (see Sections 5.3.6 and 5.3.7.)

To access the specification variable databank use the **Databanks/Equipment /Specification Variables...** menu item from the main menu (or hit **F11** as a shortcut.) The following dialog (Figure 5.20) appears:

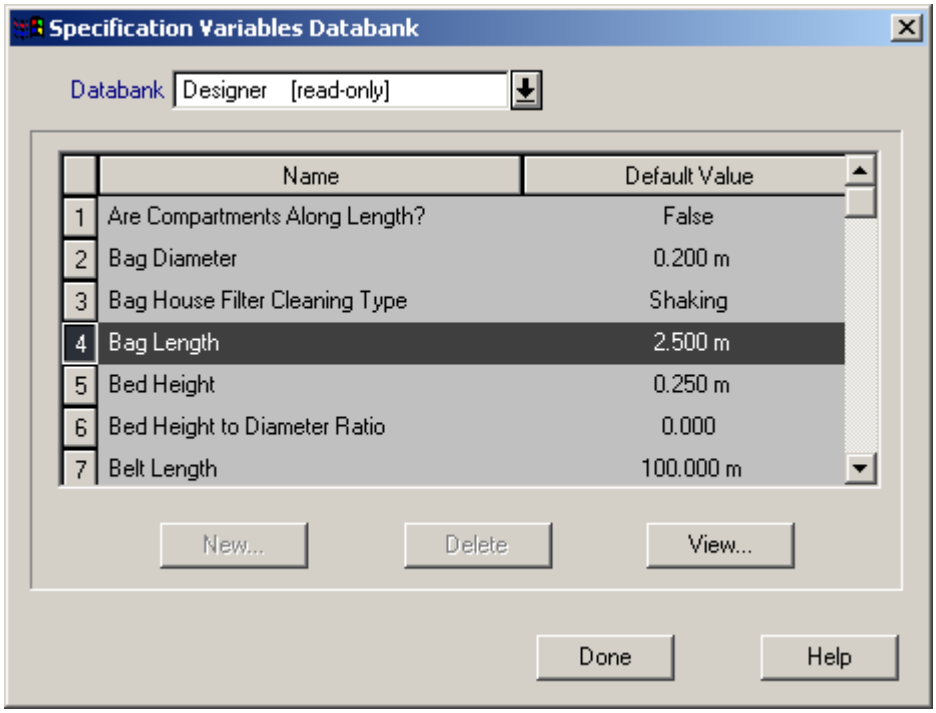


Figure 5.20: The equipment specification variable databank dialog.

By pressing the **New…** button in the User databank you can declare a new variable. You can view (in the Designer databank) or edit (in the User databank) a variable by selecting it and clicking the **View…** or **Edit…** button or double-clicking on its table index column. The variable definition dialog that pops up is shown in Fig. 5.21.

What needs to be defined in this dialog is a unique name for the variable, its type, its default value and optionally comments or notes on what it represents or where it is used. A variable can be one of the following four types: numerical, range, boolean or

selection. An example of a range variable is the operating temperature range, for example 200-500K. For a numerical or range variables, you need to define its default value(s), the corresponding units (if any), the number of decimal values that will be used when setting or displaying this variable and (optionally) its minimum or maximum value. A Boolean variable can only take two values: true or false. A selection variable includes a list of options from which a value can be chosen, for example a 'color' variable can have green, blue, red as options.
Note that for a user-defined variable that is already used by databank equipment you will not be able to change its type or delete from the User databank. You will have first to remove it from the specification list of all equipment and then change its type or delete it. Any other change in the specification variable databank will have no (direct or indirect) effect in existing design cases or other components of the databank.

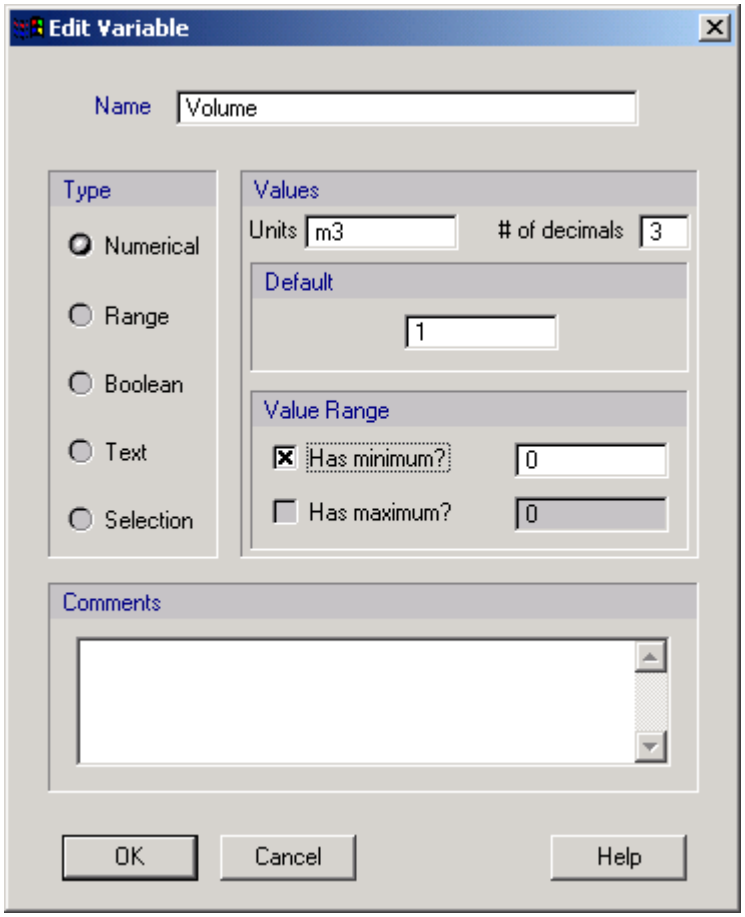


Figure 5.21: The variable definition dialog.

5.4 Sections

5.4.1 What is a Section?

A process section is a group of unit procedures that are put together with a certain goal in mind. For instance, typical sections in a process describing a biochemical plant might include the following: raw material preparation, fermentation, primary recovery, product isolation, final purification, product formulation and packaging. As described in Chapter 8, many economic factors in Pro-Designer are maintained and calculated on a section-by-section basis and that provides an additional incentive to organize your design case along sections. By default, every design case includes a Main Section where all procedures belong. The Main Section can be renamed but not deleted. You can add, however, any number of additional sections and assign procedures to them as you will see later on.

Every section is associated with a (real or hypothetical) physical site whose equipment and resources it uses to carry out its assigned tasks. A default *generic site* is assumed to exist behind any section. The generic site is a hypothetical entity with no limits on the type of available resources or the type and size of available equipment. When a section is associated with the generic site it is said to be *unallocated*. It is conceivable, however, that a section is associated with a specific real site that has a finite number of equipment and resources. Starting with Pro-Designer v5.0, you can declare existing sites with their resources in the User databank and *allocate* sections to them. In that case, equipment and resources of the databank sites become available to the allocated sections and their procedures. Sharing of resources among sections is allowed only when these sections are allocated to the same site.

A string (in fixed order) of process sections that work towards a given goal is called a process *branch*. For instance, in a complicated, multi-step chemical synthesis process (quite common for synthetic pharmaceuticals and agrochemicals), you may want to distinguish between the main path and the side-synthesis paths (frequently performed by toll manufacturers.)

5.4.2 Adding a Section and Assigning Procedures

All parameters related to process sections and branches of a process can be accessed and modified through the sections toolbar shown in Figure 5.22.

Adding a New Section

1. Make sure you are in select mode.
2. From the section toolbar click on the “Create New Section” button and provide a unique name for the new section.

Assigning Unit Procedures to a Section

1. Make sure you are in select mode.
2. From the section drop-down list box, select the name of the section you intend to add the unit procedure(s).
3. Create a unit procedure selection set by selecting the first procedure (by clicking on it), and then adding / removing procedures to the selection set by Shift+Clicking on icons. Alternatively, you can create a selection set by dragging a large enough rectangle that encompasses all procedure icons that you wish to include.
4. Click on the "Add to Section" button

   This is the left-most button of the toolbar (see Figure 5.20).

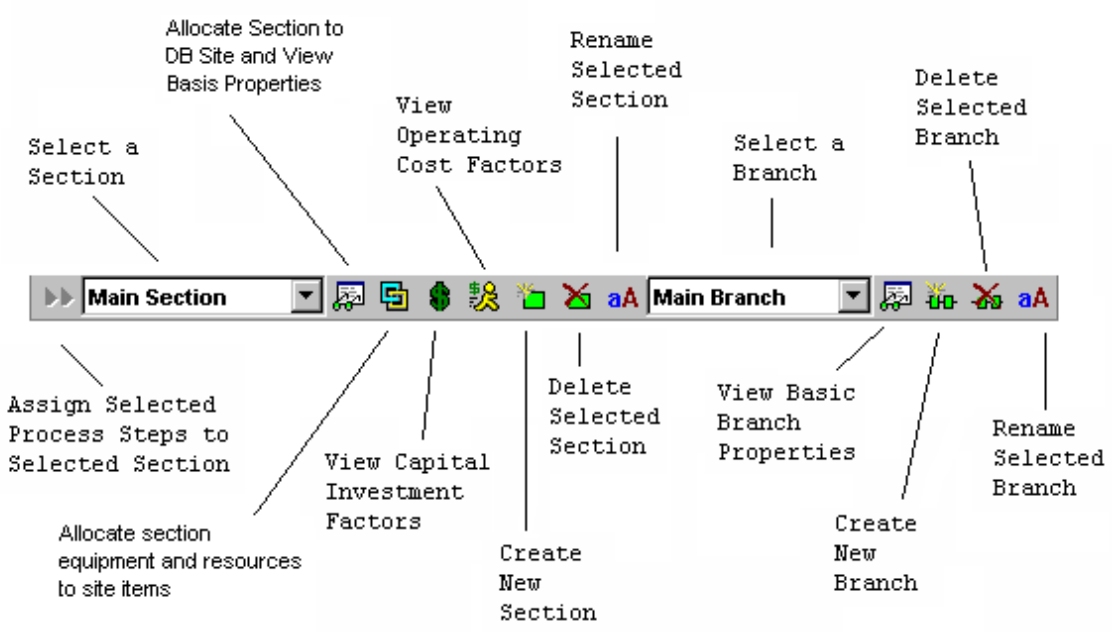


Figure 5.22: Sections and branches toolbar.

5.4.3 Editing Section Properties

To view the unit procedures that belong to a certain section, select **View/All Procedures**…from the main menu. To view the equipment items that belong to a certain section, select **View/All Equipment**… from the main menu.

To view / edit the properties of a section, make sure you are in select mode, select the name of the section you intend to view its properties, and click on the "Edit Section" button (this the button right next to the section list-box - see Figure 5.22). The dialog that comes up contains three tabs.

Through the **Allocation** tab you can specify a databank site where a section is allocated to or leave it as unallocated (the default option.) The selection of the databank site is done through a selection box that displays the databank sites in a hierarchical tree as

defined in the User databank (see Section 5.4.4.) For convenience, the resources belonging to each site are shown on the right-hand-side pane of the selection box.

Through the **Yields** tab (shown in Figure 5.23) you can specify the starting material and active product of a section that are used to calculate and report the Gross Mass Yield, the Refined Mass Yield, and the Molar Yield around a section (their definitions are shown on the bottom of the dialog). The starting material of a section can be based on the total flow or the flow of a specific component of an input stream of the section. In the latter case, non-product components can be designated as impurities, thus affecting the calculation of the Gross Mass Yield. Similarly, the active product of a section can be based on the total flow or the flow of a specific component of an output stream of the section. See Chapter 8 on economics to find out how this information is used.

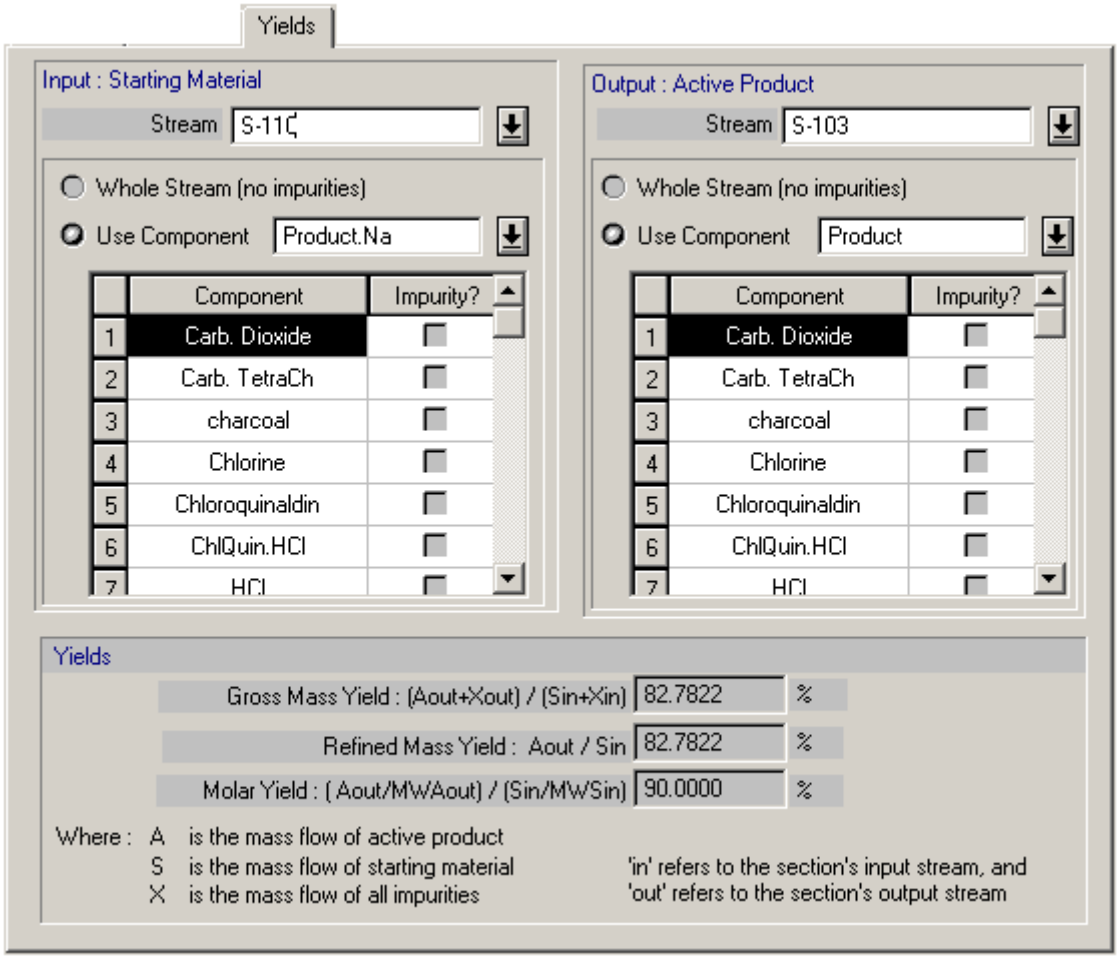


Figure 5.23: The Yields Tab of the section properties dialog.

Through the **Icon Color** tab of the same dialog you can designate a common color for all the unit procedures of a section. When setting the color-code of a section, and if you have already overwritten the default style in any of the section's procedure(s), Pro-Designer will give you an option to either keep the styles as you have set them, or

allow Pro-Designer to overwrite the color element of the style to match your new section color code.

Viewing and editing cost-related properties of a section is described in Chapters 2 and 8.

5.4.4 Sites and Resources

Pro-Designer lets you define in the User databank existing physical sites and facilities along with their equipment and resources that can then be mapped to sections in your design cases. As shown earlier, the allocation process allows you to declare that a given procedure is to be carried out in a piece of equipment as exists in the databank and will also use the corresponding site resources. For obvious reasons, the provided User site databank comes initially empty. To access and edit the site databank use the **Databanks/Sites and Resources...** menu item from the main menu. See Chapter 16 (section on ***Site Databank***) for more information.

5.4.5 Editing Section Resources

To view / edit the resources used by a section, make sure you are in select mode, select the name of the section you intend to view its properties, and click on the "Allocate Section Resources" button (this the button right next to the "Edit Section" button - see Figure 5.22). The dialog that comes up contains up to four tabs (depending on whether the section is allocated or not) and lets you edit the resources of that section. The same dialog will also appear automatically when visiting the Edit Section dialog and making a change to the allocated site.

Through the **Equipment** tab you can specify databank site equipment where flowsheet equipment are allocated to. This provides a shortcut to visiting the Allocation Tab of every equipment and making the allocation there. This tab will appear only when the edited section is allocated to a databank site.

Through the **Utilities** tab you can view utilities used by the edited section and, if desired, substitute them with others shown in the eligible utilities list. If the edited section is allocated, the eligible utilities list will contain also utilities in the allocated site and all its parent sites in the site hierarchy (see Chapter 7.) If you choose to substitute one utility for another, the change will be propagated to all procedures / operations belonging to that section.

Through the **Labor** tab you can view labor types used by the edited section and, if desired, substitute them with others shown in the eligible labor list. If the edited section is allocated, the eligible labor list will contain also labor types and staff in the allocated site and all its children sites in the site hierarchy (see Chapter 7.) If you choose to substitute one labor type for another, the change will be propagated to all procedures/operations belonging to that section.

Through the **Economic Flags** tab you can specify which section economic parameters while be set according to the allocated database site. See Chapter 8 for an explanation of these economic factors. This tab will appear only when the edited section is allocated to a databank site.

GO TO TOP LEVEL CONTENTS