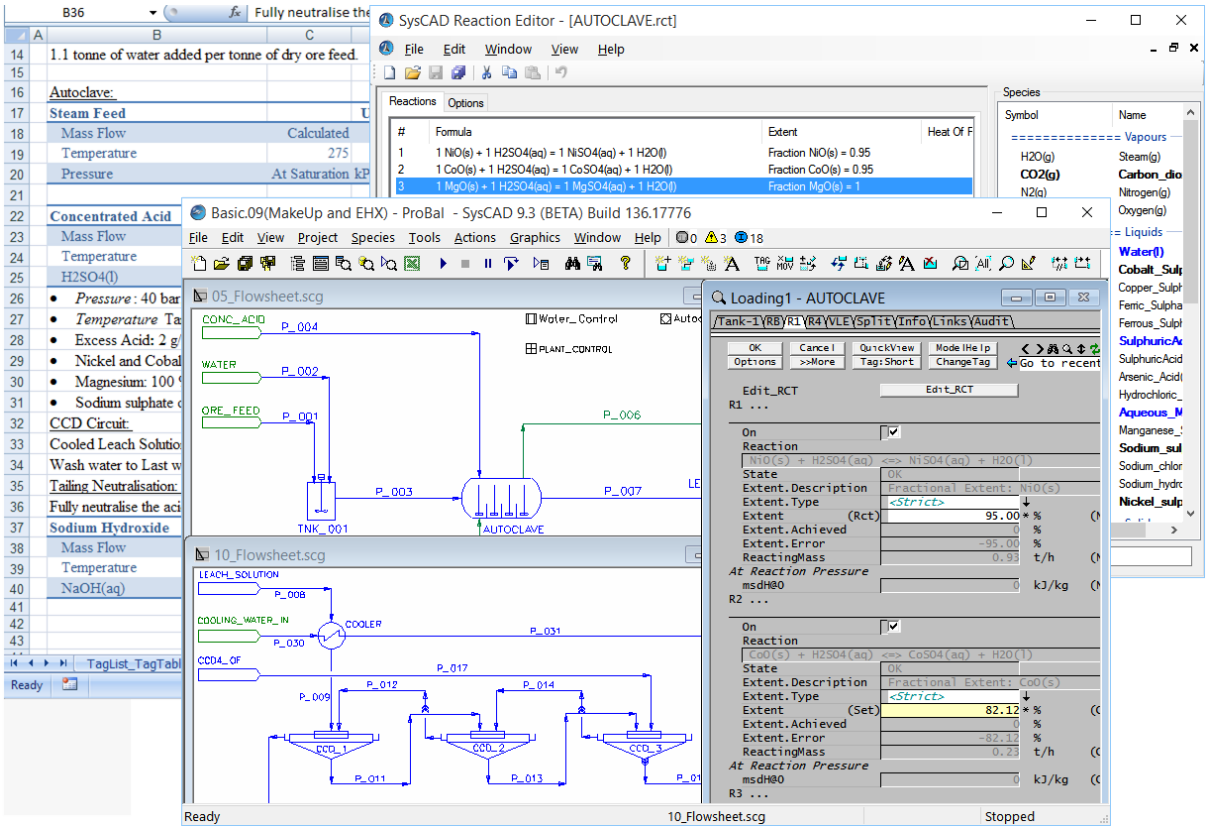
SysCAD

Innovative Software for Plant Simulation



Basic Tutorial

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Providing Technology and Engineering Software Solutions

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Preface

The Company

KWA Kenwalt Australia (Pty) Ltd is the developer of the process modelling software package SysCAD. We provide the software, training, support and related product services.

Kenwalt also provide a range of process modelling and simulation services for process plant studies, design, optimisation, control philosophy development, control software commissioning, operator training, R&D, production planning, surge & availability studies and model development for use in operating plants.

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Software versions

This tutorial has been developed using SysCAD 9.3 Build 136. Using another version of SysCAD may produce slightly different dialog boxes to those presented in this tutorial.

Software License

SysCAD can be installed on any computer. By default, it will run in "Demo Mode" which restricts project sizes and the number of options available to the user. To invoke the full version or obtain a licensed version for training purposes, a site license key is required from Kenwalt. Kenwalt will normally provide extra licenses for training use as part of a formal SysCAD training course.

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Tutorial prerequisites

This tutorial has been designed as a 'hands-on' document for those who understand the basic principles of process engineering, control and process modelling, but who may have no previous experience with SysCAD. For users with **NO** knowledge or background, it is strongly recommended that they read up on some basic Process balancing information before starting the tutorial. Also, SysCAD utilises MS Excel for its reporting, so the user should have some understanding of MS Excel before using the reporting functions.

Tutorial design

This document provides descriptive and operational information designed for use both during and after the tutorial. It can be used as a helpful reference after the tutorial has been completed. Various exercises are included in this tutorial. It is recommended that you complete all the exercises. There may be sections that are not applicable to your intended use of the software, these may be skipped or briefly reviewed, and then revisited later if required.

SECTION 1

1. Introduction

1.1. SysCAD Overview

A brief SysCAD demonstration may be given here by the trainer.

If the tutorial is done **WITH** the presence of a TRAINER: The trainer may open an existing project to take you through the basic operations of a SysCAD model.

If the Tutorial is done **WITHOUT** the presence of a TRAINER and the user has **NO** previous knowledge of SysCAD, then it is recommended that the user first reads the "SysCAD 9.2 Getting Started" document, found under ..\SysCAD93\Tutorial\SysCADGettingStarted.pdf.

1.1.1. What is SysCAD?

SysCAD is a powerful and versatile plant simulator. It can be used to simulate anything from the simplest processing circuit to a complex full plant operation. When used to its full potential, it can serve in every aspect of the plant life cycle from Feasibility Study, Design, Commission, Operations and Maintenance to Expansion.

It is an invaluable Process Design tool that will help users gain tremendous insight into their process operations. This knowledge can translate into better decision making, improved plant operation performance, cost saving and more efficient and knowledgeable operators.

SysCAD simulation can be performed using either Steady State (ProBal) mode or Dynamic mode. This document will only cover the training for the Steady State operating mode.

1.1.2. How does SysCAD work?

A brief description of the SysCAD workflow is as follows:

1. A project configuration file is set up with a set of user defined chemical compounds (done via SysCAD Database and configuration file.)
2. A process flowsheet is created by inserting **"Process Units"** onto the "**Graphics Window**". These process units are then linked together with "**Pipes**"
3. SysCAD **Process Units** may include:
   a. Feeder/Sink (for Inputs and outputs of the process)
   b. Tanks and Ties (for mixing and splitting of stream);
   c. Tank with Reactions Sub model (for reactors)
   d. Heat Exchangers and Flash Tanks (for heat transfers);
   e. Filters and Washers (for mass separation);
   f. And many more.

   For a complete list of the SysCAD Steady State Models included in the package, please refer to the SysCAD online documentation: *http://help.syscad.net/index.php/Models*.
4. When solving a SysCAD project, the SysCAD solver will build and solve a network of simultaneous equations internally. Users only need to supply information such as:

a. Feeder information such as Feed rate, Temperature, Pressure and Composition. This is done through the "**Access Window**", which can be viewed by right clicking on the unit operations.
b. Configuration information of each Process Unit operation, such as reactions, mass separation, heat transfer, etc.
c. Various controls to set constraints and/or set-points in the project.
d. SysCAD can handle any number of complex recycle streams within a project.

5. When a project is solved, mass and energy will be balanced at each process unit and node point in the project.
6. SysCAD results can be reported using MS Excel for analysis.

1.1.3. What can be expected from a SysCAD model?

By simulating a Process Operation with SysCAD, the user can:

1. Obtain a Mass and energy balance of the plant. As a general rule: Mass and Energy are conserved within a SysCAD Model.
2. Gain better knowledge of the operations and control of the process.
3. Gain understanding of the cause and effect of changes to the process.
4. Establish the sensitivity of the process to operational parameters.
5. Gain understanding of the chemistry of the process.
6. Have a graphical representation of the process flow.

1.1.4. Things to keep in mind when using SysCAD

1. The user should have a clear scope prior to creating the SysCAD model. This includes knowing what outcome is needed from the model, whether it is for Mass or Energy Balance, Design or control logic testing. This will normally define the required SysCAD mode of operation (whether it is Steady State or Dynamic).
2. Define and check all required species/chemical compound data in the project species database, SysCAD.93.db3. (This can be extended and changed at any stage of the project)
3. Setup the models configuration data. (This file has the cfg extension.)
4. Use any existing Process Flow Diagrams (PFDs), or have a sketch / drawing of the process to be modelled. Go through each unit operation and determine which unit operations need to be simulated.
5. Determine which SysCAD unit model best simulates each unit operation in the project. Reading through the Models help (*http://help.syscad.net/index.php/Models*) may be useful when choosing the most appropriate SysCAD unit models.
6. Insert required unit models onto the graphics window and connect them as required. The graphical representation of unit models may be selected so that the SysCAD model closely resembles the PFD.
7. Configure the SysCAD models – This includes all feed streams and all downstream unit operation configurations. Define any reaction and control points.
8. Save the project often when changing or constructing the graphics, especially before solving or any major change.
9. SysCAD is not a black box (nor a magic box) - it requires sensible inputs to give sensible answers. As a general rule: garbage in = garbage out. It only does what you tell it to do (whether you meant it or not).
10. SysCAD may need to solve several thousand non-linear simultaneous equations to find a solution for large projects (much number crunching). So it is best to analyse what needs to be included in the model beforehand to avoid un-necessary complexity which can slow down the model.
11. In general, the logic and control that applies to the real operating plant should be applied to controls in the model.

12. SysCAD may not be able to find a valid solution if a model is incorrectly configured - users need to have enough knowledge of the operations to check the process criteria and assess the results.
13. Use reporting features to create Mass and Energy Balances for analysing and debugging projects.

1.2. Work Flow of the Tutorial

1.2.1. Topics Covered

This tutorial will teach the user how to create a simple SysCAD model using a predefined exercise project. Information on this project can be found in the next heading.

While building the model given in the exercise we will cover some basic functions and features of SysCAD in a step-by-step manner.

In summary, the following topics will be covered in this document:

1. The basic Commands required in building a SysCAD project.
2. Entering Data into the SysCAD Model.
3. Editing the SysCAD Species Database and Configuration file.
4. Adding Reactions.
5. Adding different types of control.
6. Merge two existing projects.
7. Connect flows between flowsheets.
8. Introduction to some advanced features.
9. Create and edit reports.

1.2.2. Tutorial Topics Video Demonstration

Supplementary video demonstration for most topics covered in the tutorial document can be found on: http://help.syscad.net/index.php/Tutorial.

1.2.3. Conventions used in this Tutorial

Convention	Description
➢	User actions, or steps, will be indicated by this symbol.
Menu Commands	e.g. *Edit - Project Configuration*. This means: from menu command *Edit* select '*Project Configuration'* from the drop down menu.
Click	This indicates a SINGLE LEFT mouse button click, unless directed to use the right mouse button.
Text in Bold Blue	**This indicates text that is entered by the user.**
Warnings	***Warnings*** are in ***bold italic***
By Example	Modules marked By Example contain step-by-step instructions to guide you to perform a task or operation.
Exercise	Modules marked Exercise are set aside to practice and revise what has been covered in a module or chapter.
Windows	This will indicate Active windows, such as *Graphics Window*, *Trend Window*
Short Tags displayed	This tutorial document shows Access Windows with the short tags. You can swap between short / long tags by clicking on the Tag:Short / Tag:Long buttons.

1.2.4. Tutorial Exercise Project – Leach and CCD Simulation

Aim

The aim of this tutorial exercise is to simulate a simplified leach process to dissolve metals (Nickel, Magnesium and Cobalt) into solution for further downstream process. The unit operations used include: ore preparation, high pressure leaching, Counter Current Decantation (CCD) circuit and tailings neutralisation.

Process Description

Ore Preparation:

The ore feed will be diluted with water at a given ratio to ensure the leach feed slurry can be pumped.

High Pressure Leaching

The metals (Ni, Mg, Co) in the ore will be leached using H_2SO_4 to form soluble sulphates. Acid addition will be in excess to keep the leached solution acidic. Steam is added to maintain reactor temperature.

CCD Circuit:

The leached slurry will first be cooled then washed and decanted in 3 stages. The amount of wash added to the CCD circuit is based on the solids feed to washer 1. Washer 1 overflow will report to downstream processing and Washer 3 underflow will be sent to tailings neutralisation.

Tailings Neutralisation:

The tailings will be neutralised with Caustic, NaOH, and sent to Tailings storage.

Process Criteria

Ore Feed

Ore Feed	Value	Units
Mass Flow	65.0	t/h
Temperature	35.0	°C
Moisture	15.0	wt%
Solids (dry wt%)		
CoO(s)	0.5	wt%Sol
Fe_2O_3(s)	30.0	wt%Sol
MgO(s)	8.0	wt%Sol
Na_2CO_3(s)	2.0	wt%Sol
NiO(s)	1.8	wt%Sol
SiO_2(s)	57.7	wt%Sol

Water Addition to Ore Prep Tank

1.1 tonne of water added per tonne of dry ore feed.

Autoclave Reagents:

Steam Feed	Value	Units
Mass Flow	Calculated	t/h
Temperature	275	°C
Pressure	At Saturation	kPa abs
Concentrated Acid		
Mass Flow	Calculated	t/h
Temperature	30	°C
H_2SO_4(l)	98.3	wt%Liq

Autoclave:

- *Pressure*: 15 bar,
- *Temperature* Target 150ºC
- Excess Acid**:** 2 g/L H_2SO_4(aq) (autoclave outlet)
- Nickel and Cobalt: 95% dissolution
- Magnesium: 100 % dissolution
- Sodium sulphate concentration in leached solution: 2.75 g/L

CCD Circuit:

Cooled Leach Solution Feed to CCD: 50ºC

Heat Loss in Washer 1 – Temperature drop of 1ºC

Wash water to Last washer: 2 tonnes water per tonne of solids in CCD feed

Tailing Neutralisation:

Fully neutralise the acid using NaOH.

Sodium Hydroxide	Value	Units
Mass Flow	Calculated	t/h
Temperature	30	ºC
NaOH(aq)	50	wt%Liq

1.2.5. Flowsheets

The flowsheet is the mechanism used to develop the model and provides a graphical interface for the user to enter and extract data. The flowsheets describing the Leach and CCD circuits are shown in Figure 1 and Figure 3. Figure 2 is an intermediate flowsheet.

- **Figure 1: Autoclave Circuit (Used for Section 2 – Creating a SysCAD Project)**
- **Figure 2: CCD Circuit (Used for Section 7 – Merging and Modifying Projects)**
- **Figure 3 : Modified CCD Circuit (Used for Section 7 – Merging and Modifying Projects – Before Copy & Paste)**
- **Figure 4 : Modified CCD Circuit Stage 1-3 (Used for Section 7 – Merging and Modifying Projects –After Copy & Paste)**
- **Figure 5 : Modified CCD Circuit Stage 4-6 (Used for Section 7 – Merging and Modifying Projects –After Copy & Paste)**

HINT:

A duplicate copy of the above information along with flowsheets can be found at the end of the Tutorial document – under Pull-Out Section. We recommend that you print out these pages to use as a guide during the tutorial.

1.2.6. Supplementary Tutorial Demonstration Videos

Some videos are available online (http://help.syscad.net/index.php/Tutorial) to supplement this Tutorial Document, and to provide clarification to some of the sections. Not all of the sections are shown in the videos. The videos are meant to be used together with this document.

Figure 1: Autoclave Circuit (Used for Section 2 – Creating a SysCAD Project)

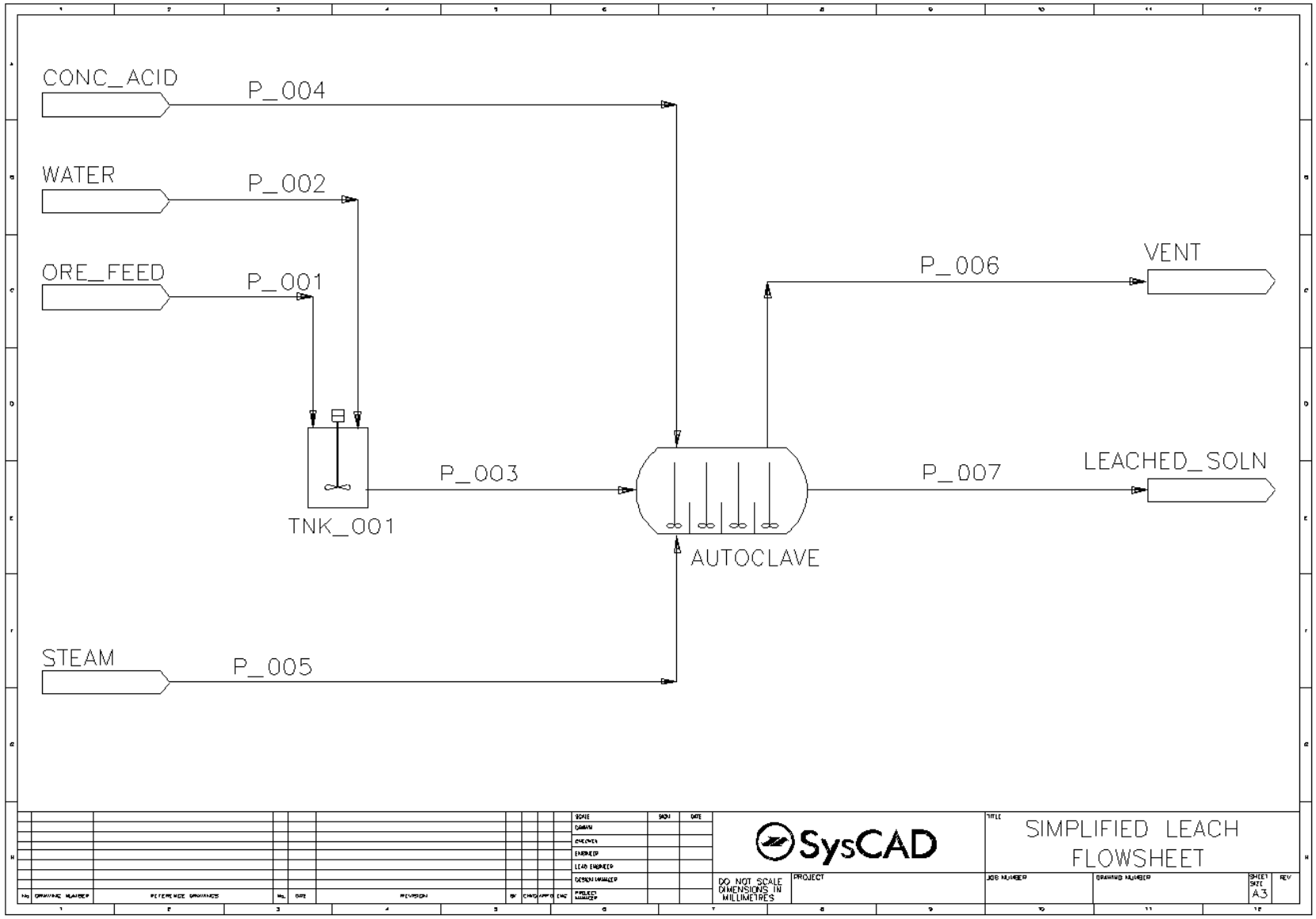


Figure 2: CCD Circuit (Used for Section 7 – Merging and Modifying Projects)

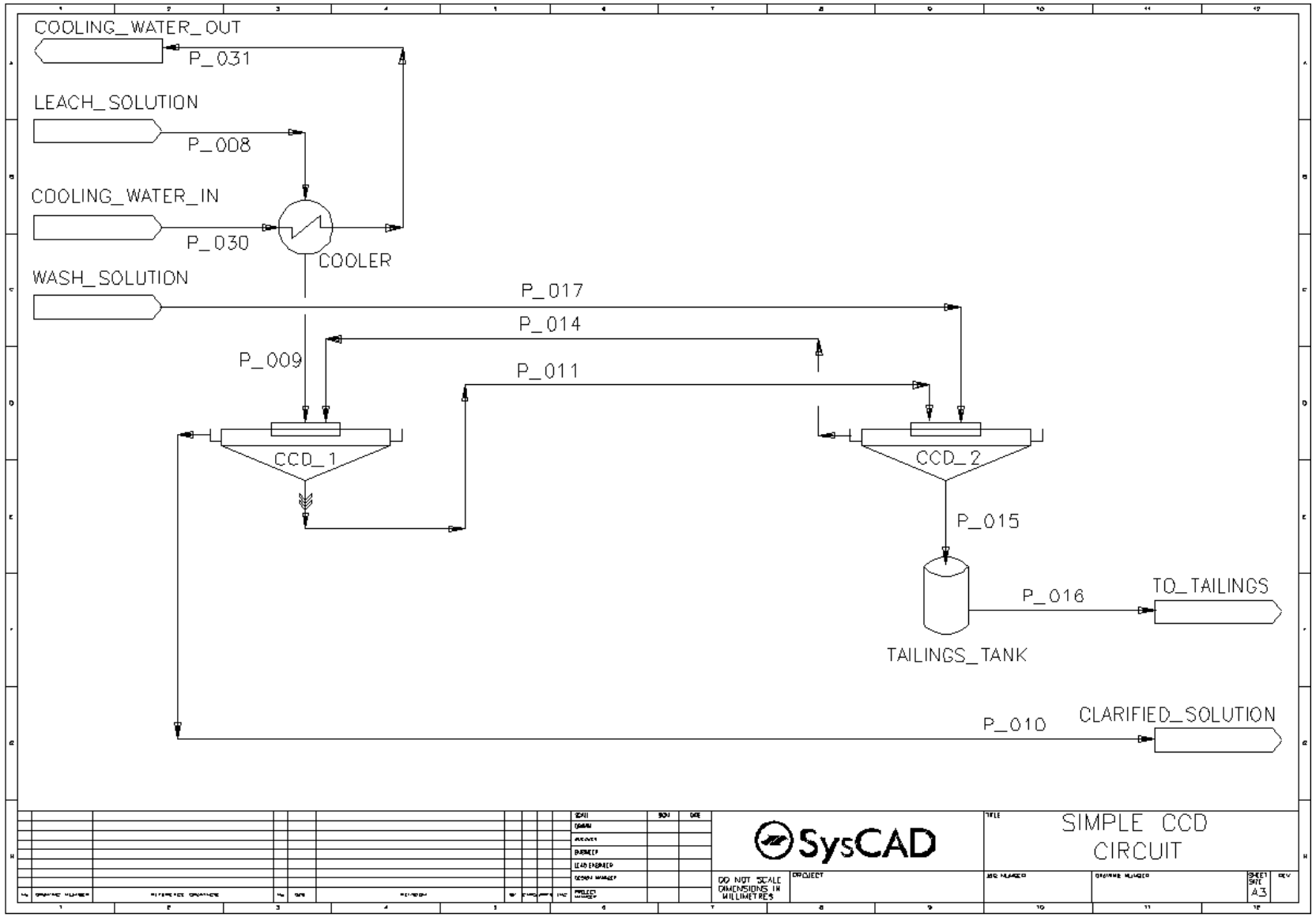


Figure 3 : Modified CCD Circuit (Used for Section 7 – Merging and Modifying Projects – Before Copy & Paste)

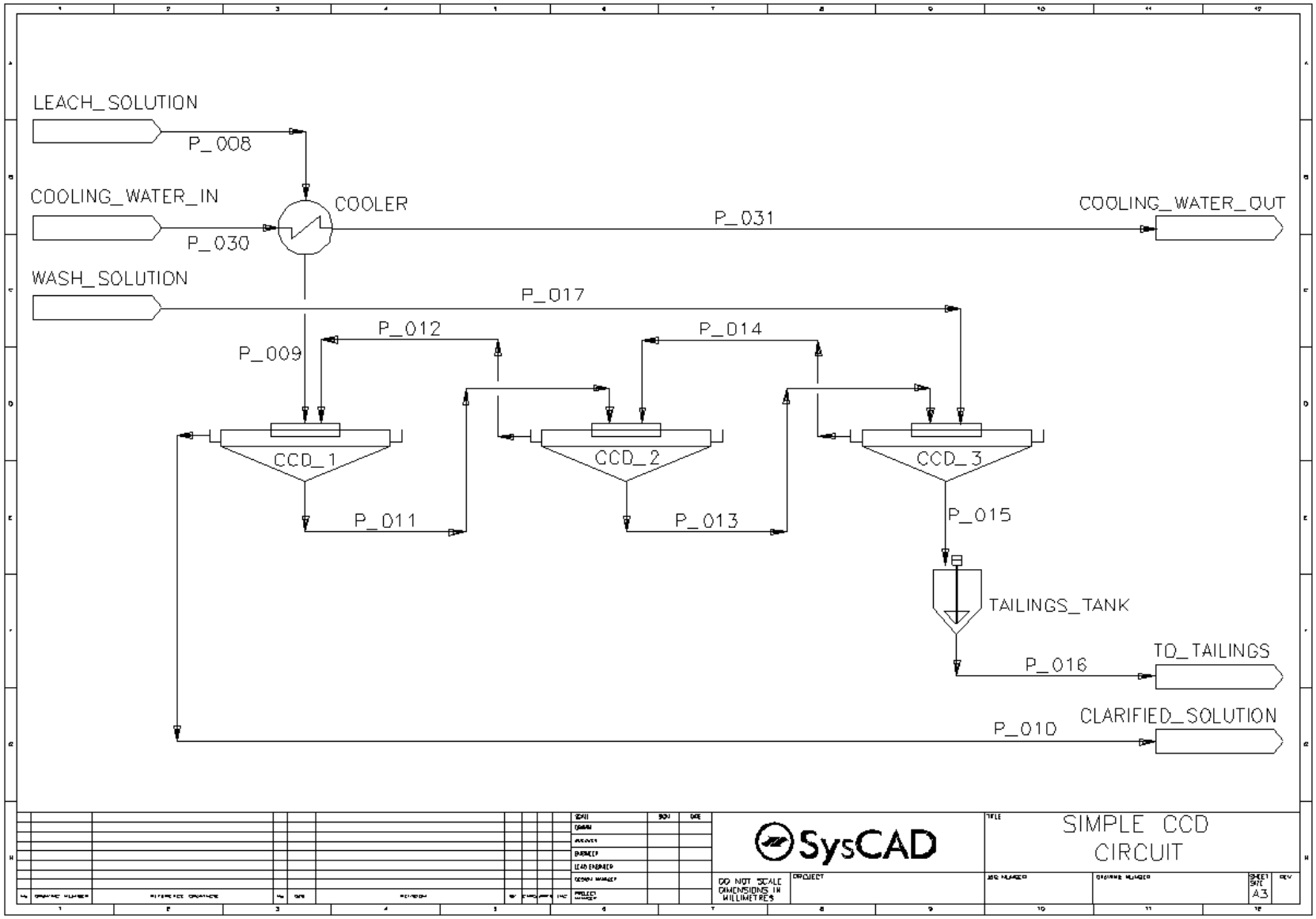


Figure 4 : Modified CCD Circuit Stage 1-3 (Used for Section 7 – Merging and Modifying Projects –After Copy & Paste)

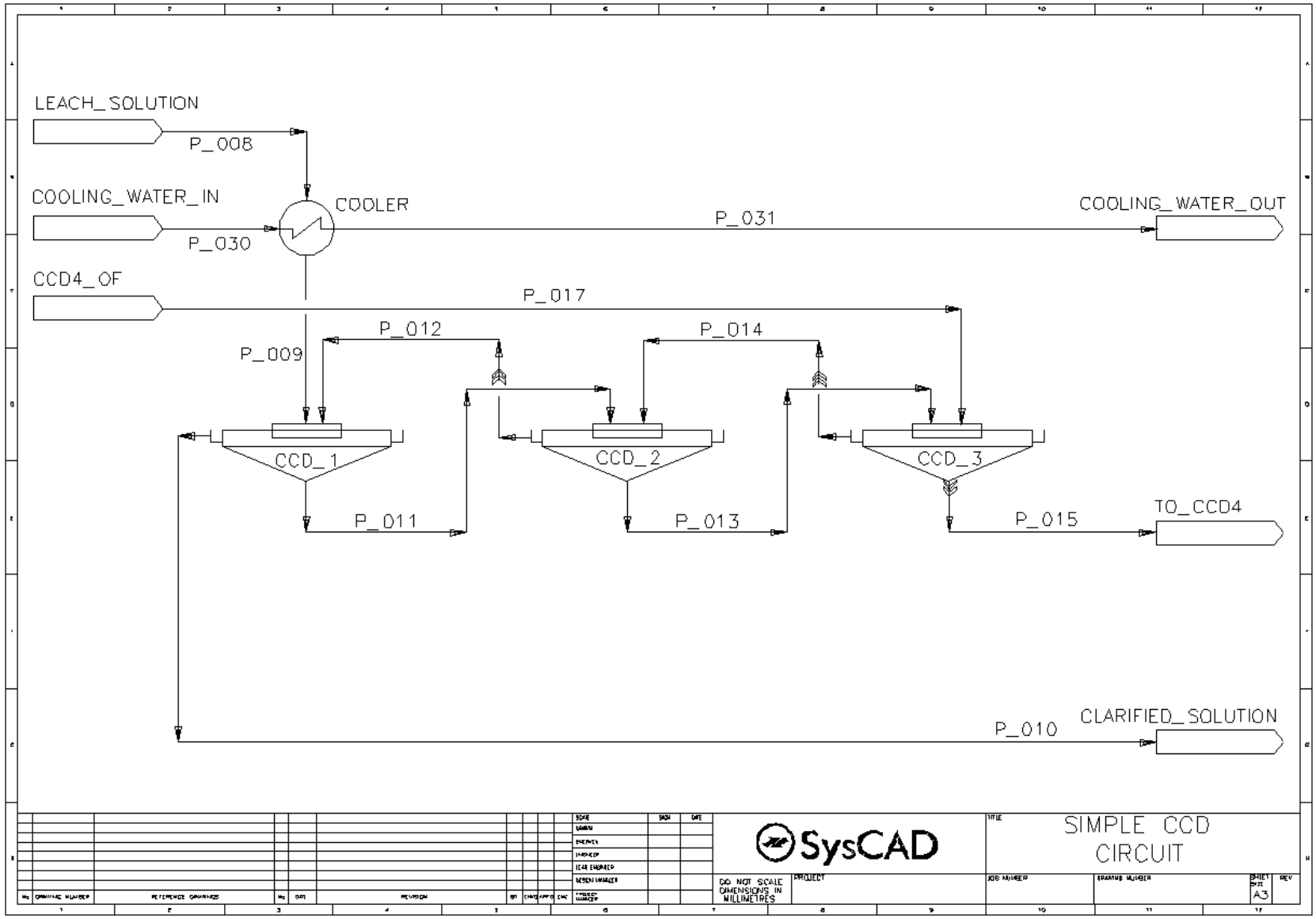
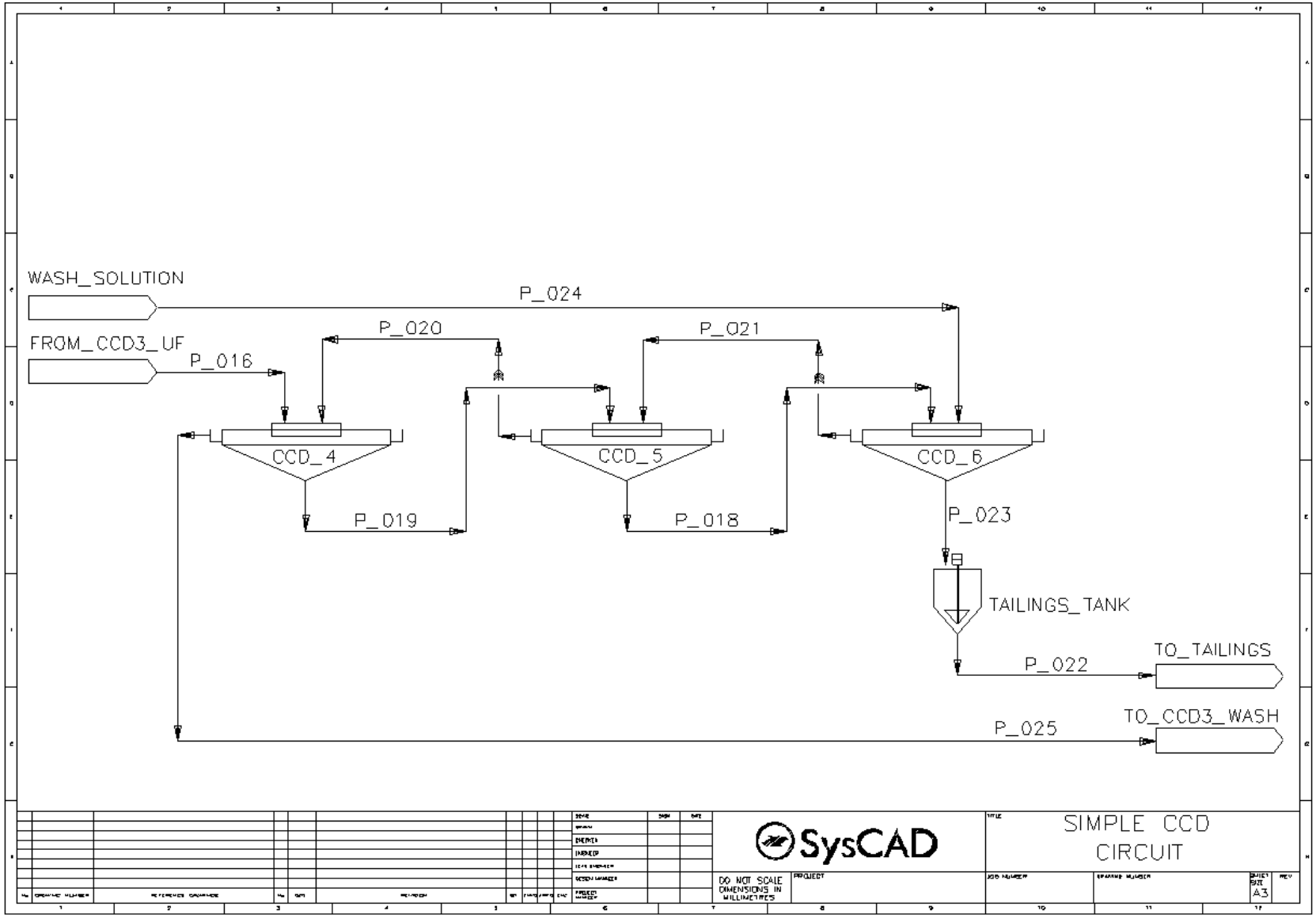


Figure 5 : Modified CCD Circuit Stage 4-6 (Used for Section 7 – Merging and Modifying Projects –After Copy & Paste)



SECTION 2

2. Creating a SysCAD Project

2.1. Module Overview

We begin the tutorial exercise project by first looking at the Leach flowsheet. This flowsheet can be found in the introduction section – Figure 1.

In this module you will learn how to:

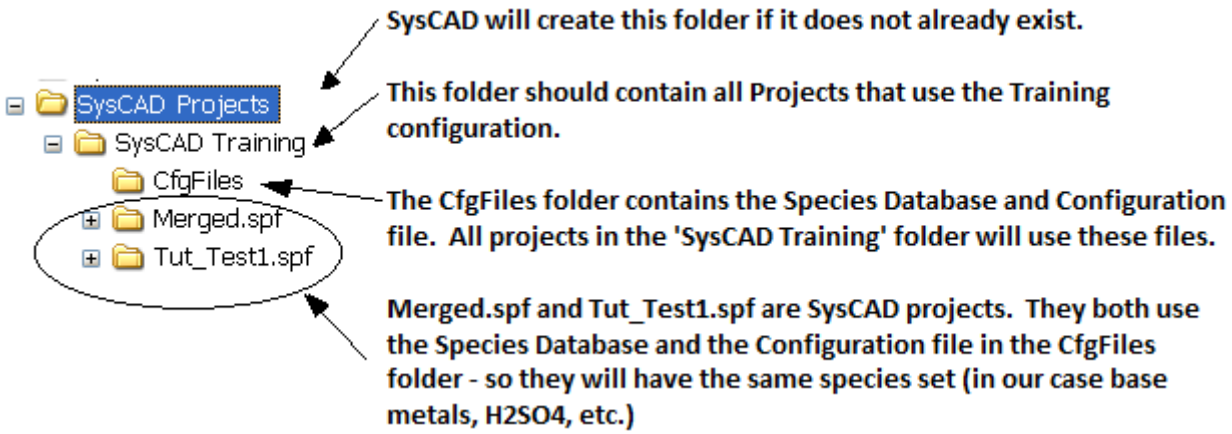
- Create a new SysCAD Projects Folder;
- Create a new SysCAD project;
- Create a SysCAD flowsheet;
- Input data into the SysCAD model.
- Solve and save the project.

2.2. Creating a New SysCAD Project Folder

Before creating a SysCAD project, we need to define a new Project Folder, in our case called SysCAD Training. This folder will contain:

- The CfgFiles Folder with the required Species database and Configuration File; and
- Any number of SysCAD projects.

The structure of the folder is shown below:



For this exercise we will copy the Base Metals configuration file and species database from the Tutorial folder. SysCAD will create the 'SysCAD Training' folder with the copy of the Species Database and Configuration file.

Note: We will learn how to create/edit the species database and the project configuration file in the next section of the course.

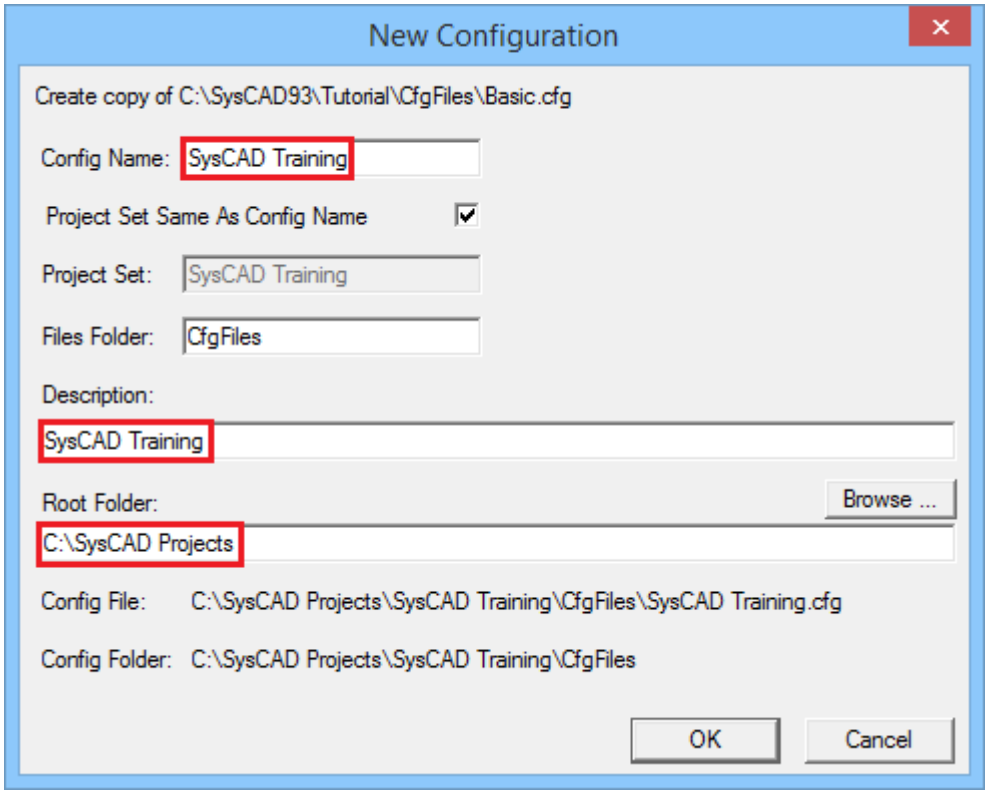
By Example

- Open SysCAD;
- ***Edit - Project Configuration*** (OR );
- Click the 

button to find the Base Metals configuration file. (The Project Configuration dialog box may be empty when you first open it.) The path is:

  ..\SysCAD93\Tutorial\CfgFiles\Basic.cfg

- Double click on the **Basic.cfg** file OR click on the **'Open'** button and this file will be imported to the **Project Configuration** dialog box;
- Click on the **'Copy'** button and you will see the following dialog box:



- Type in **'SysCAD Training'** for the Config Name and **'Training Projects'** for the Description;
- Click on the **'OK'** button;

  SysCAD will create a new folder called 'SysCAD Training' at the following path:

  C:\SysCAD Projects\SysCAD Training

  This folder will include the **CfgFiles** folder that contains the species database and configuration file that we will use for our training.

  You will be returned to the **Project Configuration** Dialog.

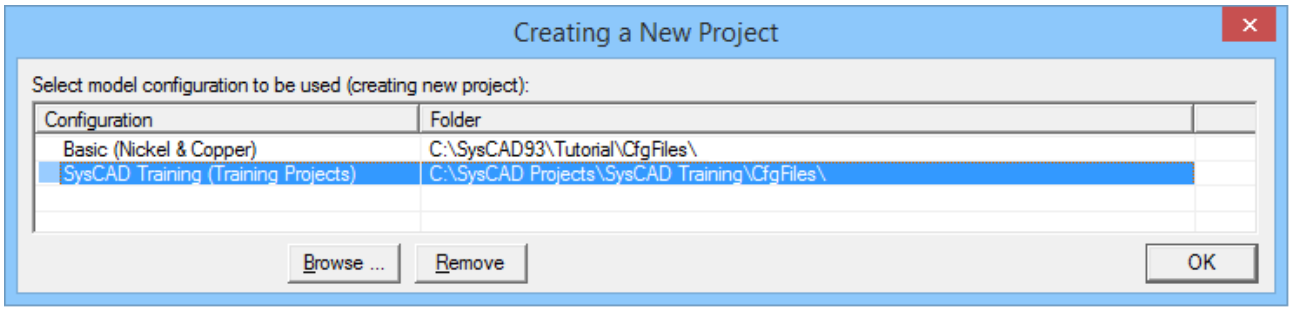
- Click on the **'Done'** button to close the dialog window.

We are now ready to create a new SysCAD project in the SysCAD Training folder, using the species database and configuration file we have just created.

2.3. Creating a New SysCAD Project

- *File - New Project* (OR  OR <Ctrl>+<N>)

  This opens the **Create a New Project** dialog box displaying the names of recently used model configuration files.

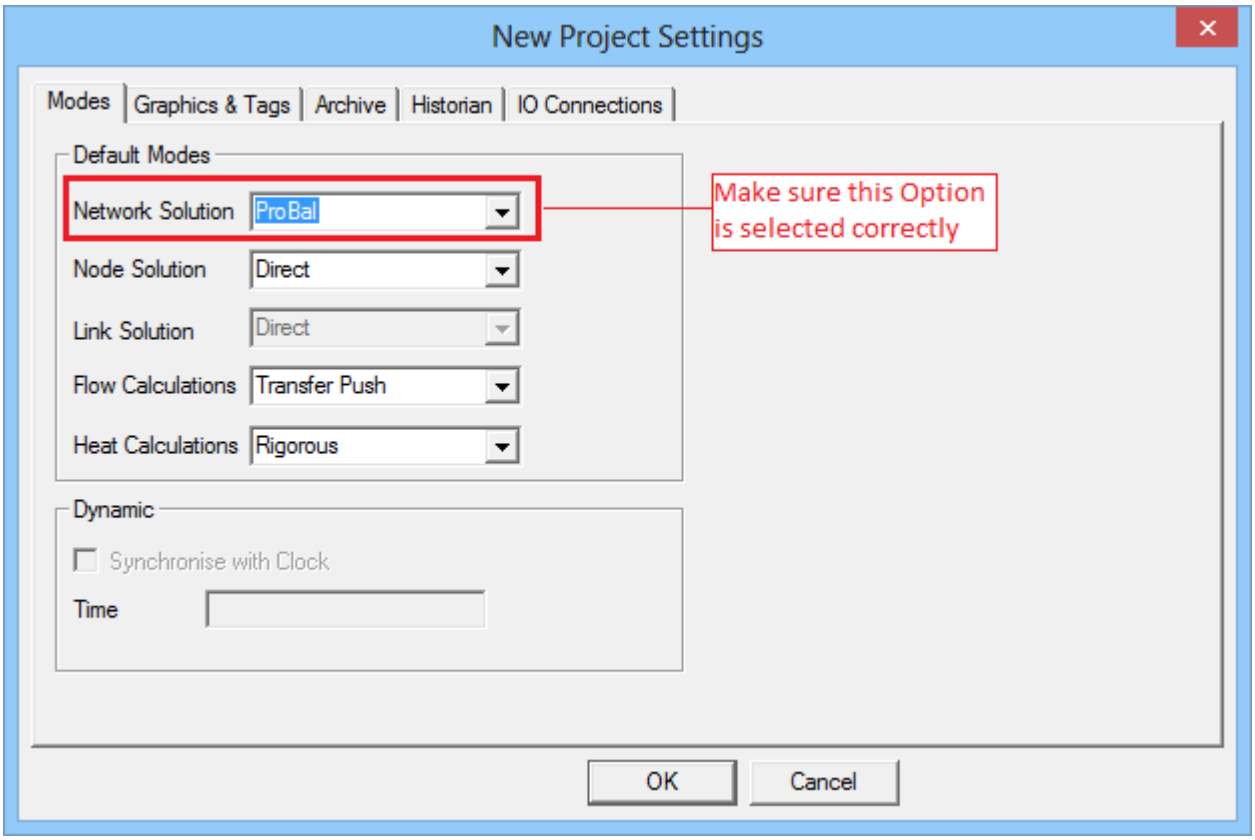


- Select the '**SysCAD Training**' configuration file and press ;

  This will open the **Create as** dialog box.

- Enter **Tut_Test1** in the file name text box and click on the Save button;

  Next SysCAD will then bring up the **New Project Setting** Dialogue box for user to define the default project setting. We will keep all of the default settings for this project.



- Press **OK**.

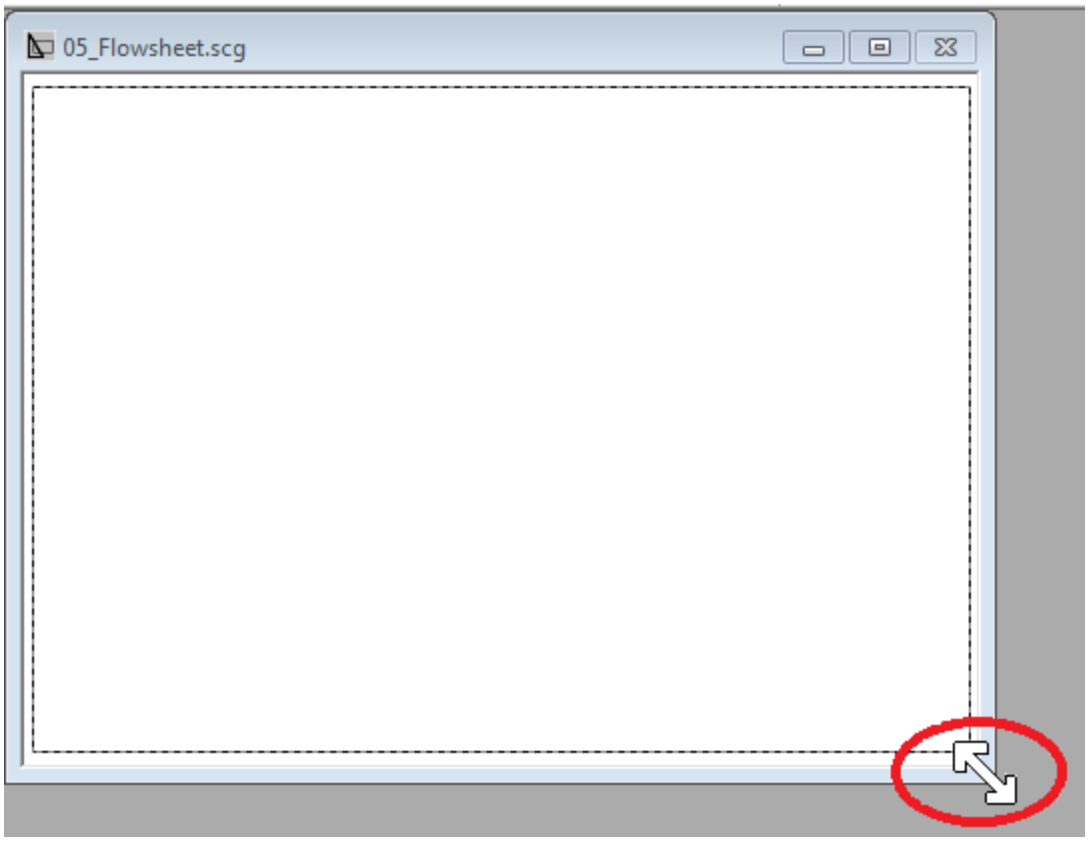
The project is opened in SysCAD with a *Graphics Window* (05_Flowsheet.scg), a *Trend Window* (Trend_1.trn), and the *Message Window*. The project folder created by SysCAD is located at the following path: *C:\SysCAD Projects\SysCAD Training\Tut_Test1.spf*

2.4. Drawing a SysCAD Flowsheet

Please have at hand **Figure 1: Autoclave Circuit (Used for Section 2 – Creating a SysCAD Project)**. The process unit operations will be inserted into the *Graphics Window* and then connected using links. (The project flowsheets and project process description can be found in Section 1 Introduction OR Pull-Out Section at the end of the Tutorial document.)

2.4.1. Optional – Increasing the Graphics window size

You may increase (or decrease) the size of the Graphics window by positioning the mouse pointer over the corner, or any edge, of the Graphics window. When the pointer changes to a double-headed white arrow (see diagram below), hold down the left mouse button and drag the corner, or edge, to increase or decrease the window size:



We do **NOT** recommend maximising the Graphics Window, as if you do this, it is not easy to move between windows. When the window is not maximised, you may move between Graphics windows, the Access window, Trend windows, etc. by simply clicking on the required window.

If the Graphics window was maximised, you would right click on a unit and the access window of that unit would also be maximised and therefore to get back to the Graphics window you would have to click on the 'Cancel' button.

2.4.2. Setting the Snap Grid Options

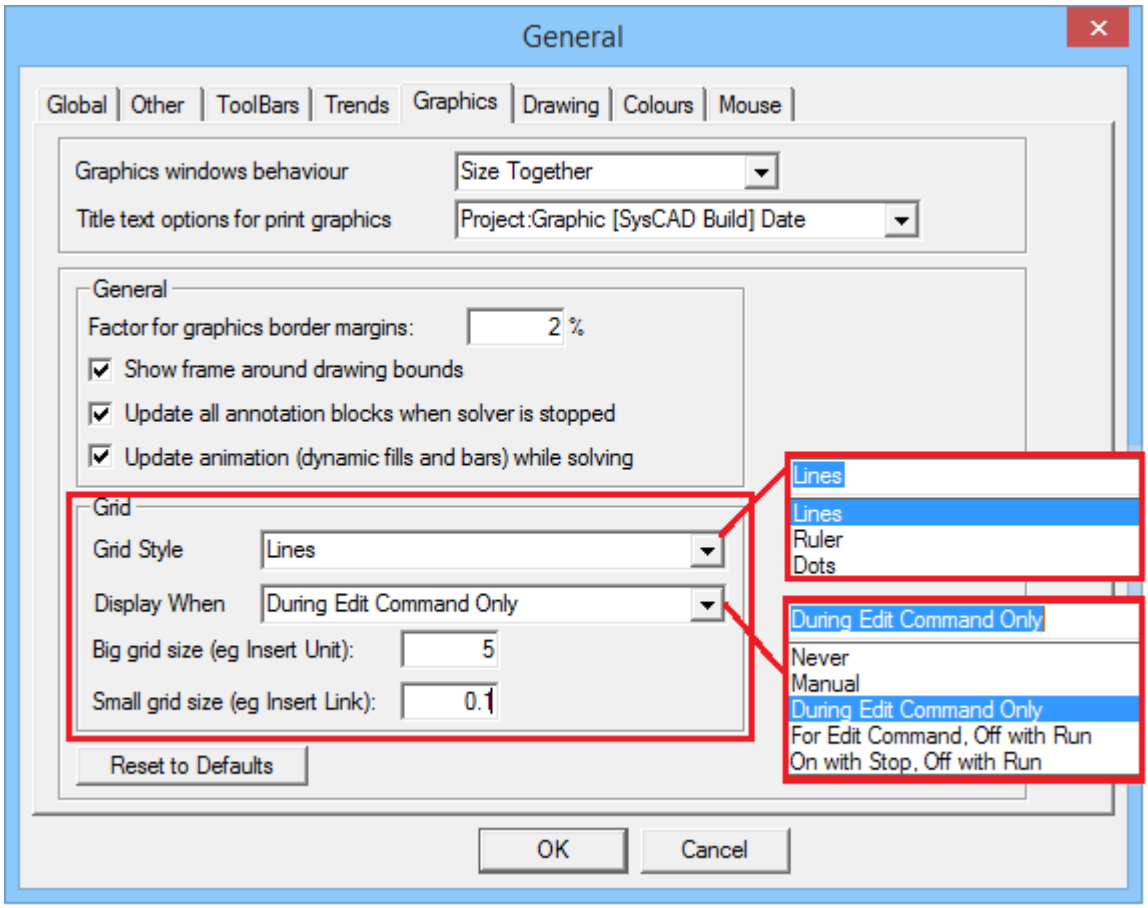
When inserting (or moving) a symbol in the graphics window, SysCAD 'snaps' the graphics onto a pre-defined grid. You may define the scale used by the grid to help "align" the graphics as you place them onto the flowsheet.

- The Large grid is used when inserting Units; and
- The Small grid is used when inserting Links connecting the units.

The recommended settings for the A3 frame are: Large Grid = 5, Small Grid = 0.1.

Note: The grid is visible on the page during certain commands.

➢ *Tools - General Options - Graphics* (OR )



➢ Select the preferred Grid Style – default is "Lines"
➢ Select when the grids will be visible – default is Grid lines will be switched on when editing commands are used, such as Insert or Move.

NOTE that Grid Lines can be toggled on/off using **Ctrl+G** when the active window is a graphics Window.

➢ Change the 'Big Grid Size' to **5**.
➢ Change the 'Small Grid Size' to **0.1**.

2.4.3. Optional - Inserting a Border

A flowsheet will always be more presentable if a drawing border is also displayed. This will help the user with the layouts while drawing a flowsheet.

Some predefined borders are available in the \SysCAD93\Basefiles\Symbols\Extras folder; these are based on Australian Standards and are of sizes A1 to A4.

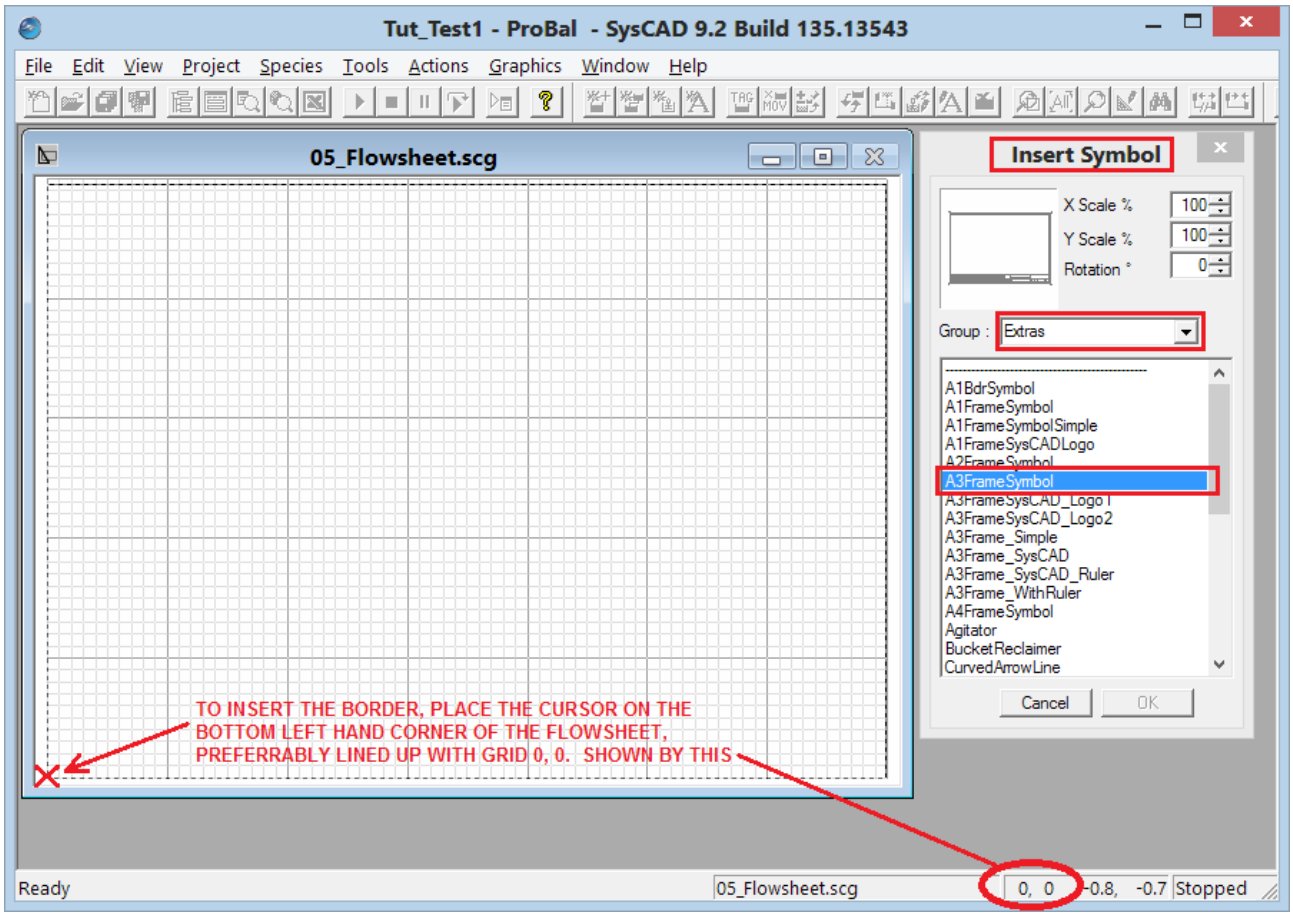
ADDITIONAL INFORMATION: Users with access to proper CAD drawing packages may modify the existing borders or add their own borders. For more information please see http://help.syscad.net/index.php/Graphics_Database#How_to_create_a_customised_drawing_frame_using_external_CAD_packages.

By Example

- Click on the *Graphics Window* (05_Flowsheet.scg).

  This gives the *Graphics Window* the focus and activates the associated graphics functions. Note that the 'Graphics' menu is now available in the menu bar.

- *Graphics - Insert - Symbol* (OR )



The Group will by default be 'Extras'.

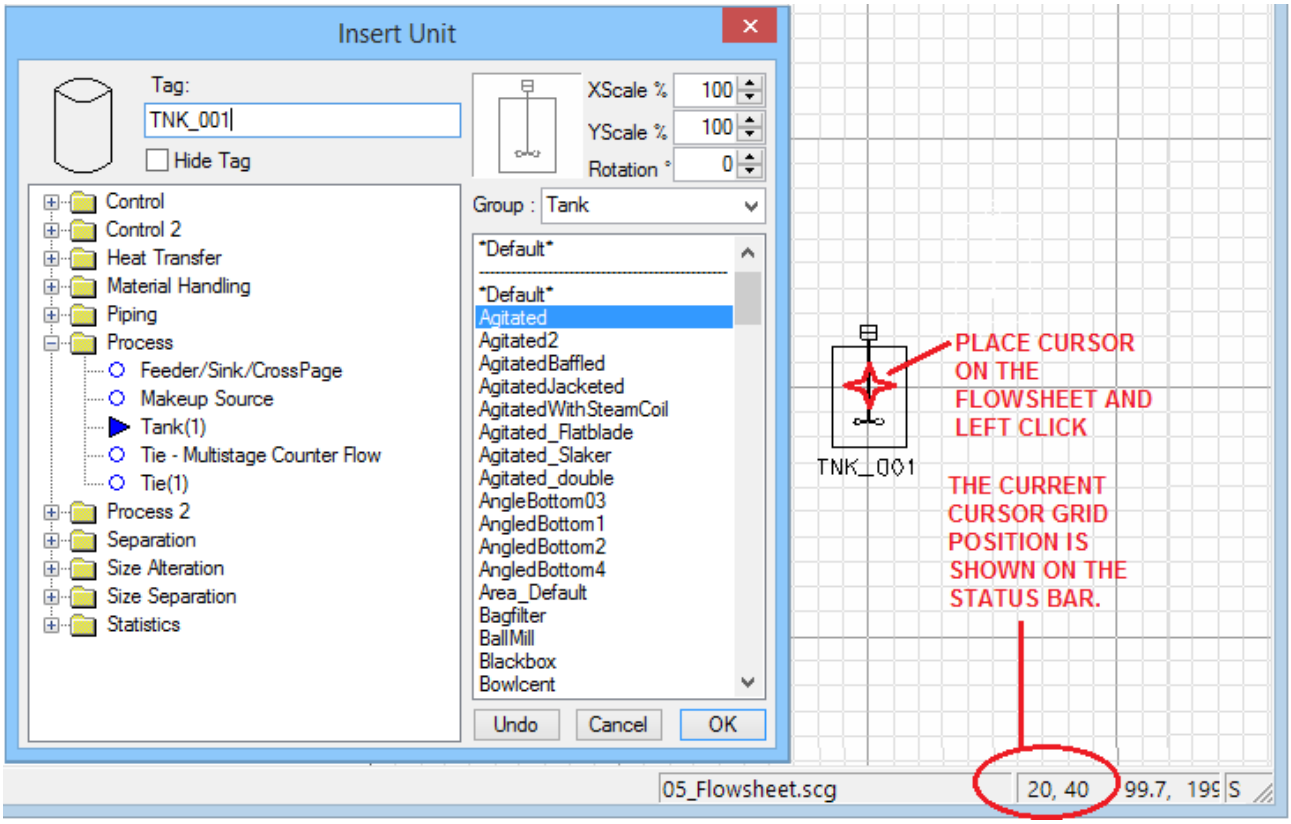
- If grids are used, the grid lines will appear on the screen, use this as a guide to insert the symbol.
- Select 'A3 Frame Symbol' from the list;
- Move the mouse pointer to the required insertion point in the *Graphics Window;*
  The insertion point for the 'Frame' symbols is always the bottom left corner of the Frame.
- Click on the bottom left corner of the Graphics page to insert the frame, shown by the red cross;
- The grid count (shown above in the status bar) also helps with object alignment, the border should be placed at grid 0,0.
- Press **OK**.

2.4.4. Insert Unit Operations

By Example

- Click on the *Graphics Window* (05_Flowsheet.scg), if this is not the active window;
- *Graphics - Insert - Unit* (OR OR <Ctrl+U>)

  This opens the **Insert Unit** dialog box listing the available process unit operations.



- From the **left hand** side of the dialog box select **Process** – **Tank(1)**;
- From the **right hand** list choose the graphic called **Agitated**;

  This is a list of the available graphic bitmaps for the chosen unit operation type. The Graphics previewing area shows the default graphics.

- With the **Insert Unit** dialog box opened, move the cursor over the *Graphics Window*

  Use **Figure 1: Autoclave Circuit (Used for Section 2 – Creating a SysCAD Project)** as a guide to find an appropriate position.

- Left click once to insert the unit onto the Graphics page.
- Immediately after the unit has been placed on the graphics page and prior to pressing the OK button,

  Use the keyboard arrow keys ↑ ← ↓ → to position object if required.

  Pressing Shift + ↑ ← ↓ → will move the objects in larger steps.
- Click OK to finish inserting the units.

SysCAD draws the unit operation on the *Graphics Window* and enters the unit operation into the model database.

Notes:

- The Insert point for all units (with a few exceptions) is in the Centre of the unit's graphic bitmap.
- Insert Unit will snap to the large grid size.
- The mouse cursor shows the type of unit you have selected, in this case - Tank(1)
- When drawing multiple unit operations on the *Graphics Window*, you do not have to click OK every time you insert a unit operation, but can continue directly with the next unit operation.
- You must click OK to accept all units have been inserted.
- The Undo button will remove last action, use this if the inserted unit is wrong.
- If you click Cancel, all unit operations drawn for that session will be cleared.
- If the **Hide Tag** box is not ticked then the unit's tag name (in this case TNK_001) will be displayed.
- The **right hand** list shows a list of the available graphic bitmaps for the chosen unit operation type. A different group of graphic bitmaps can be chosen from the **Group** drop down list. Choosing the ***All*** group allows access to the full list of graphic bitmaps. All drawing symbols are stored in folder – ...\SysCAD93\BaseFiles\Symbols.
- The scale and rotation of the graphic can be changed prior to inserting it (or after it has been inserted as will be shown later in the tutorial), using the boxes in the top right hand corner of the dialog box.

Exercise

➢ Insert the following unit operations on the *Graphics Window*:

Unit Operation Type	Graphics Symbol used	Tag	Scale (%)		Rotation
			X	Y	
Process – Feeder/Sink/CrossPage	Feed | Feeder04_TagTopLeft	Ore_feed	100	100	0
	Feed | Feeder04_TagTopLeft	Water	100	100	0
	Feed | Feeder04_TagTopLeft	Conc_acid	100	100	0
	Feed | Feeder04_TagTopLeft	Steam	100	100	0
	Feed | Feeder04_TagTopLeft	Leached_soln	100	100	0
	Feed | Feeder04_TagTopLeft	Vent	100	100	0
Process – Tank(1)	Tank | Agitated	Tnk_001	100	100	0
	Tank | LeachTank_4C	Autoclave	125	125	0

Use **Figure 1: Autoclave Circuit (Used for Section 2 – Creating a SysCAD Project)** as a guide to place the unit operations on the *Graphics Window*.

Quick Help on Graphics Commands



This table provides a summary list of some the commands used during a flowsheet generation. Most of the editing commands will be explained in more detail in later sections.

Function	Command	Button	Action
Insert Unit Operation	Graphics | Insert | Unit		Select the Required Unit Operation Type and preferred graphics symbol from the dialog box, then left click once on the graphics window to insert. Keyboard arrow keys can be used to position object. Shift + will move the object in larger steps.
Insert Link	Graphics | Insert | Link		Use this function to connect two unit operations together. The user must select the source unit, then the destination unit. The user may then accept the default line drawn by SysCAD or construct the line themselves. (see section 2.5.4 below)
Insert Symbol	Graphics | Insert | Symbol		Select the required symbol to insert from the dialog box. NOTE that the insert symbol will only add the graphics symbol to the flowsheet, it has no intelligence behind it. Use this function to add a drawing frame or standby equipment or pumps, valves etc., to show this equipment exists, but is not actually modelled in the project. Keyboard arrow keys can be used to position object. Shift + will move the object in larger steps.
Insert Text String	Graphics | Insert | Text		Type in the required text, and then left click on the flowsheet to place it at the desired position. The user may change the size - both height and width of the text string. Use Create next to create more text. Keyboard arrow keys can be used to position object. Shift + will move the object in larger steps.
Change **Tag** Position or Hide or Show tag displays & Change tag size or rotation.	Graphics | Edit | Tag Position, Show or Hide		1) **Set Tag Position** tick box **Checked** – Used to reposition the tags. Left click once to select the graphics, then left click to position the tag to a new spot. Press Next to move another tag. 2) **Set Tag Position** tick box **NOT Checked** – Used to change the tag size and rotation as well as hiding or showing the tags. Left click to select the required symbols, multiple selections are allowed, press the apply button to apply the changes.
Move Graphics Symbols	Graphics | Edit | Move		Left Click once to select the Graphics Symbol, use the keyboard arrow keys to move/scale/rotate the object. Pressing Shift + will move the objects in larger steps. Pressing Ctrl + will rotate the objects. Pressing Ctrl + will scale the objects.

Function	Command	Button	Action
Resize / Rotate Graphics Symbol	Graphics | Edit | Scale/Rotate		Use the floating toolbar buttons to increase or decrease size, rotate clock/anti-clock wise, or use the dialog button to enter customised x and y scale and rotation. Alternatively, the keyboard arrow keys will function as per **Move** function above.
Change the mathematical model of a unit operation.	Graphics | Edit | Change Unit		Select the unit operation by left clicking, then select the new model type from the dialog box. The user must check all existing links connected to the model and re-define the connections, if required.
Redraw the Link to change the appearance of the link	Graphics | Edit | Redraw Link		Left Click on a link to select it, then re-dot the line by left clicking to redraw the link. Use this function after a unit operation has been moved to reposition the link. NOTE: this only changes the appearance of the link and **not** the connectivity.
Change the **Symbol** used for a unit operation.	Graphics | Edit | Change Symbol		Left click on the unit operation to select it, then select the new symbol from the dialog box. The user may also change the size and rotation of the symbol before pressing OK. NOTE: this only changes the symbol and not the unit operation TYPE.
Edit Text string inserted by Insert Text	Graphics | Edit | Change Text		Left click on any text inserted by the Insert Text function, edit the text/size/width/rotation then press Apply to change the text. Use Create Next for new text or Change Next to select another piece of text to edit.
Delete Unwanted Graphics	Graphics | Delete | Delete		Left Click on the unwanted graphics symbol or symbols, or use the 'Window' options to select all graphics in a window. When ready, press the Tick button on the floating toolbar to delete.
Zoom with selection box	N/A		Zooms into a selected area. The selection box is created by <Left click + Drag>. Alternatively, pressing <Ctrl +  mouse wheel> will zoom in / out.
Zoom Out	N/A		Clicking on this button will zoom out to full flowsheet view.
Zoom In or Out	Graphics | Zoom		Use the floating toolbar buttons to zoom in or out, pan left/right/up/down or press the All button to zoom back out to full view. (The mouse roller wheel will also zoom in and out)
Refresh the Graphics Window	Graphics | Redraw		The action refreshes the graphics window, removing any insertion markings from the graphics window (e.g. Green crosses)
Disconnect	Graphics | Edit | Disconnect Link		Used to disconnect either the source or the destination unit, or both, from a link.
Connect	Graphics | Edit | Connect Link		Used to connect either the source or the destination unit, or both, from a link.

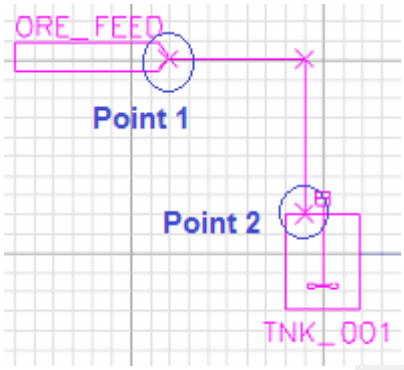
For more SysCAD Graphics command help, please see http://help.syscad.net/index.php/Menu_Commands and http://help.syscad.net/index.php/Graphics_Command_Summary.

2.4.5. Inserting Links to Unit Operations

After the Unit operations have been inserted into the *Graphics Window*, they can be joined together by links.

By Example

We would like to draw the link as shown below, to do so:



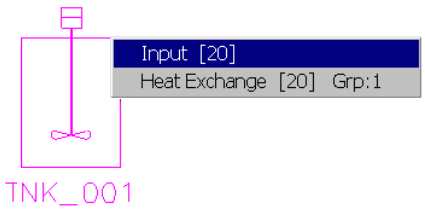
- *Graphics - Insert - Link* (OR  OR <Ctrl+L>)
- Move the cursor over the *Graphics Window*;

  The cursor will change to the Source pointer.

- Click the left mouse button on the **ORE_FEED** graphics symbol
  - Recommended clicking position is marked by Point 1 on the diagram above
  - NOTE: when using Auto Route Method, this position maybe used as the *Start* point of the link;

  The cursor will then change to the Destination pointer.

- Click the left mouse button on the **TNK_001** graphics symbol
  - Recommended clicking position is marked by Point 2 on the diagram above.
  - NOTE: when using Auto Route Method, this position maybe used as the *End* point of the link;



As you click on the Tank, you will be presented with a pop up list of all the connection points. The available connection points are in black and the unavailable connection points are in grey.

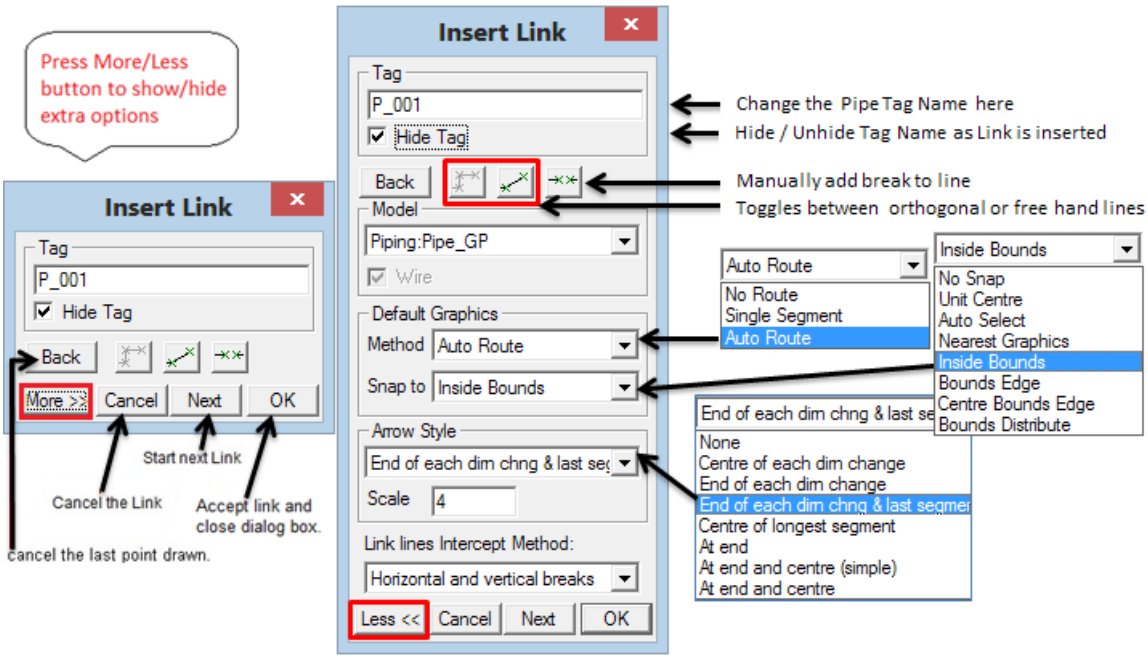
The number in square brackets refers to the number of connection points available. The tank may have 20 connections to the input and 20 connections to the Heat Exchange.

Note: *If the unit operation has only one possible connection point, SysCAD will not give you a choice. This was demonstrated with the Feeder/XPG connector model previously.*

- Choose **Input** from the pop up list;

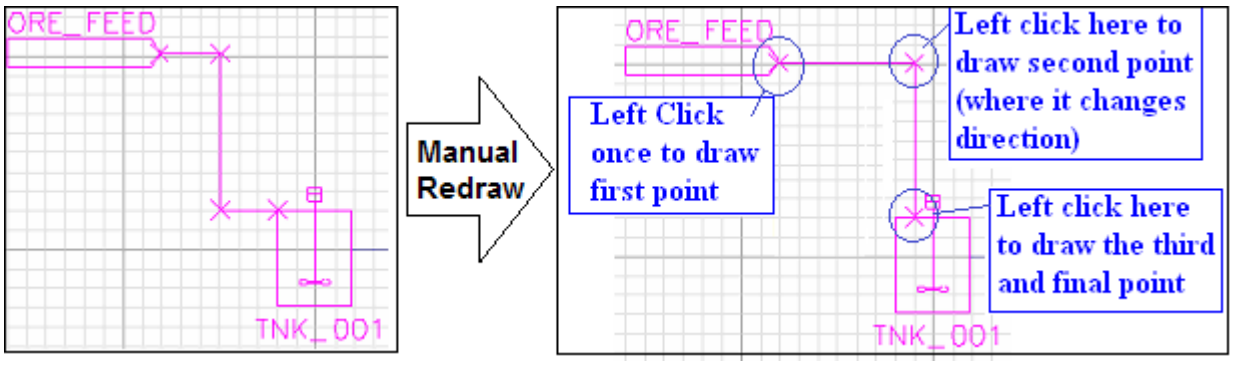
  Unit operations **ORE_FEED** and **TNK_001** are now connected and the flow of material will be from **ORE_FEED** to the Input of the **TNK_001**.

  SysCAD will connect the two units with a default link and opens the Insert Link dialog box, as shown here:



NOTE: For explanation and illustration of the Default Graphics Method and Snap To options, please see http://help.syscad.net/index.php/Default_Graphics_for_Insert_Link

- You may change the Tag name now or later. For this exercise, we will use the default name P_001.
- You may accept the line that SysCAD has constructed by clicking on the 'Next' or 'OK' button, or you may redraw the link yourself if it did not turn out as expected.



- To draw the line yourself, move the cursor over the *Graphics Window*;

  The *cursor* changes to the POINT *pointer*:

- Position the mouse pointer on the right hand tip of the Ore_Feed graphics symbol (as shown above) and click the left mouse button. This defines the starting point of the link graphics line;

  Notes:

  1. **The line drawn by SysCAD will disappear as soon as you click on the graphics page to select the first point of the line**.
  2. If you click and hold down the left mouse button SysCAD will display large cross-hairs to help you position the point. When you release the mouse button the cross-hairs will disappear.

- To choose the second point of the link, click the left mouse button above the tank TNK_001, as shown above. This defines the first segment of the link;
- Click the left mouse button on the top of the TNK_001. This defines the second segment of the link;
- Click on Next to insert the next link (in the Table below);
- Click OK when you have finished inserting the links.

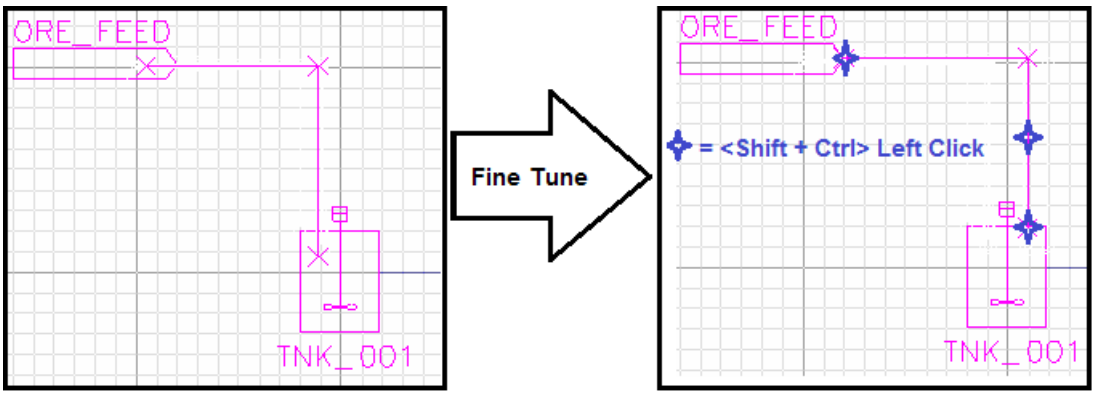
Exercise

➢ Draw the following links on the *Graphics Window*:

Tag	Source unit	Source IOTag	Destination unit	Destination IOTag
P_001	Ore_feed		TNK_001	Input
P_002	Water	-	TNK_001	Input
P_003	Tnk_001	Output	Autoclave	Input
P_004	Conc_acid	-	Autoclave	Input
P_005	Steam	-	Autoclave	Input
P_006	Autoclave	Output	Vent	-
P_007	Autoclave	Output	Leached_soln	-

Hints:

1. Use **Figure 1: Autoclave Circuit (Used for Section 2 – Creating a SysCAD Project)** as a guide to draw the links.
2. On the **Graphics** menu select **Redraw**. This removes temporary marks on the *Graphics Window*.
3. You may hide or show the link Tag on the graphics by clicking the 'Hide Tag' tick box.
4. When drawing the link, each two points selected are joined together by a straight line. The user can choose whether the line is orthogonal or "free" by toggling the Orth/Free buttons - .
5. The Back button will allow the user go back one segment (per click) and redraw the link until a satisfactory result is obtained.
6. You may change the method by which SysCAD automatically draws the link by changing the selection in the 'Graphics' box. (The default is for SysCAD to draw orthogonal lines between the selected points.)
7. You may change the position of the arrows on the links by changing the selection in the 'Arrow Style' box. (The default is to locate an arrow at each direction change and at the end of the line.)
8. The Auto-Route Links can be fine-tuned by holding down <Shift + Ctrl> keys to move a link segment or Start/End points.
    a. left clicking close to the Start / End points of a link will reposition them;
    b. left clicking close to a segment of a link will reposition the segment up/down/left or right.



In the above example, the starting point and the 2nd segment have moved right, and the end point has moved up.

2.5. Saving a project

➢ *File - Save Project* (OR  OR <Ctrl+S>)

It is always a good idea to save your work regularly, especially when you are constructing a project model.

Once the project has been saved, you may open Windows Explorer, and go to folder:

..\SysCAD Projects\SysCAD Training\Tut_Test1.spf, and have a look at how the project is saved.

All the model information is saved in a database file called **ModelData.db3**.

2.6. Editing Tag Displays

2.6.1. Changing Tags

You can change the Tag name when you insert a unit or link, or you can change the Tag name after it has been inserted as follows:

By Example

- Right click on the graphics symbol. The *Access Window* will be opened;
- Click on the button: (Change Tag OR TAG), which is located at top of the *Access Window*;
- Change the tag name as required.

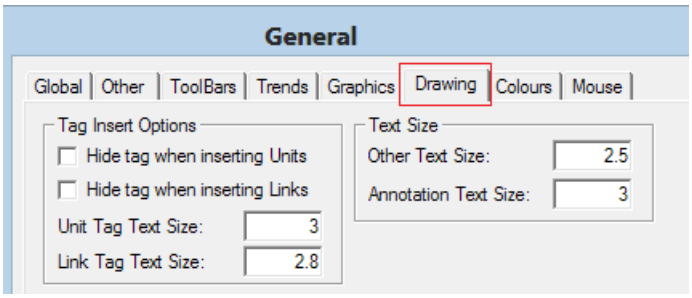
(An alternate method of changing Tags is to Shift + Left - click on the reactor graphics symbol, click on *Change Tag* from the popup menu and change the tag name as required.)

Exercise

- Rename all of the units to match Figure 1.

2.6.2. Setting up Default Tag display Options

- User can set the default options for the Unit / Link Tags from *Tools – General Options – Drawing Tab*

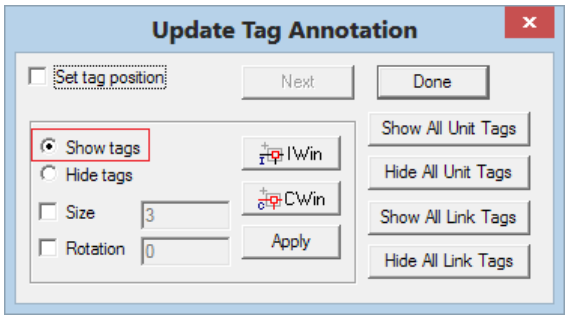


2.6.3. Showing and Hiding Tags

When you draw a unit operation or link on a *Graphics Window*, SysCAD allows you to show or hide the Tag. Once the unit operation is inserted, the Tag position, size or rotation can be altered.

By Example

- *Graphics - Edit - Tag Position, show or hide* (OR TAG)



Ensure the **Show Tags** box is checked.

- Click on P_001, the selected link turns magenta;
- Click Apply.

The tag P_001 appears on the graphics screen.

To hide the tag P_001, repeat the above with **Hide Tags** box checked. The tag P_001 will disappear from the graphics screen.

Alternative Method:

Menu Command: ***Graphics | Display | Show / Hide Unit / Link Tags*** options can be used without going into the Tag Dialog box.

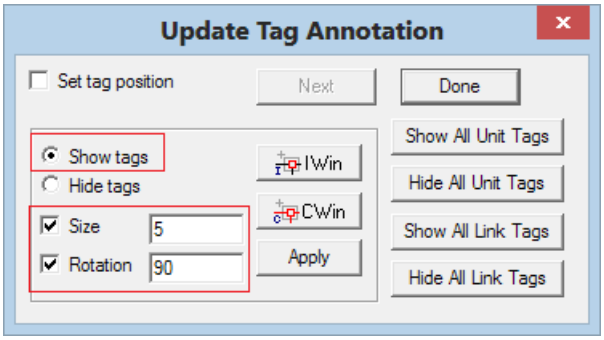
2.6.4. Changing Tag Size, and Rotation

The Tag's initial size, position and rotation are given by default. You can alter them using the Update Tag Annotation dialog box.

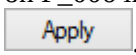
By Example

To change the size and rotation of Tag P_006:

- *Graphics - Edit - Tag Position, show or hide* (OR )



Ensure the **Show Tags** box is selected

- Click on the **Size** and **Rotation** boxes;
- Change Size to **5** and Rotation to **90**;
- Click on P_006 in the *Graphics Window;*
- Click .

The size and rotation of the Tag P_006 are updated on the *Graphics Window*.

Alternative Method for Tag Sizing only:

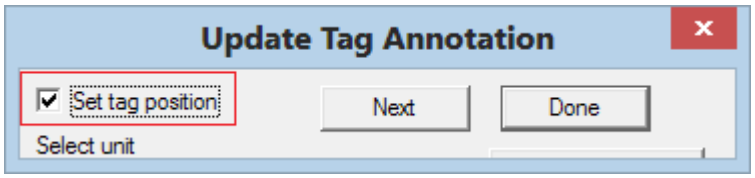
- Menu Command: ***Graphics | Display | Size All Unit / Link Tags*** options can be used without going into the Tag Dialog box. The size as specified in the ***Tools – General Options – Drawing Tab*** will be used.

2.6.5. Changing Tag Position

By Example

To change the **POSITION** of the Tag P_006:

- *Graphics - Edit - Tag Position, show or hide* (OR )
- Click on the **Set tag position** box;



- Move the cursor over the *Graphics Window*;

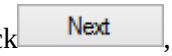
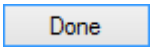
  The cursor will change to the Unit pointer.

- Click on the graphic for P_006;

  The cursor will change to the Position pointer.

- Position the cursor to the new Tag position and click;

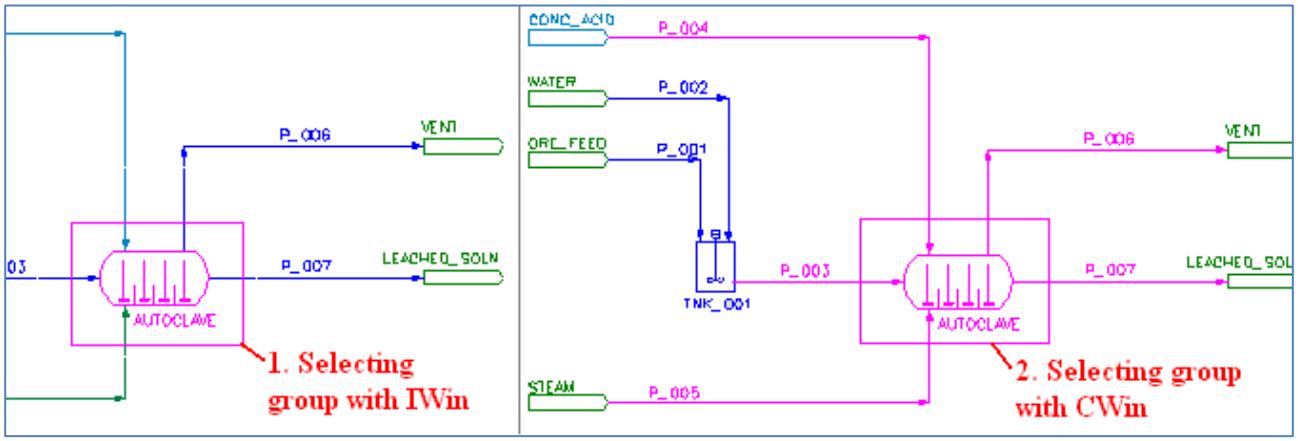
  The start of the Tag is positioned where the click was made.

- To proceed with repositioning another Tag, click , or click  to finish.

2.6.6. Making Grouped Changes

The In-Window IWin and Cross-Window CWin buttons allow you to alter groups of Tags.

- In-Window: only graphics completely within the drawn selection window will be selected.
- Cross-Window: any graphics touched by or within the selection window will be selected. (As demonstrated below.)



By Example

To change the Tag size for all the graphics on the flowsheet:

- *Graphics - Edit - Tag Position, show or hide* (OR TAG)

  Ensure that the Set Tag Position tick box is not selected.

- Press the either IWin or CWin button;
- Draw a selection window around all the unit operations (as shown in the diagrams above);

  Ensure the **Show Tags** box is selected.

- Click on the **Size** and **Rotation** boxes;
- Change Size to **5** and Rotation to **0**, click Apply;
- Click Done to finish.

Exercise

- Use Set Tag Position to place the tags neatly in the *Graphics Window*.

2.7. Changing Engineering Units

Internally SysCAD stores all data in SI units. However, you can change how the Engineering units are displayed in the model or how they are reported elsewhere.

You may select to use either Metric or American units or a combination of both. The default units in a new project will be Metric. The user may define the default unit and which units are shown or hidden (refer to http://help.syscad.net/index.php/Conversions for more information).

By Example

- Right click on the **Steam** feeder to open its *Access Window;*
- Select the first page tab (**Feed_XPG_1)**;
- Right click on the variable **T**;
- Select Conversions;

  Note: The current unit will be the Metric (default **C**)

- Choose **K** from the drop down list.

  The temperature is now displayed in Kelvin.

Exercise

- Right click on other Feeders, e.g. **Ore_Feed**

  Note the displayed T units, but also note that the T_Reqd units remain as C.

- To change back to C, choose **Default** from the drop down list.

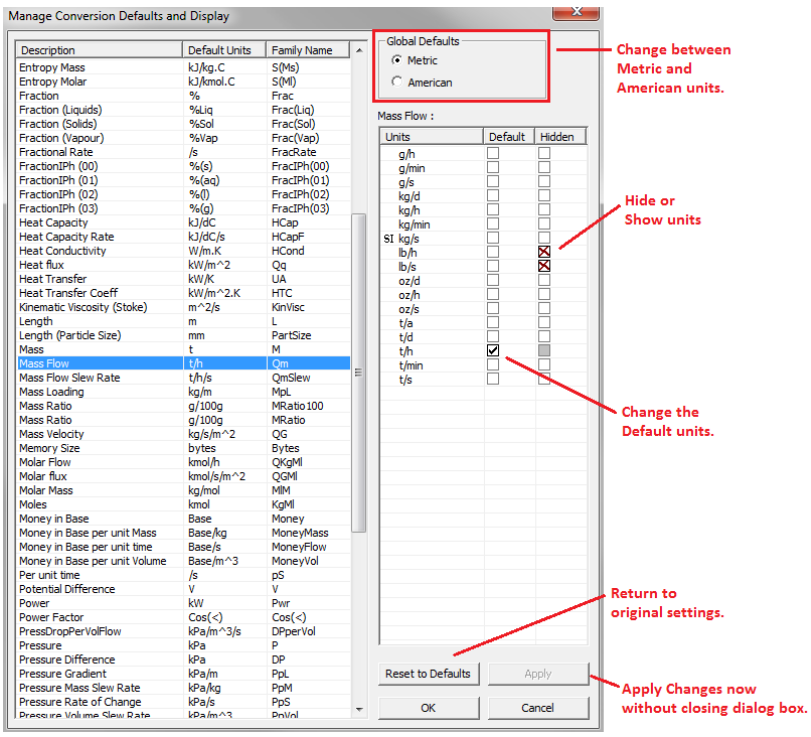
You may change the set of units (Metric/American), the default unit or to show or hide units at any stage.

By Example

- Right click on any variable;
- Choose Change Default…:

  This will open the **Manage Conversion Defaults and Display** dialog box as shown to the right.

- Change the default unit for **Pressure** to from **kPa** to **bar**.
- Hide the **Mass Flow** units **oz/d**, **oz/h** and **oz/s** for the Metric Set.
- Click OK when you have finished.



Notes:

1. This dialog box can also be opened via *Edit - Conversions - Defaults and Display*.
2. Many units are hardwired in SysCAD but you may add your own conversion to the Project or Default Database.

2.8. Entering Feed Data

Once the flow sheet is drawn, the next step is to configure the Feeders – that is, entering the Feed Rate and Feed composition.

We will enter data using the *Access Window*. Each unit has an access window with one or more pages that can be selected by clicking on the page tabs at the top of the window.

- Values that can be changed are in white text boxes;
- Values that cannot be changed are in grey text boxes.

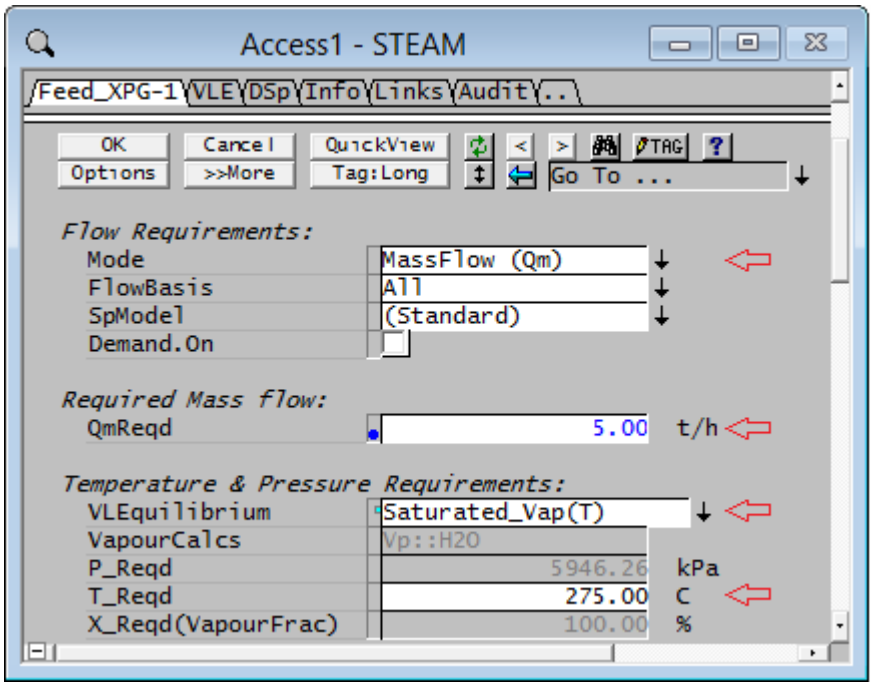
By Example

Entering the Steam flowrate:

In Steady State, the flowrate is entered into SysCAD in the form of Mass Flowrate or Volumetric Flowrate. We will use the default of Mass Flowrate in this example.

- Click on the *Graphics Window* (05_Flowsheet.scg);
- Click the right mouse button on the **Steam** graphics symbol;

  You are presented with the *Access Window* for the **Steam** process unit.



- Click the left mouse button in the white text box for **QmReqd;**
- Type **5** and press <Enter>;

  The value is displayed in blue. The blue writing indicates that the change has not yet been confirmed.

- To confirm the value press the OK button.

Now, we need to define the temperature and pressure for the steam. In this case we are using **Saturated** steam, so we allow SysCAD to calculate the pressure for a given temperature.

- Click on the drop-down box next to the **VLEquilibrium** (Vapour-Liquid Equilibrium) parameter;
- Select the Saturated_Vap(T) option;

  Note that the P_Reqd is now greyed out, as the saturated pressure at the specified temperature is calculated by SysCAD.

- Click in the text box for **T_Reqd**;
- Type **275** and press <Enter>;

  The default engineering unit for **T_Reqd** is C.

- Click OK to update the new inputs.

You will see the composition of the stream has been set to 100% H2O(g). This was pre-set by VLE method, Saturated_Vap(T).

Exercise

- Set the Mass Flowrates, Temperatures and Compositions for all of the Feeders using the Table below.
- Click on the **DSp** tab of a Feeder to define the Species Compositions. (The default species configuration is 100% water.)

	Units	Ore_Feed	Water	Conc_Acid	Steam
FeederSinkTab	/FeederSink\VLE\DSp\Info\Links\Audit\				
Mode		MassFlow (Qm)	MassFlow (Qm)	MassFlow (Qm)	MassFlow (Qm)
FlowBasis		All	All	All	All
SpModel		Standard	Standard	Standard	Standard
QmReqd	t/h	**65**	**20**	**0**	**5**
VLEquilibrium		Off	Off	Off	**Saturated_Vap(T)**
P_Reqd	Bar	1.01	1.01	1.01	-
T_Reqd	C	**35**	**30**	**30**	**275**
DSp Tab	/FeederSink\VLE\DSp\Info\Links\Audit\				
View		Mass Frac	Mass Frac	Mass Frac	Mass Frac
SpBasis		Phase	Phase	Phase	Phase
Solids	%	**85**	**0**	**0**	**0**
Liquids	%	**15**	**100**	**100**	**0**
Vapours	%	**0**	**0**	**0**	**100**
VAPOURS					
H2O(g)	%Vap	0	0	0	**100**
LIQUIDS					
H2O(l)	%Liq	**100**	**100**	**1.7**	0
H2SO4(l)*	%Liq	0	0	**98.3**	0
SOLIDS					
CoO(s)	%Sol	**0.5**	0	0	0
Fe2O3(s)	%Sol	**30**	0	0	0
MgO(s)	%Sol	**8**	0	0	0
Na2CO3(s)	%Sol	**2**	0	0	0
NiO(s)	%Sol	**1.8**	0	0	0
SiO2(s)	%Sol	**57.7**	0	0	0

* In SysCAD the relationship between H2SO4(l) and H2SO4(aq) is set such that you cannot have less than 98.3wt.% H2SO4(l) with water. If the user enters a mass fraction for H2SO4(l) less than 98.3% then SysCAD will automatically change this to H2SO4(aq). Similarly, if the user enters a mass fraction greater than or equal to 98.3% for H2SO4(aq), then SysCAD will automatically change this to H2SO4(l).

Note this table will be referred to in later modules, **only used components are listed in this table.**

- Save the project.

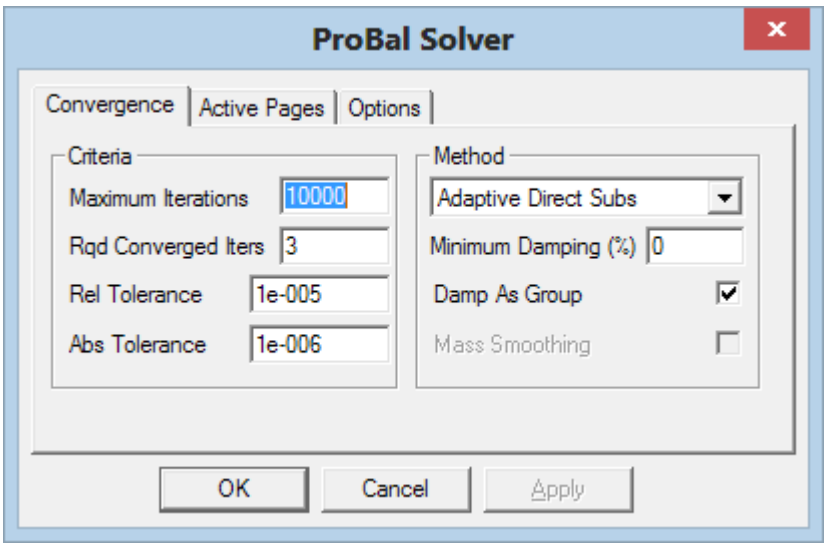
2.9. Solving a SysCAD Project

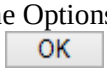
The model now contains enough information to perform a static mass and energy balance. We will now show you how to solve the project. Note at this point that all pipes in the flowsheet are a "fade" blue colour. This denotes all pipes have no flow information present. However, at the end of the following example when the project is solved, the colour of the pipes should change to blue indicating the presence of flow. We will cover more on the colour topic in the next module.

By Example

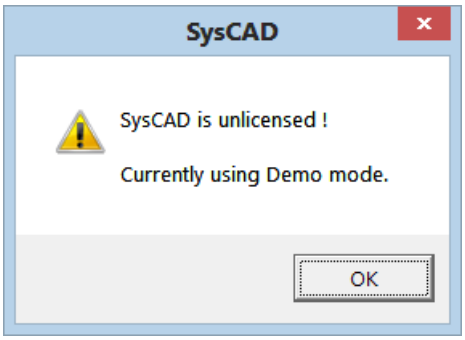
- Click on the *Graphics Window* (05_Flowsheet.scg).
- Click on the Solve Options button,  or *Project - ProBal Setup*.

  You will be presented with the **ProBal Solver** dialog box.



- On the Options page tab, tick the Keep Status Display Pinned option.
- Press  to close the solver dialog box.
- Click on  or on the **Actions** menu, select **Run**.

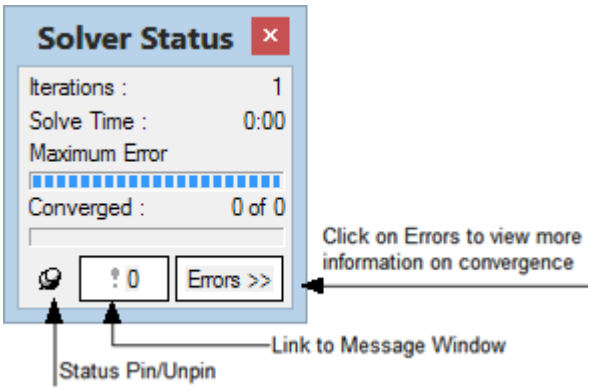
  If you are running SysCAD in Demo or Trial License mode, a little message box will appear every time Solve or Solve Go is pressed. In Demo mode, the message box is as follows:



- Click OK to close the message box.

  You will be presented with the Solution dialog box. SysCAD will now solve the model using the parameters as configured.

When the model is solved, the Maximum Error will display the word Solved.



- Click ✕ to close the Solver Status dialog box.

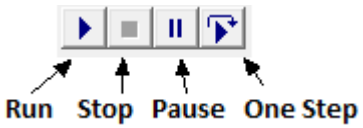
2.9.1. Observe the Changes in the Flowsheet

- Click on the *Graphics Window* (05_Flowsheet.scg).
- Click the right mouse button on the links around the flowsheet and observe the flows through the streams, the Qm or mass flow values:

  The output streams from Autoclave, P_006 and P_007, have equal flows.
  The Conc_Acid to Autoclave, P_004, remains a “fade” blue colour as it has no flow.
  Steam to Autoclave, P_005, has a different colour (the default is green) to indicate that it has vapour flowing through it.
  The output from the mixing tank, P_003, is the sum of P_001 and P_002.

2.9.2. Solve Commands

The user may click on any of the other Solve command buttons as shown below:



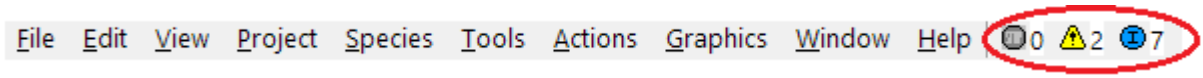
These allow the user to Run, Pause, do One Step at a time or Stop the simulation at any stage.

2.10. Message Window and Version

2.10.1. The Message Window

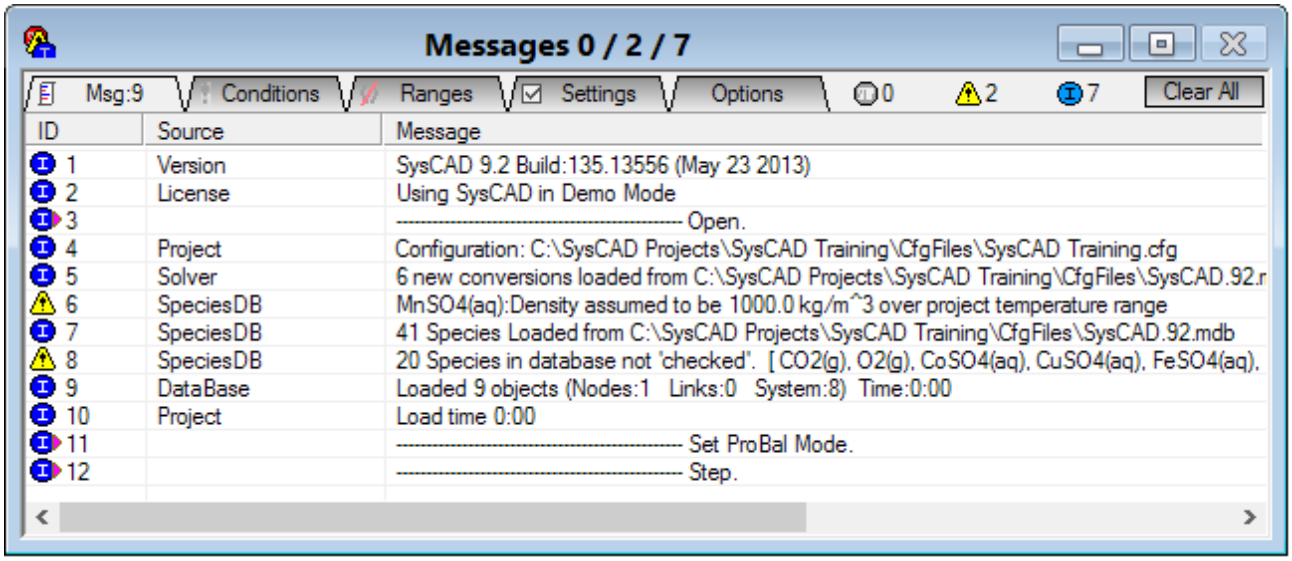
SysCAD uses the *Message Window* to display error, warning and information messages. You may access this via *View - Messages*

Or a shortcut to open the *Message Window* is to click on the "hot spot" located to the right of the menu item Help.



By Example

The window gives three types of messages: warning, information and error.



The boxes scroll up to display the latest messages as they are generated.

The message window has five tabs:

1. General **Message** Log Tab – displays general messages
2. Solver **Condition** Messages Tab – displays model or solver messages while SysCAD is running or solving
3. **Range** Check Conditions Tab – displays range check errors while SysCAD is running or solving
4. **Settings** Variation Tab – updated when SysCAD is run, these displays settings which are not recommended which may need changing
5. **Options** Tab – contains a series of options (Tick boxes)

Important features:

- Clear All button – clears all messages; by default, SysCAD will clear all message when solve is started, this option can be found on the Options Tab of the message window.
- Left double click on a message to access the source unit of the message
- Right-click to find source unit, clear tab page or copy text of message

For more information on this, please refer to *Message Window* in the documentation
http://help.syscad.net/index.php/Message_Window

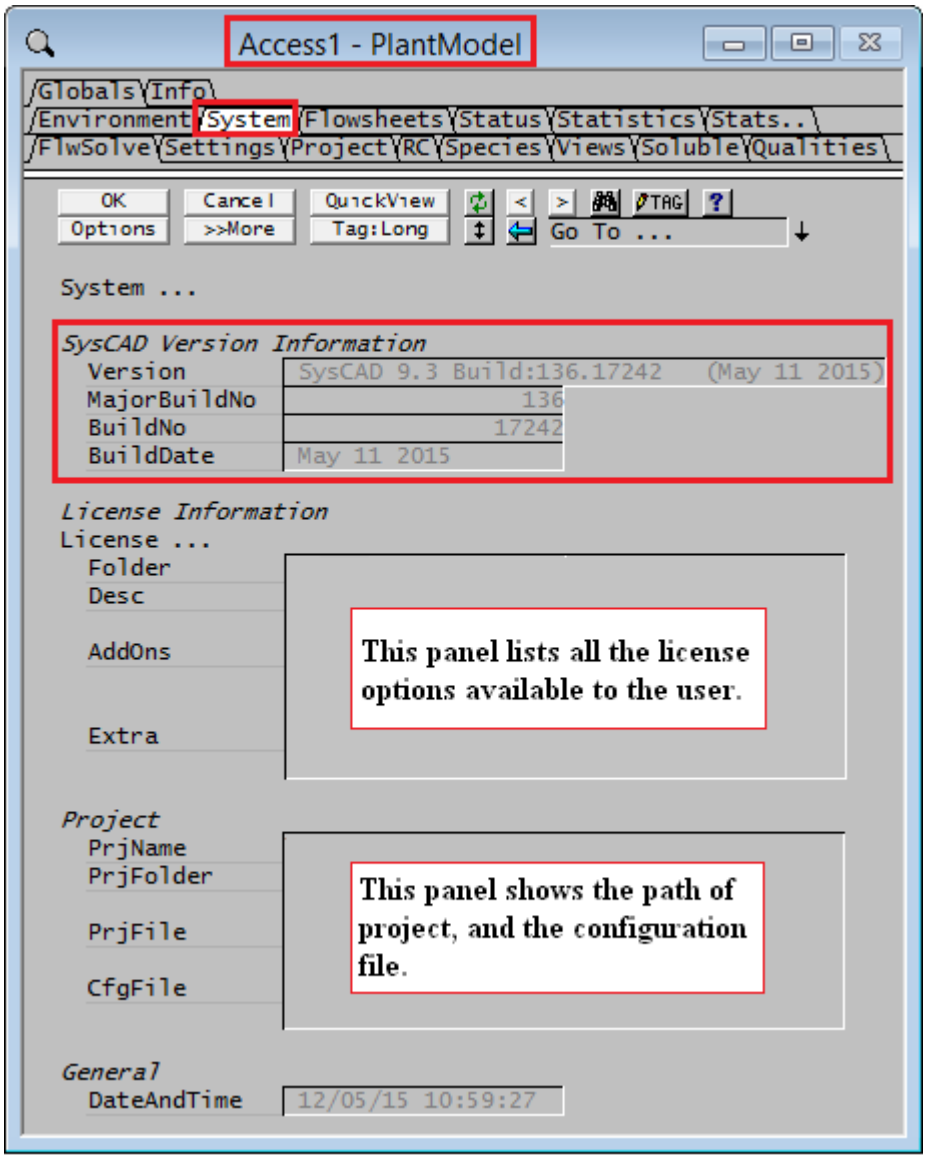
2.10.2. SysCAD Version Information

The SysCAD version is displayed at the Window Title Bar, together with the name of the project:

Test_Tut - ProBal - SysCAD 9.3 (BETA) Build 136.17242

You may also access this information via *View - PlantModel - System Tab*

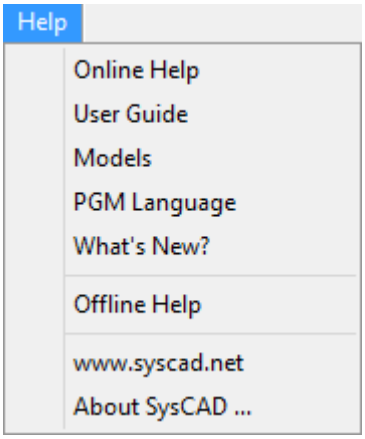
The PlantModel | System Tab displays the SysCAD version and build number. Other information displayed in this tab includes License and project information.



When asking a question of the SysCAD support team, it is always useful to quote the SysCAD version number.

2.11. Help files

The **Help** menu has the following options:



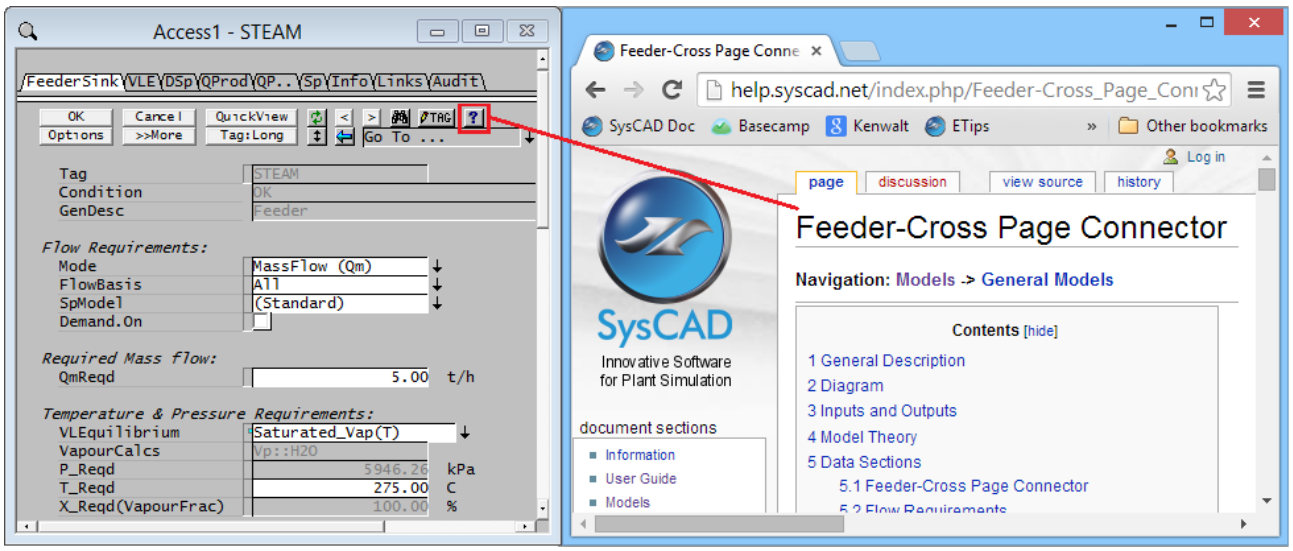
If you have access to the Internet, then the top five options will direct you to the Online help documentation.

The Help files are a valuable resource and will assist in selecting appropriate models, describing functionality and giving hints and tips.

The online help files have a search option allowing you to find the help topics of interest.

2.11.1. Unit Model Help

For SysCAD Models help, you may access online help for a specific unit model directly from the access window of the unit operation by clicking on the Mode IHe lp OR ? button.

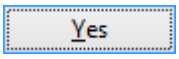


2.11.2. Offline Help

If you do not have access to the Internet at any stage, then the Offline Help will have all of the help documentation.

Please note that the offline help is not installed together with SysCAD - it is a separate install. You may download and install the latest version from the SysCAD website.

2.12. Closing a SysCAD project

- *File - Close*
- Click 

to save the project.

  SysCAD saves all the files and closes all the project related windows, leaving only the Command and *Message Window*s open.

Since a SysCAD project consists of a number of files, the Close Project command must be used to close a project.

Graphics and *Trend Window*s can be individually closed.

IMPORTANT: The user should never close any windows in a project unless they are no longer needed. If a Graphics or *Trend Window* is closed before they are saved, they will be permanently lost, if the window is closed after a save, it can be reopened by using the **File – File - Open File** command. In general, just use the minimise button to hide the window.

2.13. Review

The basic techniques in creating a SysCAD project have been covered in this module. A quick review of what we have covered so far is as follows:

- In order to create a SysCAD project, the following must be present:
  - a clearly defined scope;
  - a defined species database file; and
  - a model configuration file.
- The project can be created using the **File | New…** command.
- Once the project has been created, the SysCAD flowsheet can be drawn on a *Graphics Window* using different unit operations and connecting them together with links.
- After the flowsheet has been drawn, model configuration data must be entered before proceeding with **Solve**.
- A project can be saved at any time with the **File | Save** Command.
- To close a project, the **File | Close** command must be used.

What's to come in the following modules

In the following module we will look at how to create/edit the species database and the project configuration file.

SECTION 3

3. Project Configuration

3.1. Module overview

All SysCAD projects use the following underlying information:

- A Species Database: This stores the thermodynamic and physical data of compounds;
- The Configuration File: This allows the user to configure the following data:
  - The minimum and maximum temperature and pressure ranges;
  - A suite of unit operations. For example, for material handling projects, where energy balance is not important, a user may choose not to include heat transfer group of models;
  - Selection and customised display of compounds used in the project.

In Section 2 we used a pre-defined database and project configuration file (with extension cfg) to create the project. In this module, we will take a look at how to modify these files to include some additional data.

3.2. Location of Database and Configuration file

When SysCAD is installed a default SysCAD Species Database (Default.93.db3) is stored in the folder \SysCAD93\Basefiles. This is the main database file SysCAD looks for while building and solving SysCAD projects. This file MUST NOT be deleted or renamed.

When a new project group is created in SysCAD a SysCAD.93.db3 file is created and stored in the …\"project group"\CfgFiles folder for project use. The purpose of this file is to store project specific data.

|__*SysCAD Projects*
  |__ *SysCAD Training*
    |__ ***Cfgfiles***
    - ***SysCAD Training.cfg*** *(this is the project configuration file)*
    - ***SysCAD.93.db3*** *(this is the project species database file)*

3.3. Editing Configuration

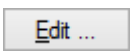
In the following example we will edit the configuration file to include the new compound CO(g).

By Example

- Open SysCAD and make sure all projects are closed;
- *Edit - Project Configuration* (OR );

  This will bring up the **Project Configurations** dialog box. Make sure the correct configuration file is highlighted:

  C:\SysCAD Projects\SysCAD Training\CfgFiles\SysCAD Training.cfg

- Press the 

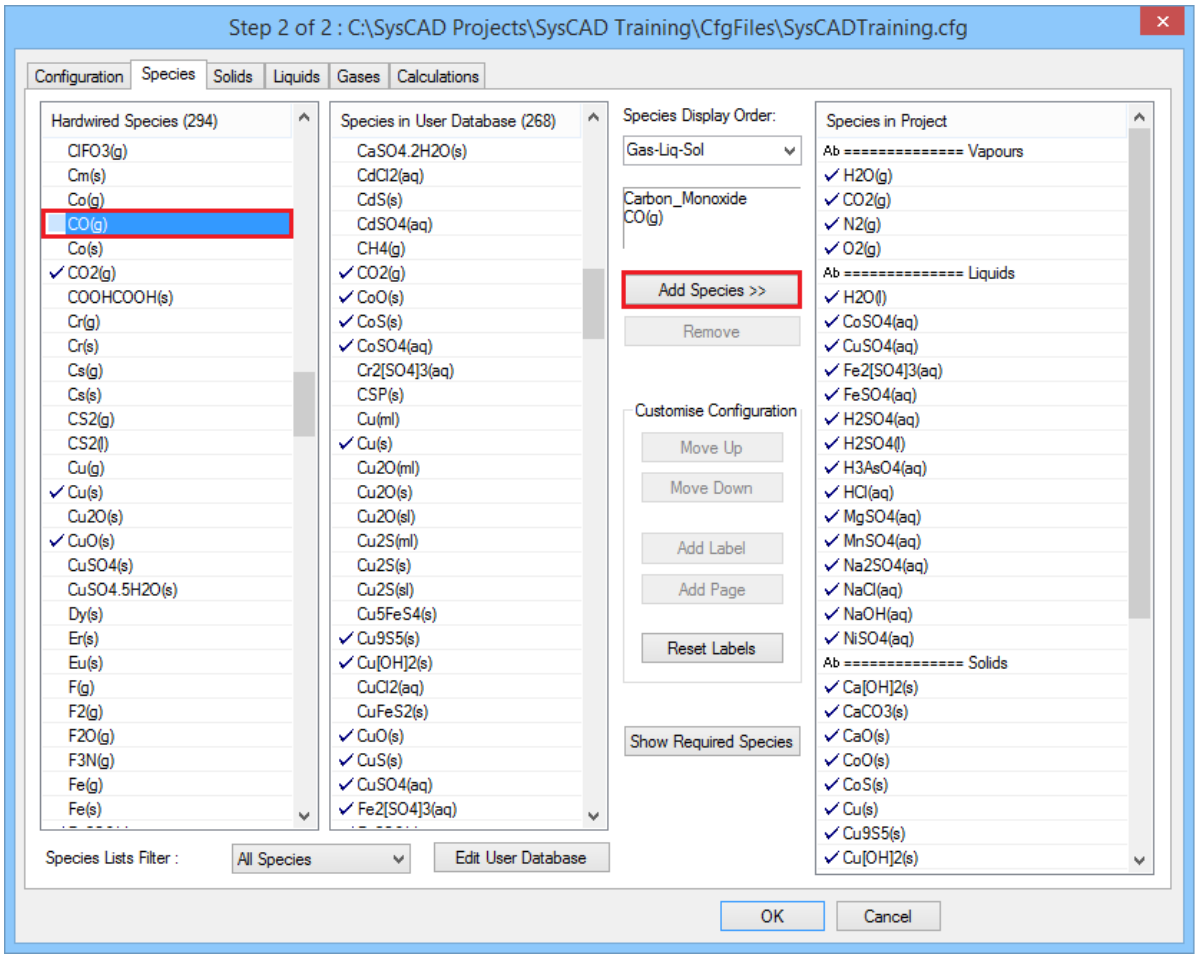
button to open the Configuration File editor;

  Step 1 of 2: A dialog box with list of models for selection will be displayed. The user may include any new models or switch on/off models that are needed/no longer used.

- Click on the Next >>> button;

  Step 2 of 2: This will open the Configuration dialog box. The number of tab pages will differ based on the models selected in Step 1.

- Click on the **Species Tab**,
  User can choose species from either the SysCAD Hardwired Species or Species in the User Database. In this exercise we will add a compound that has already been defined in the SysCAD Hardwired List.
- On the *Hardwired Species* Column, click on CO(g);
- Press Add Species >>.



The compound CO(g) will be added to the **User Database** and the **Species in Project** list.

Notes:

1. The user can select an option from the **Order** section on the right hand side of the dialog box to sort the compounds automatically; or
2. Choose any of the **Custom** options to order the list manually by using the Move Up and Move Down buttons.

- Please keep this dialog box **OPEN** for the next section.

3.4. SysCAD Species Database

3.4.1. Opening and Editing the Project SysCAD Database

If the required compounds are not yet defined, we can add the compound into the Species Database. In this example, we would like to create a compound to represent some undefined "impurities" in the solids. We can call this compound "MUD".

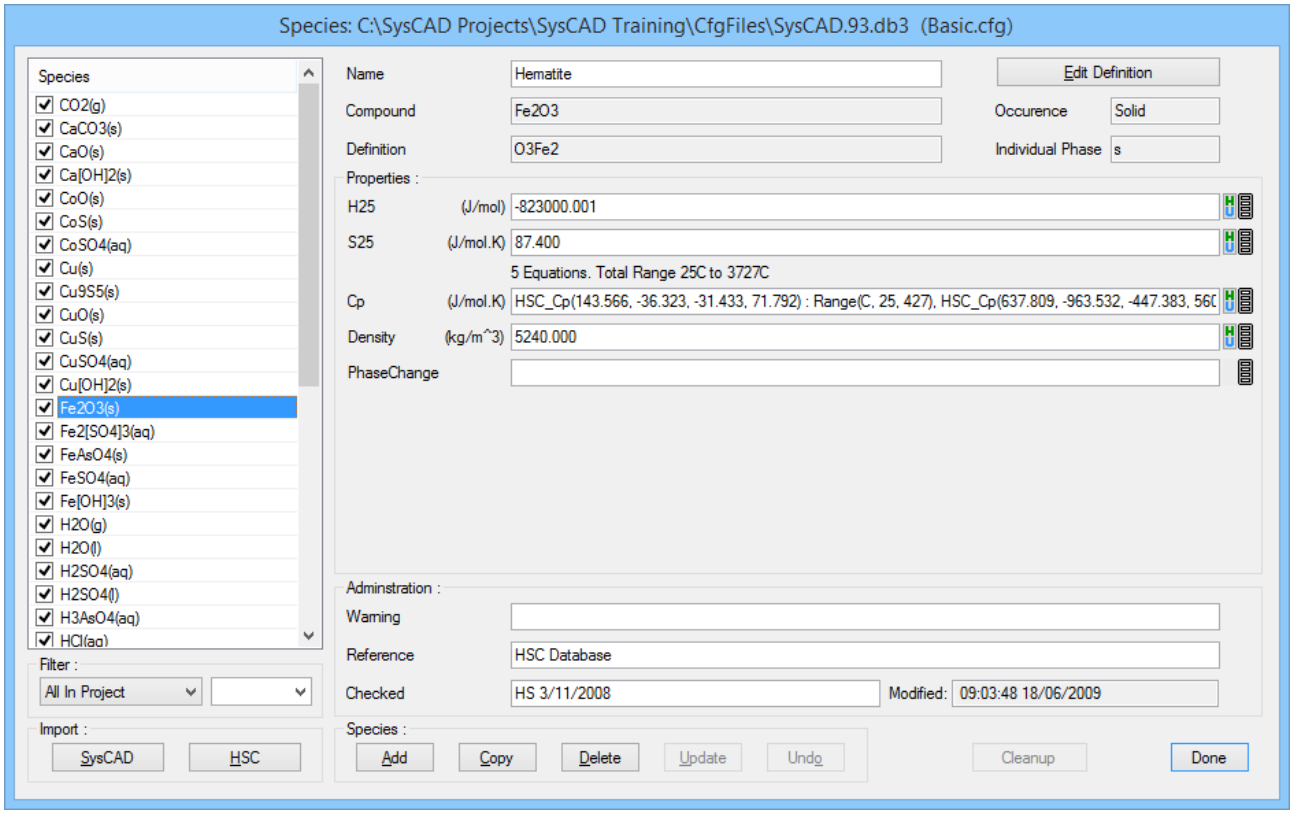
By Example

- We should still be on the ***Step 2 of 2 of Edit Configuration*** dialog box, if not please repeat the steps listed in Section 3.3;
- Press the Edit User Database button.

This will open the species database associated with this configuration file which is:

C:\SysCAD Projects\SysCAD Training\CfgFiles\SysCAD.93.db3

The species displayed with a tick are included in the species list in the SysCAD Training cfg file.



You can import data for a species from any other SysCAD database by pressing the SysCAD button, or import from the HSC Chemistry database by pressing the HSC button.

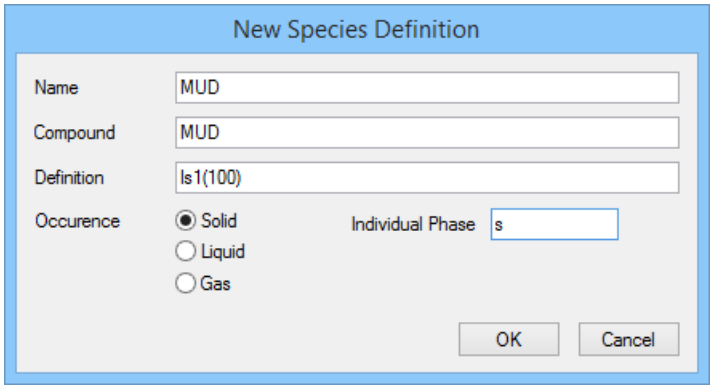
For more information on importing or other information on editing the database, please refer to http://help.syscad.net/index.php/Editing_User_Species_Database_9.3,

3.4.2. Adding a new chemical compound

You can add a new Species by either clicking on the Add or Copy buttons.

By Example

- Press the Add button.
- Press the Define New Species button.
- Type in the new Name, Compound, Definition, Occurrence and Individual Phase of the new compound as shown below:

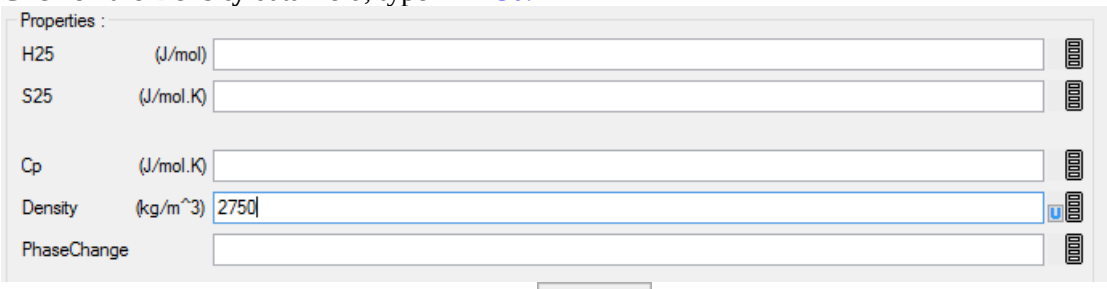


In the definition, notice we have used "Is" as an element. This is NOT a real element, we use this to define compounds with unknown composition. The number 1 after "Is" means 1 count of "Is" in this compound and the number in brackets (100) means it has an artificial molecular weight of 100.

- Press the OK button.

The compound is added and we can enter extra data if available. In this case, let's add in a density value.

- Click on the **Density** data field, type in 2750.



- If you are happy with the existing data, Press Update to add the new data to the database. (If you wish to undo the changes made, press Undo.)
- Click Done when you have finished.
- This will return to the ***Step 2 of 2 of Edit Configuration*** dialog box.
- Find and select MUD(s) from the **Species in user Database** Column
- Press Add Species >> to add this to the Species in project List.
- Press the OK button to finalise the Edit Database and Project Configuration.
- Open the SysCAD project you have been working on in section 2 and check that the two new compounds are now available in the project.

For more help on how to edit the species database, please see:
http://help.syscad.net/index.php/Editing_User_Species_Database_9.3

3.5. Viewing Species Properties

The Species Properties window allows the user to view various properties of the compounds used in the project. Information such as the enthalpy, heat capacity, density etc. can be obtained via this *Access Window* (refer to http://help.syscad.net/index.php/Species_Properties_($SDB)_9.3)

By example:

- *Species - View Properties*

Common User input fields and buttons found on various tabs:

- Mass Basis Tickbox: if this option is not selected, the values specified will be on a molar basis.
- T, P – species properties are calculated at the user defined temperature and pressure.
- SoluteMF - Used to calculate properties such as heat of dilution, density correction.
- SpeciesTag – This toggles the compound name between Species:Long (common name – eg. SulphuricAcid) and Species:Short (chemical form H2SO4) ;
- CopyToClipboard – Species Configuration this will make a copy of the Species Properties Data to the clipboard, where you may manually paste them into packages such as MS Excel;
- Species Properties Reports – Species Properties This reporting function can export selected Species Property Data to the clipboard, where you may copy the data to other software packages, such as MS Excel, for analysis. This is useful for fitting equations or for data validation. Please refer to http://help.syscad.net/index.php/Species_Properties_Reports for more information.

FS_SDB Tab:

This tab displays the species count in the project.

Thermo1 and Thermo2 Tabs:

These two tabs display thermodynamic properties at the temperature and pressure specified. The enthalpy of any species with heat of dilution defined (e.g. H2SO4(aq)), will be calculated at the HtDilnMF specified.

Vapours Tab:

This tab displays the density, vapour pressure, vapour temperature and ratio of Cp to Cv for all vapour species in the project.

Liquids Tab:

This tab displays the density, corrected density (for aqueous species with a density correction function), boiling point elevation (BPE), solubility and negative Log H for all liquid species in the project. All of these properties except density are solute fraction dependent properties which are calculated at the specified SoluteMF.

Solids Tab:

This tab displays the density for all solid species in the project.

Definition Tab:

This tab displays the elemental definition, molecular weight, Charge, Equivalent Weight and species index for all species in the project.

Properties Tab:

This tab page displays the source of data for each property for each species in the project. Most sources of data are either 'User' (entered by user in Species Database) or hard-wired data (reference displayed).

Other Tab:

This tab displays the symbol (compound), tag (name), occurrence and individual phase for all species in the project.

Elements Tab:

AllElelements Tick box: by default, this is not selected and the project only shows the elements in used on the Elements tab. If selected, then the full periodic table will be shown.

The molecular weights of the elements are displayed here for user information.

Components Tab:

This tab page displays the Elemental definition, Molecular Weight, Species Count (how many species match this component) and index for the component used in SysCAD.

3.6. Review

This topic briefly explains how to edit the database and configuration files. For more information on editing the Species Database file and Model Configuration file, please refer to
http://help.syscad.net/index.php/Editing_User_Species_Database_9.3,
http://help.syscad.net/index.php/Species_Configuration_9.3 and
http://help.syscad.net/index.php/Species_Properties_Configuration_9.3

What's to come in the following module:

In the following module, we will look at how to use the Access Windows and related features.

SECTION 4

4. Access Window & Quick View

4.1. Module overview

The *Access Window* displays the model information, including input and calculated variables, as well as some SysCAD solver information.

In this module:

- You will learn the various functions associated with the *Access Window*; and
- Add configuration data for the various unit operations.

Note:

The *Access Window* is permanently opened - the user may minimise the window if required.

The *Access Window* can only display data for a single SysCAD unit operation at any one time.

A second *Access Window* can be opened at the same time by holding Shift and the right mouse button.

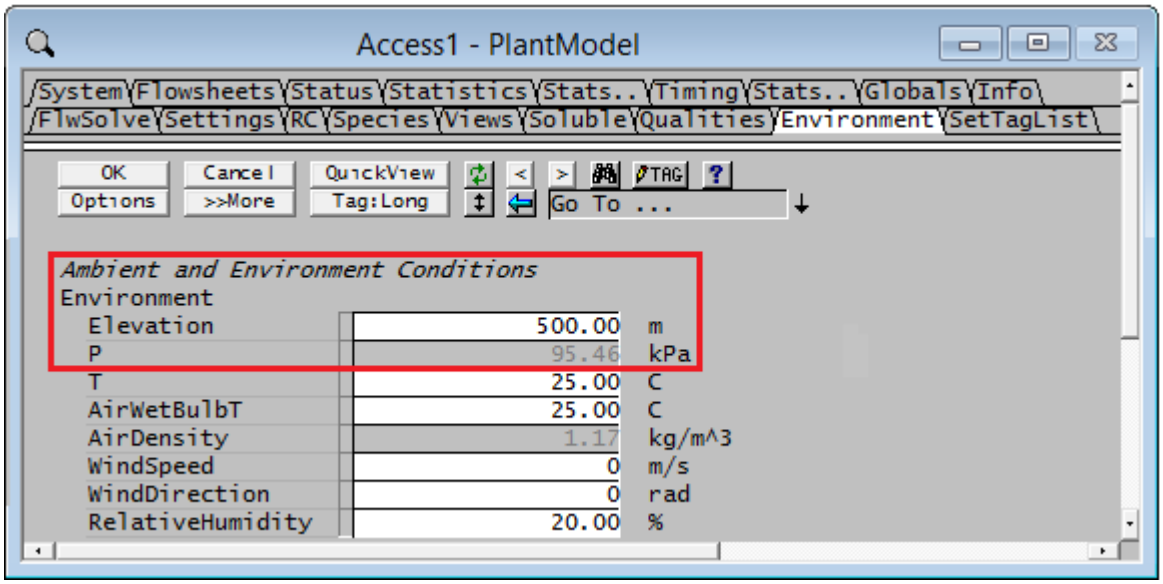
4.2. Project Environment Global Data

We can view and change global project settings such as elevation, wet bulb temperature, relative humidity etc. These values may be used by SysCAD for selected unit operations or calculations.

The atmospheric pressure is affected by elevation. The default setting in SysCAD is 0 metres (sea level). For projects set at higher altitudes, simply change the *Elevation* on the *Environment* tab. SysCAD will re-calculate the atmospheric pressure (P) based on the defined elevation.

By Example

➢ *View - PlantModel - Environment Tab*



➢ For the purpose of this tutorial, keep the Elevation = **0** meters, so that atmospheric pressure is **101.325** kPa abs.

4.3. Configure the unit operations

In SysCAD, when the *Graphics Window* is activated, right clicking on a unit operation will load an *Access Window* for that unit operation.

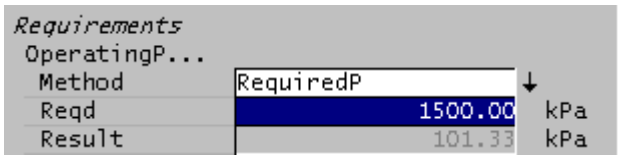
For each unit operation the *Access Window* will display different fields for different mathematical models. For more information on the individual models and how to use them, please refer to the models help file. (http://help.syscad.net/index.php/Models)

4.3.1. Setting Pressure (if Required)

Recall in Section 2 we learned how to configure the Feeder. In this section, we will configure the Tank model.

By Example

- Open project, Tut_Test1, or the Tutorial\T1 Basic\Basic.02(Creating a SysCAD Project).spf;
- Right click on the **Autoclave;**
- Click on the **Tank-1** Tab page;
- Go to OperatingP – Method;
- Choose the 'RequiredP' (Required Pressure) Method;
- Enter a required pressure of **1500** kPa;
- Click OK.



Note: "Result" is a calculation field; it is only calculated after SysCAD has started solving.

Some General Notes about Data Field Access:

- The Data Fields that appear in **White are changeable** and user inputs are normally required. These fields can be number boxes, text boxes with or without pull down lists or check boxes. All required fields come with default values. The SysCAD Models Documentation offers more help on Data input for individual models.
- The Data Fields that appear in **Grey are NOT changeable by the user**. These fields are calculated by SysCAD internally.
- Some Data Fields can only be changed when SysCAD is not solving. Therefore, when a flowsheet is solving, some originally changeable data fields may be greyed out. Examples are solving methods or unit operation on/off.
- Most Data Fields can be copied and pasted into trends, Controllers, MS Excel, etc. using the <Ctrl + T> and <Ctrl + V> key strokes. Note that multiple fields can be copied at a time. (For more information, please refer to http://help.syscad.net/index.php/Copy_and_Paste)

4.3.2. Switching on VLE Sub Models

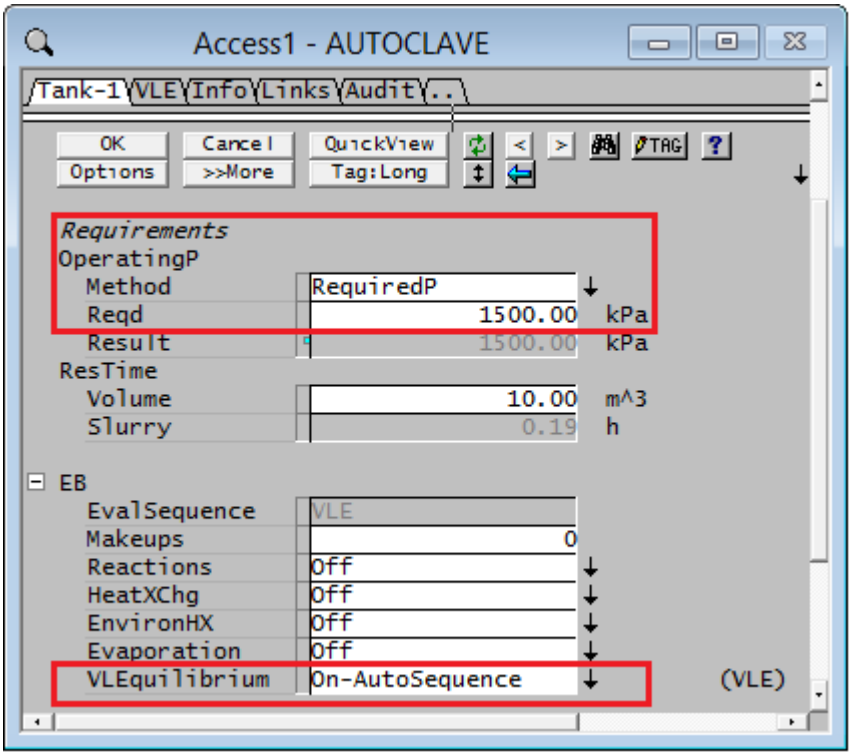
In this project, we are adding steam to the HP Autoclave (Tank-1 Model). In this model, if no sub models are turned on, it will act purely as a mixing tank. Therefore, all inputs will be added together with no change in phase and leave the system as a mixture of steam / water.

This is of course not the correct behaviour. To correct for this, you may use either:

- Add a VLEquilibrium (Vapour Liquid Equilibrium) sub model to let SysCAD work out the quality of steam/water; or
- Write a Chemical reaction to convert the Steam to Water. (This uses the Reaction Sub model which will be covered in the next section, Adding Chemical Reactions.)

By Example

- Right click on **Autoclave** to bring up the *Access Window;*
- On the **Tank-1** Tab, select VLEquilibrium to be **On - AutoSequence**.



SysCAD will auto calculate the quality of the steam when the project is solved.

- **Solve** this project now;
- Take note of P_007 leaving the Autoclave, observe its change of composition and temperature.

Note: The user may set the sequence of the sub-models in a unit, or use the AutoSequence option, in which case SysCAD will set any sub-models that have been enabled in the following order:

1. Makeup Blocks,
2. Reaction Block,
3. Environmental Heat Exchange,
4. Evaporation Block, and
5. Vapour-Liquid Equilibrium.

(We will cover Reactions in Section 5 and the other sub-models in Section 11.)

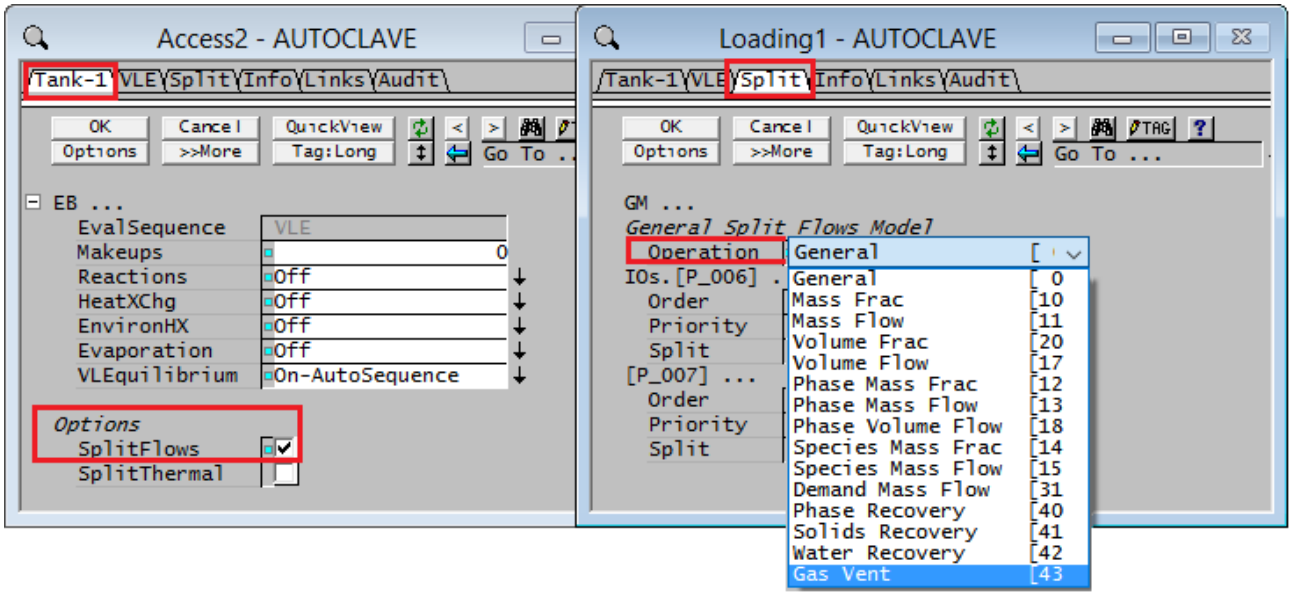
4.3.3. Configuring a Splitter

The Tank unit operation model will allow multiple inlets and outlets. When a tank unit operation has multiple outlets the default behaviour is to split the flow equally between the outlet streams. If this is NOT the required behaviour, then the user must specify how to distribute the output streams using the Splitter sub-model.

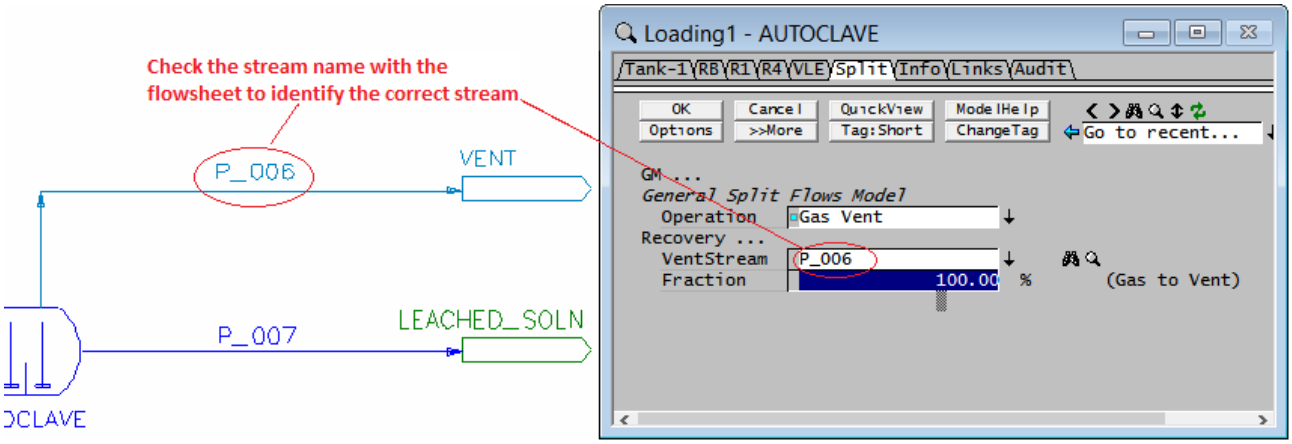
The Autoclave in our example has two outputs: *Vent* and *Leached_Soln*. One way to split these two streams is to use phase split.

By Example

- Right click on **Autoclave** to bring up the *Access Window;*
- On the **Tank-1** Tab, tick the **SplitFlows** checkbox – this creates a new tab, **Split**, in the access window;



- Click on the new **Split** tab page;
- Select **Gas Vent** for the **Operation** as shown above;
- Select the correct pipe to represent the **VentStream**. In this case, it is P_006.
- Type in 100% for **Fraction** of Gas to Vent;
- Click OK.



- **Solve** the project and observe the results.

Some Notes about the General split flow Model:

- You cannot set the flow from ALL streams leaving a unit (with one exception, see http://help.syscad.net/index.php/General_Model_(GM)#OPERATION_-_Demand_MassFlow for more

information); one stream must be 'free' to allow the flows to balance. This will always be the stream at the bottom of the list – stream P_007 in the above diagram. To move the position of a stream in the list, change the priority of the stream, as shown above.

- SysCAD sets the flows in the exiting streams sequentially – so it will first try to satisfy the required flow in the first stream, then the second stream and so on down the stream order.
- You may split the flow from the unit based on Mass Flow or Fraction, Volume Flow or Fraction, by Phase or by individual species. You accomplish this by setting the 'Operation' type.
- For multiple outlets, you may use the **Priority** field to change the order of pipe outlets. The Pipe that will take the balance flow should be the one with the largest **Order** number (lowest priority).
- If you leave Operation = 'General', you may split the flow to each stream using a different method. For example, if you have 4 streams exiting a unit you may set the splitter up as follows:
    - Operation = 'General'
    - Stream 1, Priority 1: Mode = 'PhaseSplit', Solid and Liquid splits = 0%, Vapour = 100%;
    - Stream 2, Priority 2: Mode = 'MassFlow', Flow required = 20t/h;
    - Stream 3, Priority 3: Mode = 'PercSplit', Split = 25%;
    - Stream 4, Priority 'Auto'. No configuration.
- When you solve the project the streams will be split as follows:
    - All of the vapour will exit in Stream 1, with no solids or liquids;
    - 20t/h of the remaining material will exit in Stream 2 – so this stream will only contain solids and liquids. If the flow < 20t/h, then all of the flow will exit in Stream 2 and the user will receive a warning that there is insufficient flow to satisfy the requirement;
    - 25% of the remaining flow will exit in Stream 3;
    - All remaining material exits in Stream 4.

4.4. Access Window Options

4.4.1. Displaying all fields

Many of the internal SysCAD calculation data can be viewed in the *Access Window*. However, to keep the display window relatively simple, many of the variables have been hidden. To display more or less variables, use the >>More <<Less buttons.

- Open the *Access Window* for the Steam Feeder;
- Click on >>More.

  Fields marked by ✕ denotes normally hidden.
- Browse through the other Tab pages and familiarise yourself with the available fields if necessary.

4.4.2. Include / Remove Variable groups

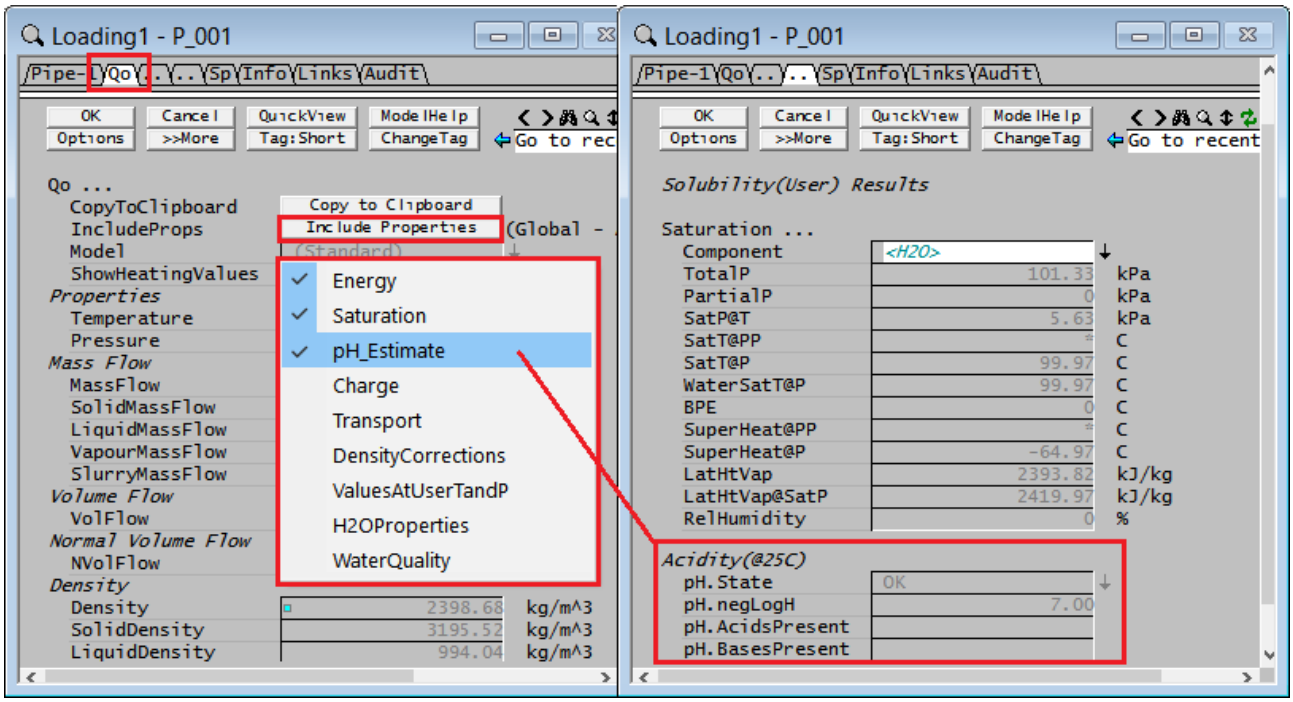
SysCAD allows users to include or remove groups of data from the *Access Window*. These variable selections will affect what is shown on the *Access Window* for all pipes and contents.

For example, if the user wishes to view the pH Estimate values for a stream, then the *pH_Estimate* Option must be selected.

By Example

- On the *Access Window* of a *Pipe*, go to the *Qo Tab*;
- Click the Include Properties button and tick the *pH_Estimate* option.

The Acidity section will be visible on the *Qo* Tab of all pipes, as shown below:



For any new project created, the user should check if the variable group of interest is included.

NOTE: The property group selection can also be done via the *View* | *PlantModel* | *Views* Tab page.

4.4.3. Hiding Zeros

When we create a SysCAD project model we include all chemical compounds required for all of the different sections of the plant. This often results in a long list of chemical compounds on the Access Window and not all compounds are present in all sections of the project model and hence have values of Zero.

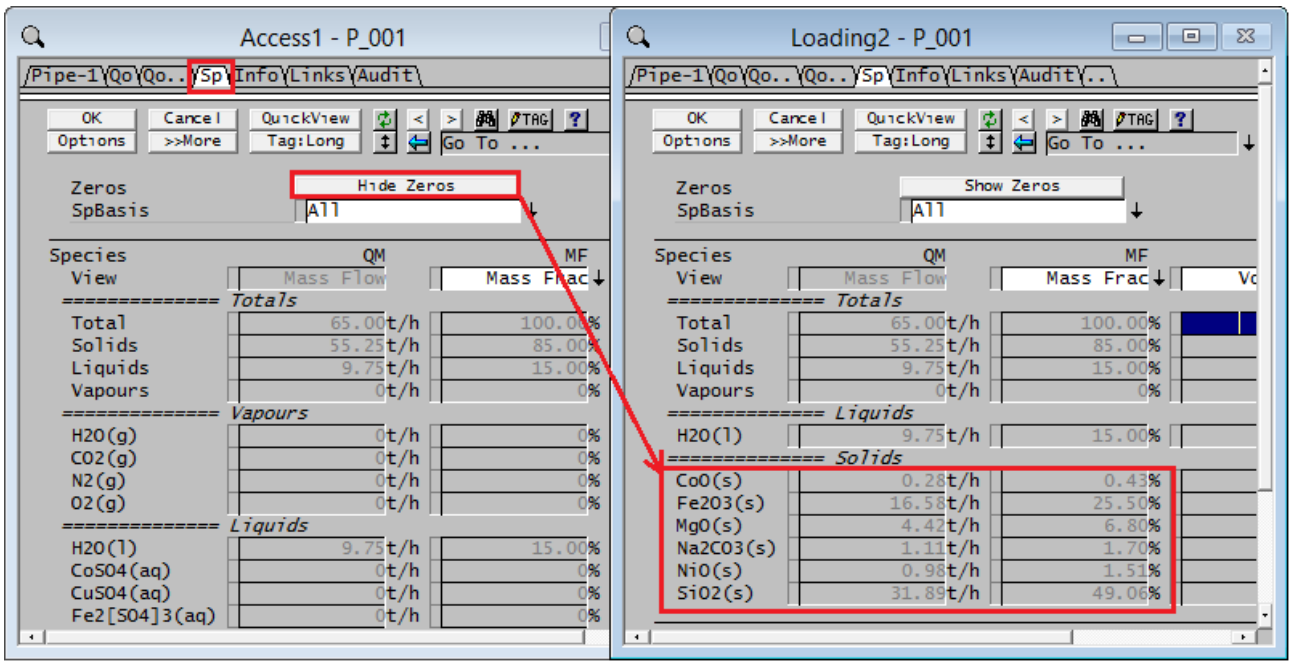
To overcome this, we can use the **Hide_Zeros** option.

Note:

The **Hide Zeros** is a global option: it applies to ALL pipes and other unit operations with contents. However, it will NOT be applied to unit operations used to SET the component compositions such as FEEDERS.

By Example

- Right Click on P_001;
- Select the Sp tab;
- Press the Hide Zeros button.



You will find the list is shortened to show only those components with flow.

- Click on the Show Zeros button if you wish to display all compounds again.

4.4.4. Refresh the Access Window Display

The button refreshes the Access Window. It is useful during solve as it updates the data every time the button is pressed.

4.4.5. Browsing the Graphics Window



From the Access Window, you can use the ‹ and › (browse left and browse right) buttons to follow the flow of material through the drawn flowsheet, making it a useful tracking tool.

By Example

- Arrange your SysCAD screen so that you can see both the *Graphics Window* and the *Access Window*;
- Right click on **Steam** on the *Graphics Window*;

  The Steam graphics turns magenta and the *Access Window* displays the Steam model.

- On the *Access Window*, press on ›;

  Notice the active unit is now P_005 on both the Graphics and *Access Window*.

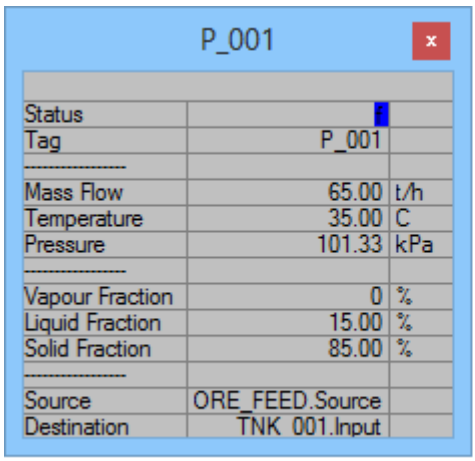
- Press on › again. The Active unit is now Autoclave;
- Press › once more. Because Autoclave has two outlets, you have to nominate which outlet to follow;
- Click on Liquor: P_007 and follow through to Leached_Soln.

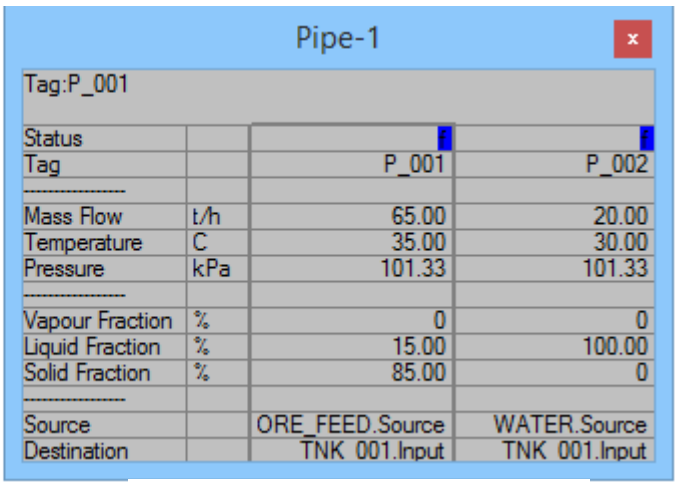
4.5. Quick View

So far, we have tracked the stream flow information from the Access Window only. Another quicker option to track stream flow is to use Quick View.

By Example

- Click and hold down the left mouse button on any pipe
- To pin the *Access Window* press Ctrl + **left click**. (shown below, left image)
- To view more than one unit on a quick-view list press Shift+Ctrl+**left click** on a number of pipes. (shown below, right image)





Pin to Window

Ctrl + **left click**

Pin to Window Multiple

Shift+Ctrl + **left click**

4.5.1. Creating a Customised Quick View List

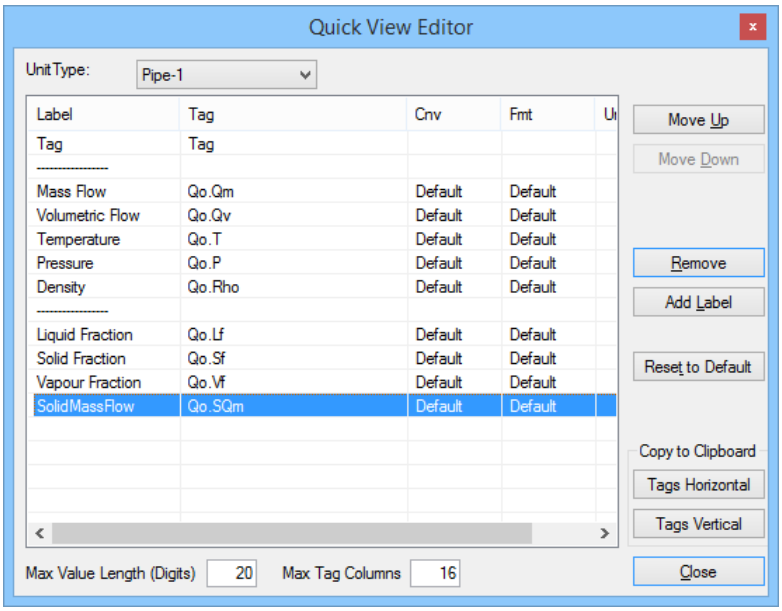
The quick view list is fully customisable by the user.

To add the variable SolidsMassFlow (SQm) to the Quick View list:

- Right click a pipe to display the *Access Window*;
- On Qo Tab, right click variable SolidsMassFlow (SQm);
- Choose **Send to Quick View** (or F6),
    - This will open the Quick View Editor with Qo.SQm added to the bottom of the list. On the access window, a small blue square ▫ will appear to the left of the variable;

You may edit a variable in the Quick View Editor as follows:

1. Use the Move Up and Move Down buttons to order the variable list.
2. Remove the variable from the list using the Remove button.
3. Right click on the label to change the conversion (engineering units) and format of the number.
4. Add a heading line by pressing the Add Label button. Left click on the label to rename.
5. Press the Reset to Default button to reset the Quick View parameters back to the default.
6. To use this list of variables as a template for an excel report, press the buttons under "Copy to Clipboard" . (This is described further in Section 11.)



The quick view information will be stored in a file in the project group C**fgFiles** folder, so that the Quick View list will be the same for all projects in the project group.

Exercise

- Fill the quick view list with a selection of variables from any tab page for a pipe. (We recommend adding GeneralDescription(GenDesc) and some elemental concentration values in preparation for excel report in Section 11).

To access the Quick View Editor directly:

- Either use *Edit - Quick View* and select 'Pipe' as the Model Type, or
- Right click a pipe to display the *Access Window*, and click on the QuickView button.

NOTE:

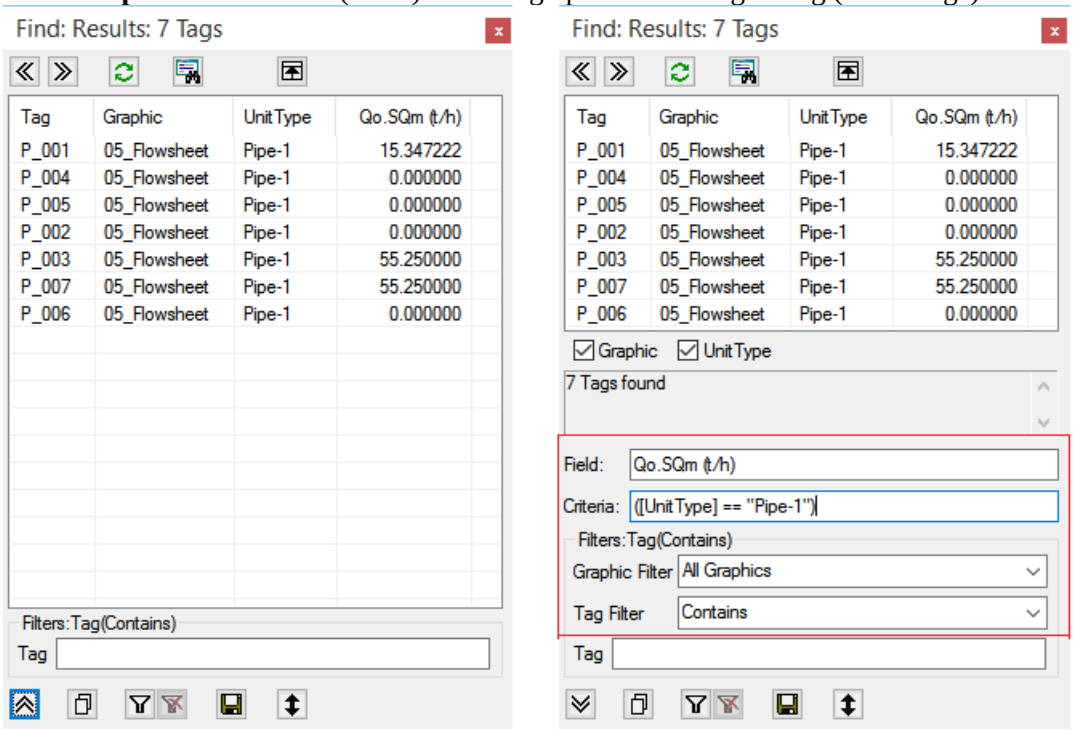
Each model type has its own quick view list. That is, unit operation Feeder and unit operation Pipe will have different quick view lists. The user can customise these lists to suit their individual preference.

4.6. Find Results

Quick view as shown above is good for showing groups of variable for multiple unit operations, if the user wishes to see a single variable for multiple units, then Find (with Query) may be used.

By Example

- Right click a pipe to display the *Access Window*;
- On Qo Tab, right click variable SolidsMassFlow (SQm);
- Choose **Open Find Results** (or F8) will bring up the following dialog (Left image):

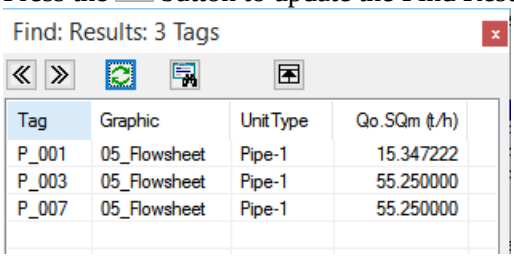


- SysCAD will find and list all the unit operation containing the variable you have clicked on.
- Clicking on the column heading can sort the list, in this example the list is sorted by Tag.
- User can use SQL Query to add criteria to the Find function to narrow down the list.

- Click on the  icon on the above dialog to bring up the query input pane (Right image)

  - The query input pane includes Criteria and filters. We will change the criteria to display only pipes with solids flowrate > 0.001 t/h.

- Change the Criteria to **([UnitType] == "Pipe-1") AND Qo.SQm (t/h) > 0.001**
- Press the  button to update the Find Results.



- The results list will be updated to show only 3 pipes.
- For more information on **Find** function including how to report the results, please see: http://help.syscad.net/index.php/Find_Units_using_Query

4.7. Review

In this module, we have configured tanks and examined some general features of the *Access Window* and we have noted that:

- The mathematical model data for a unit operation can be accessed from the *Access Window*.
- Each unit operation model will have a different *Access Window*, displaying different fields for different mathematical models.
- The *Access Window* is permanently open. The user may minimise the window if required.
- Two *Access Windows* may be open at any one time;
- During solve, the information on the *Access Window* is not updated, the refresh button  can be pressed to update the screen as required;
- Some *Access Window* views can be customised to suit the user.
- The Quick View List can be customised from the *Access Window*.
- Find Results can be used to search for unit operations matching some criteria, and display the results on the screen.

SECTION 5

5. Chemical Reactions

5.1. Module overview

Chemical reactions are defined in a text file in a balanced stoichiometric format. This text file can be created and edited using the SysCAD Reaction Editor or any text editor (e.g. Notepad++, UltraEdit). Parameters of the reactions are specified in the text file. These parameters can include heat of reaction, extent of reaction, reaction selectivity and reference temperature. Many unit models in SysCAD allow the user to include Reactions.

The syntax of the reaction file (with examples) is given in detail in the following Help area:

http://help.syscad.net/index.php/Reaction_Block_(RB)

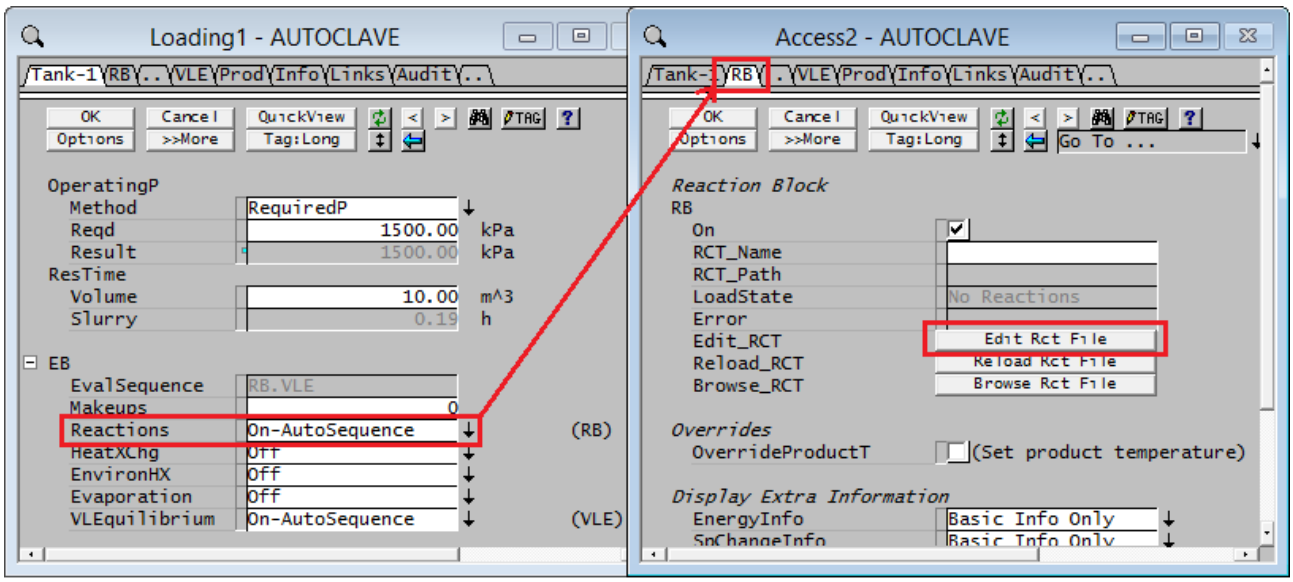
In this module, you will learn to add chemical reactions to the Autoclave using the SysCAD Reaction Editor.

- Open Tut_Test1 or the Tutorial\T1 Basic\Basic.04(VLE and GM Split).spf;
- Select the Graphics Window.

5.2. Switching on the Reaction sub model

By Example

- Right click on the **Autoclave;**
- Select Reactions – On-AutoSequence;
    - A new tab page **RB** will appear, as shown below:



- Click the "**Edit Rct File**" button to create a new reaction file.

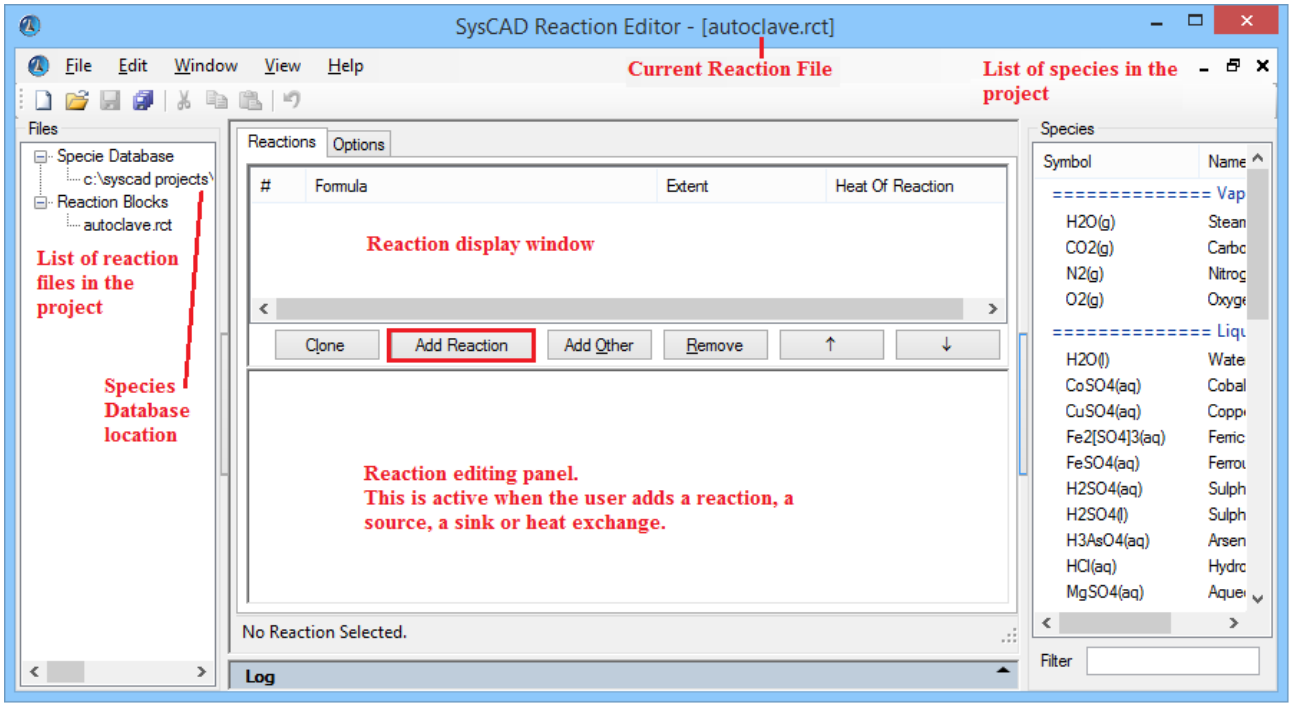
  The Reaction Editor will load the current list of species from the SpecieData.ini file and create a blank reaction file called Autoclave.rct as shown in the next section.

Notes:

1. You do not have to change the selection for VLEquilibrium, as the Auto Sequence will ensure that reactions are performed prior to VLEquilibrium, as shown by **EvalSeq**.
2. If you wanted the VLEquilibrium to occur BEFORE the Reactions, you could change Reactions to *On-Sequence2* and VLEquilibrium to *On - Sequence1*.
3. The reaction file name defaults to the tag name of the Unit Operation if the RCT_Name is left blank.
4. Otherwise the user may type in a name for the reaction file first, then press the Edit_RCT button.
5. If the required reaction file already exists, then press the 'Browse' button and browse to the required reaction file.

5.3. Adding a Reaction using the SysCAD Reaction Editor

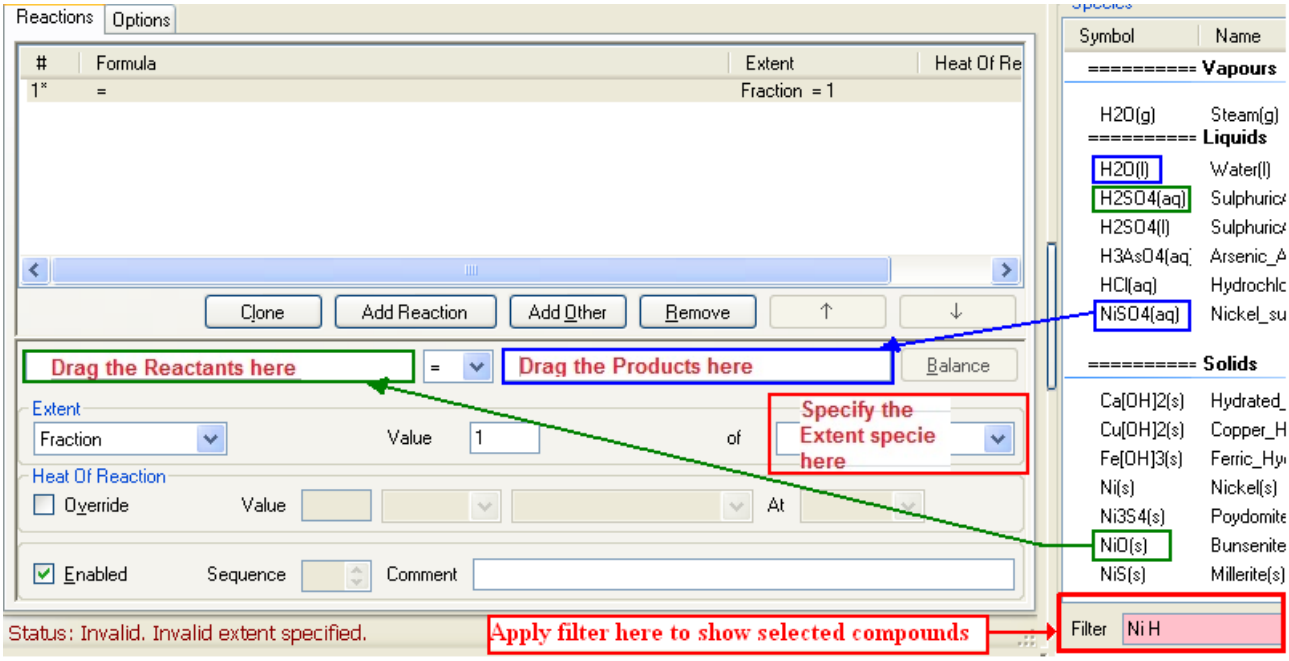
The previous commands will start up the *SysCAD Reaction Editor*, as shown below:
(If the SysCAD Reaction Editor does NOT start, please see http://help.syscad.net/index.php/Reaction_Editor for details on how to install it and set it as the default reaction editor.)



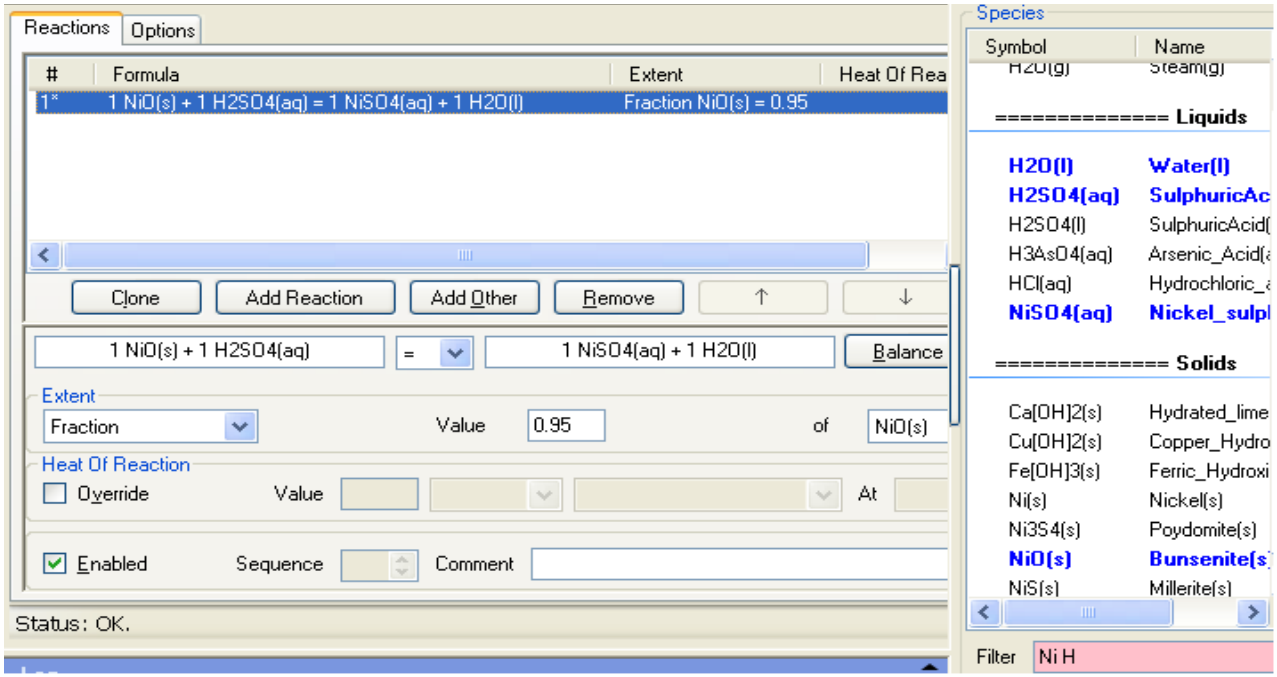
➢ We will add the first reaction from Table 5.1:

$NiO(s) + H_2SO_4(aq) = NiSO_4(aq) + H_2O(l)$ Extent: Fraction NiO(s) = 0.95

- Click on the 'Add Reaction' button in the reaction window



- Select **NiO(s)** from the list of species on the right and drag it into the **Reactants** box;
- Drag and drop **H2SO4(aq)** into the reactants box;
- Select **NiSO4(aq),** drag it into the products box;
- Drag and drop **H2O(l)** into the products box;
- Click on the 'Balance' button to ensure that the reaction is balanced;
- Use **Fraction Extent**, which is the default selection;
- You may set the extent to 0.95 (or leave it at 1 and change it in the SysCAD Access window after loading the reaction file into the Autoclave);
- Set the extent species as **NiO(s)** (select from the drop down menu);
    - Do NOT tick the Override function for **Heat of Reaction** - we will allow SysCAD to calculate the Heat of Reaction (HOR) based on the Heats of Formation and Specific Heats (Cp values) in the species database.



- Carry out the above process for the remaining 3 reactions.

  All of the reactions are shown in the table below:

Table 5-1 - Autoclave Reactions

Reaction	Reactants		Products	Extent		
				Type	Species	Value
1	NiO(s) + H2SO4(aq)	=	NiSO4(aq) + H2O(l)	Fraction	NiO(s)	0.95
2	CoO(s) + H2SO4(aq)	=	CoSO4(aq) + H2O(l)	Fraction	CoO(s)	0.95
3	MgO(s) + H2SO4(aq)	=	MgSO4(aq) + H2O(l)	Fraction	MgO(s)	1
4	Na2CO3(s) + H2SO4(aq)	=	Na2SO4(aq) + H2O(l) + CO2(g)	Final Conc.	Na2SO4(aq)	2.75

- Leave the temperature field blank for Reaction 4. This will ensure that the final concentration will be achieved at the stream temperature;
- Save and minimise or close the Reaction file.

Notes:

1. If the reaction you create is not a balanced equation, the Reaction Editor will warn you.
2. Press the *Balance* button and the Reaction Editor will suggest changes. If you agree with the proposed changes, press OK, or
3. Press cancel and balance the equation manually by adding stoichiometric coefficients.
4. The species which are used in the current reaction are highlighted in blue in the species list on the right. Species which are used in other reactions in the same reaction file are bold.
5. Keep in mind that this reaction file is created and modified using the SysCAD Reaction Editor (or a text editor of your choice). Therefore any change to the file must be reloaded into SysCAD.

5.3.1. Loading / Updating the Reaction file in SysCAD

- **Activate** SysCAD.

  By default, the AutoReload check box is selected. Therefore, SysCAD will reload the reaction file automatically when it is changed.

- Review the reactions on the RB tab of the Autoclave;

  Once the reaction is reloaded (auto or manually using Reload Rct button), SysCAD will read the reaction file and interpret the commands in the file.

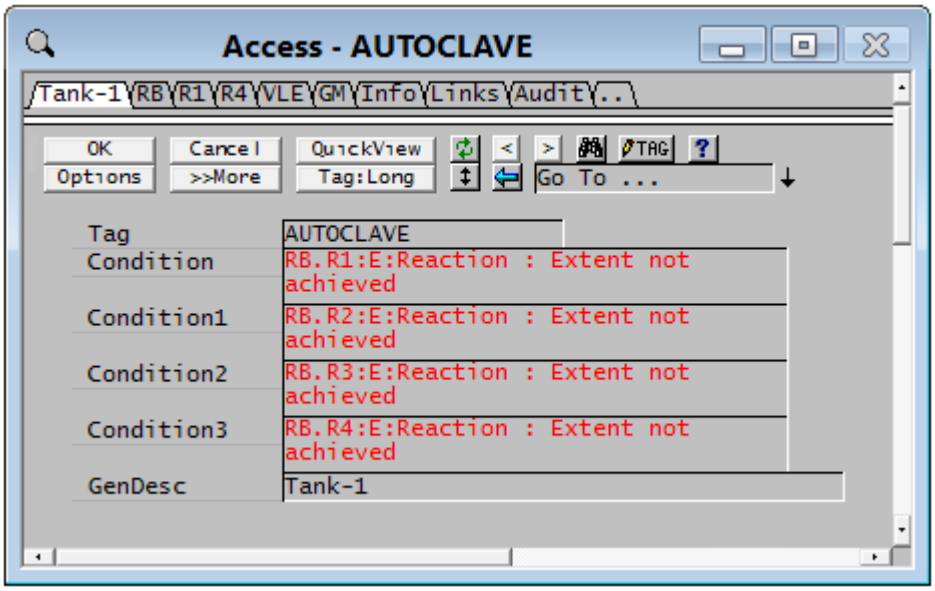
  SysCAD will add the reactions to the *Access Window* and parameter fields to change the reaction extent.

- **Solve** the project.

5.4. Debugging the Reaction Block

After solving the project the Autoclave is RED and there are 4 error messages. To determine the problem:

- Right Click on the Autoclave;
  On the Tank-1 Tab, you will see the following messages:



  So from the Condition box we see that Reactions 1 to 4 on the RB block have not reached their required extents. When this occurs in a Reaction file it means that there is insufficient reactant - in this case H2SO4(aq).

- Right click on slurry line out of the Autoclave;
- Click on the Sp tab.

  We see that there is 0 t/h of H2SO4 acid in this pipe.

  To correct for this, we obviously need to add acid to the Autoclave. We will do this in the next exercise (adding PID controllers).

- **Save** the project.

5.5. Review

- Reactions in SysCAD are specified in stoichiometric format in text files separate to the project itself.
- The SysCAD Reaction Editor is the recommended editor.
- The reaction files are read and interpreted by SysCAD.

Help Topics online:

For more information on reactions, please refer to the Models Help – Sub-Models – Reaction Block (RB) http://help.syscad.net/index.php/Reaction_Block_(RB) for a detailed description of the formats and options.

For more information on how to use the Reaction Editor, refer to the Reaction Editor help (http://help.syscad.net/index.php/Reaction_Editor).

SECTION 6

6. Trend Window, PID & Ratio Controllers

6.1. Module overview

In this module you will learn:

- How to work with Trend Window;
- How to add PID controllers to
    - control the temperature of the reactor by adding steam;
    - control the acid concentration in the autoclave by adding acid; and
    - trend the control variables;
- How to add a Ratio Controller (Water addition is based on ore input).

6.2. Working with Trend Windows

By Example

➢ Open Tut_Test1 or the Tutorial\T1 Basic\Basic.05(With Reactions).spf

There are two types of *Trend Windows*:

- Normal (many per project allowed); or
- Controller Trend (one per project). This is a special Trend Window designed that auto generates watch variables for all PID controllers created in the project. For more information see http://help.syscad.net/index.php/Trend_Window_(with_PID_Controllers)

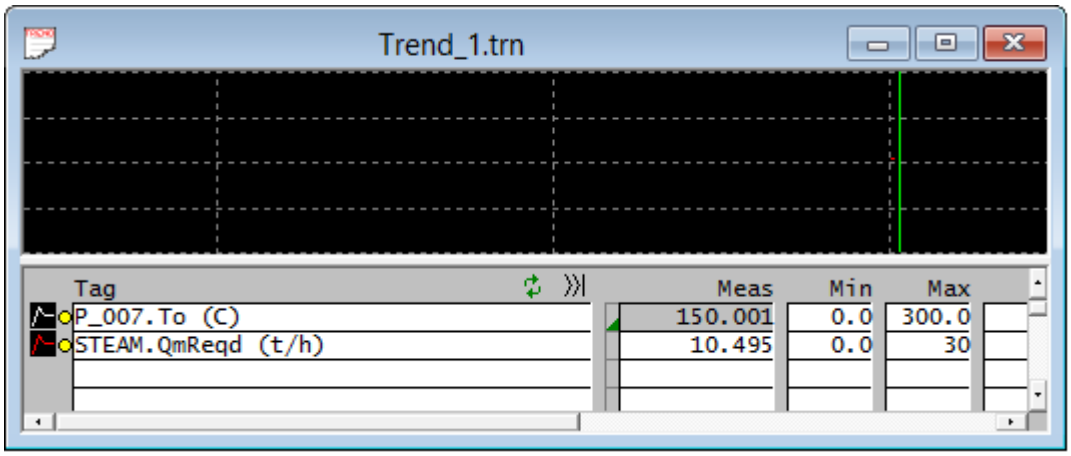
The tutorial will explain the general features of a Normal *Trend Window*, as the features of the two types of *Trend Windows* are similar.

Each entry on a *Trend Window* refers to a variable on the Access Window. Grouping related variables together allows you to see graphically how the values vary between solutions. The trend functions allow you to add or edit entries in the *Trend Window*.

6.2.1. Trend Window Configuration

A *Trend Window* displays values in a list and linear graphical format. Any SysCAD variable, e.g. flow rates, temperatures, pressures and so on, may be trended.

The *Trend Window* may look as follows:



When solving steady state problems, the trends indicate how the values are converging towards the solution. The *Trend Window* has two sections, the top section - the Trend Line View, which is used to display the trends, and the bottom section – the Trend List View, which is used to define the trends.

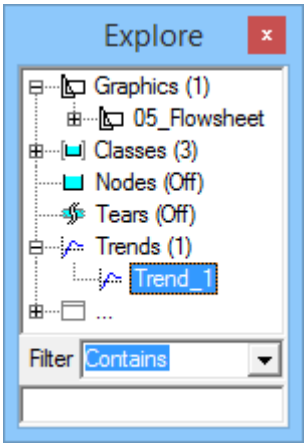
Defining Trends (Trend List View)

We want to copy two variables into the *Trend Window:*

- The temperature of the stream from the reactor; and
- The required mass of steam from the STEAM feeder.

By Example

- *View - Explorer* (OR  OR <Ctrl>+<E>);
- Click on Trend_1 to activate the trend window;



- Click on the Graphics Window;
- Right click on the link from the Autoclave (this is P_007 in Figure 1);
- On the Pipe-1 tab page under Outlet Flow Conditions, find the text ***To*** (*TemperatureOut*);
- Copy the field using <Ctrl>+<T>, or 'Copy Full Tag';
- Paste the field into the Trend window using <Ctrl>+<V> or 'Paste';
    - We see that the full tag name, including engineering unit "*P_007.To (C)*", current value, default minimum & maximum values are entered in the row.

- The grey cell for the current value (in column **Meas**) indicates that the parameter is calculated by SysCAD and cannot be altered by the user.

- Click in the **Max** value and change it to **300**.
- Click once on the small square button to the left of the parameter. A small yellow dot will appear next to the button and the button will display a coloured line (). This will **Record** the trended variable.

  The yellow dot will only appear if the SysCAD Historian is on and the value is being stored in the Historian. (The Historian is on by default.)

- Repeat the above process and copy the QmReqd value from the STEAM feeder;
- Change the value in Max to **30**.

  You will see that the value in the Meas column has a WHITE background, indicating that it can be changed by the user.

- **Save** the Project.

Notes:

1. Another method of copying a field to a Trend window is to right click on the field and select "**Send to Trend**".
2. The **Min** and **Max** values define the vertical scale of the trend line for that particular trended variable. By changing the **Min** and **Max** values, you can control the appearance of the trend line.
3. The **Min** value specified corresponds to the bottom point of the vertical scale and the **Max** value specified corresponds to the top point. You may have different scales for different variables.

General Hints on adding trend entries:

- When using "Send to Trend" from the right click pop up list, SysCAD normally sends it to the first empty row it can find. However, if you first select a row (where you would like the trend entry to be added), then press Send to Trend, it will add the trend entry to that location. So it is a good idea to first open the trend window, select an entry location before sending the trend.
- If there is more than one trend window in the project, trend entries will be added to the most recently accessed trend window.
- The copy (<Ctrl>+<T>) and paste (<Ctrl>+<V>) functions can be used in the *Trend Window* to add entries, copy and paste maximums, and minimum values and so on.

6.3. Adding controls using PID controller model

The following example will give you a brief idea on how to add a PID controller (Proportional Integral Derivative Controller) to the project.

For more information about the PID controller, see: http://help.syscad.net/index.php/PID_Controller

Task:

We wish to control the temperature of the HP Autoclave to 150°C by controlling the flow of steam to the reactor.

The PID controller is a **Feed-Back** controller: it measures the desired process variable (in this case the reactor outlet temperature), then compares it to the set point. Based on the error, it will either increase or decrease the controller output variable (in the case the Steam requirements) to bring the measured variable to the set point.

6.3.1. Manual Control

Before we add a controller, first do the work manually to get an idea of the methodology.

In this project we have specified fixed flow rate for all the stream inputs, including the steam. Once the project has been solved, you can see that the current value of 5t/h of steam does not heat the reactor to the required temperature of 150ºC.

We will use the *Trend Window* to watch the reactor temperature and change the steam requirement as follows:

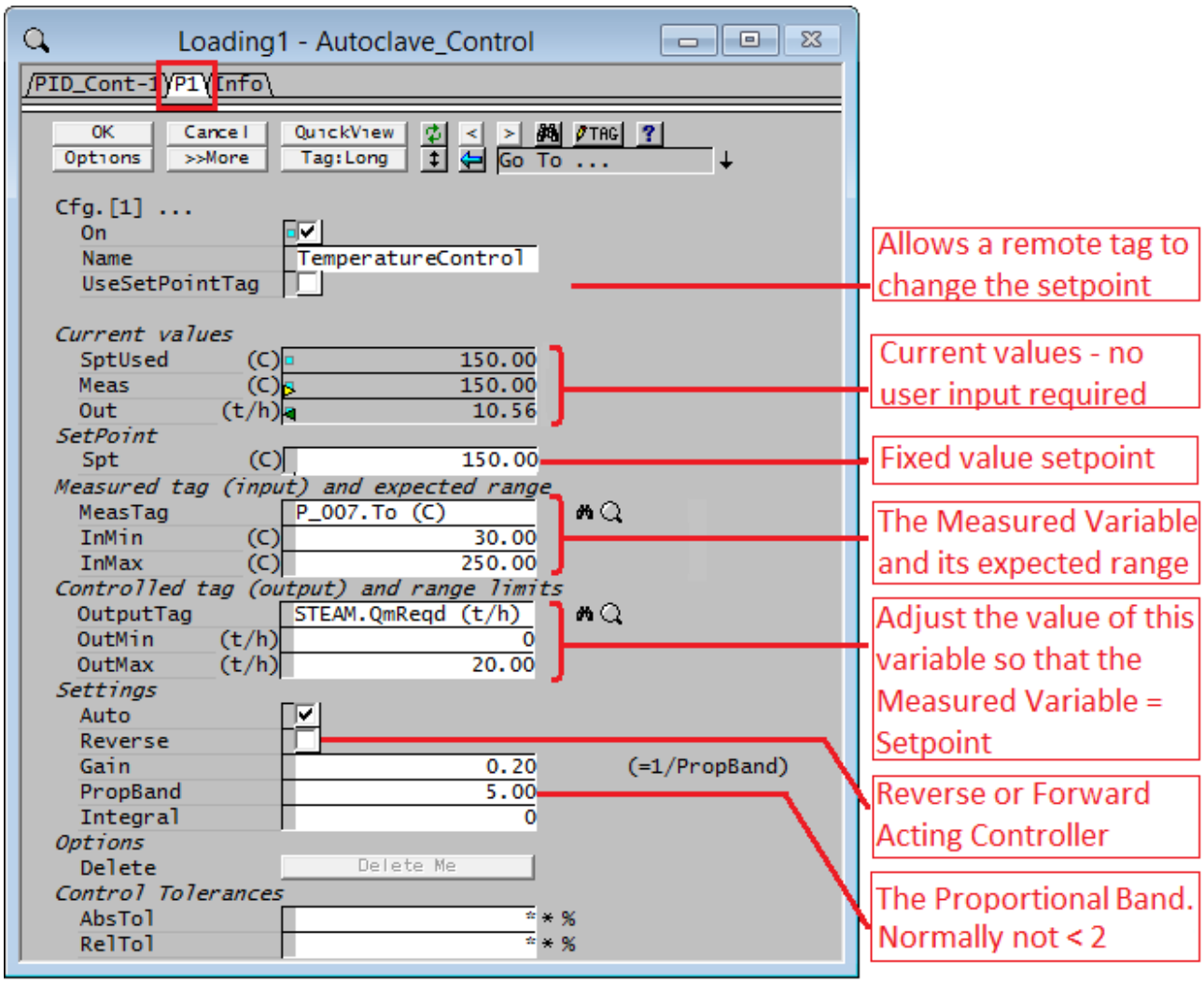
- **Solve** the project and watch the temperature in P_007 on the *Trend Window*;
- Adjust the mass of steam required in the *Trend Window* until P_007 is approximately 150ºC.

This method of control is tedious, and if any of the other streams change, such as the Ore Feed, the amount of steam will need to be adjusted accordingly.

So in order to take the manual guesswork out, we can use the controller - PID unit operation to do the work.

6.3.2. Adding the PID controller

- Select the Graphics Window;
- Using Insert Unit, add in a Control-PID;
- Rename the unit to **Autoclave_Control**;
- Right click on PID unit and click on the **P1** Tab.
- Enter the data in the fields as shown below:



- Enter a value of **150**°C in the **Spt** field – this is the set point for the controller;

Next we input the Measured Tag **(Meas_Tag).** This is the controller's input variable - in this case the Autoclave output stream temperature:

- Right click on P_007 and copy the '**To**' field;
- Right click on the PID unit;
- Click in the Meas_Tag text box and Paste the 'P_007.To (C)' tag into the **Meas_Tag** field;
- Type **30** into the InMin field;
- Type **250** into the InMax field;

The **InMin** and **InMax** are the minimum and maximum of the measured variable.

- An easy way to decide what to put here is to think of it in terms of the field instrument. For example, what temperature range should the temperature gauge have? The temperature range should cover for all process fluctuations as well as set point changes and the required set point for the controller MUST fall within the minimum and maximum range.

In this case we have used a Minimum value of 30^0C and a maximum value of 250^0C.

Next we input the **Output_Tag.** This is the controller's output variable - in this case the Steam flow to the Reactor.

- Right click on Feeder **Steam**;
- On the first tab, click on QmReqd and press <Ctrl+C> (it **MUST** be a white field!);
- Right click on the PID unit;
- Click in the Output_Tag text box and press <Ctrl+V>. The tag copied should be: 'Steam.QmReqd (t/h)'.
- Type **0** into the OutMin field;
- Type **20** into the OutMax field;

The **OutMin** and **OutMax** are the minimum and maximum of the controlled variable.

  - In this case this is the expected range of steam required to heat the reactor. Here we indicated that we may need between 0 and 20 t/h of steam.

NOTE: If the controller requires less than the minimum or more than the maximum output, it will give the user a message that it has reached a limit.

- Set PropBand to 5;

PropBand is the Proportional Band of the controller. This is the inverse of the Gain, so the user may set one or the other. As a rule of thumb, the minimum proportional band for a stable controller is 2, but sensitive controllers may have much larger proportional bands.

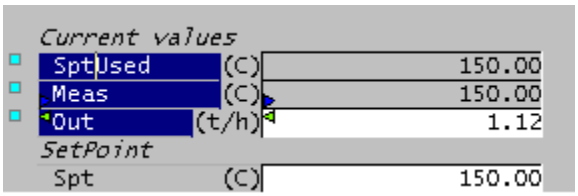
- Press the OK button.

Notes:

1) **Current values**. No user input is required, as these show the current values of the Set Point, the Measured value and the Output value. These 3 fields are useful for display purposes, and the user may copy them as a block to the *Trend Window* to track the convergence of the controller.
2) If the **UseSetPointTag** option HAS been selected then the user must input **SetPoint_Tag** – used if the set point is read from a remote unit.
3) **Reverse** refers to a direct acting controller (0) or a reverse acting (1) controller. The action is based on process response. For example:
4) If we need to INCREASE (↑) steam addition to INCREASE (↑) temperature, it is a direct acting controller. This field will be set to 0.
5) If we need to INCREASE (↑) cooling water to DECREASE (↓) temperature, it is a reverse acting controller. This field will be set to 1.
6) **Auto** sets the controller to Automatic or Manual. If this is NOT ticked the controller will be in Manual mode and the user may set the controller Output value.

6.3.3. Using the PID controller

- Copy the Setpoint, Measured value and Output values. The three values may all be highlighted and copied as a block – see the following diagram:



- Switch to the *Trend Window*;
- Select where you would like the trend entries to be added, then highlight AT LEAST 3 rows and Paste the 3 fields;
- Click on the small square button to the right of each field to trend them in the Trend View window.
- **Solve** the Project and watch how the measured and output values change.

If the PID controller has been configured correctly, the measured (meas) variable and the setpoint should be identical when solved.

If the controller could not reach the set point required, SysCAD will flag a warning message in the *Message Window* – condition section.

Typical warnings are shown below:

Warning	Description	Possible Fix
Input High	The measured variable value is higher than the input maximum.	Increase the input maximum value.
Input Low	The measured variable value is lower than the input minimum.	Decrease the input minimum value.
Output High	The output variable value is higher than the output maximum.	Increase the output maximum value.
Output Low	The output variable value is lower than the output minimum.	Decrease the output minimum value.

Other common configuration errors:

- Direct or Reverse Action.
- Controller too sensitive – Increase the measured or controlled range or increase the PropBand value.
- Output_Tag used is a calculated variable, thus not changeable.

Exercise

➢ Change the set-point (Spt) in the PID Access Window and check how the controller responds.

6.3.4. Adding more controllers

You can have more than one PID controller in a PID unit model.

To add more controllers:

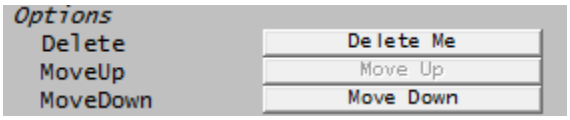
➢ Right click on the **Autoclave_Control;**
➢ On the PID_Cont-1 Tab, change **Count** to 3;
➢ Press the OK button. Two new tab pages P2 and P3 will appear in the *Access Window*.

6.3.5. Disable the controller

You can disable all controllers in the Autoclave_Control model by un-ticking the **On** check box just above the **Count** field on the first tab page. Or you can disable the individual controllers by un-ticking the **On** check box just above the **Name** field.

6.3.6. Deleting the controller

If there are more than 1 controller block in the PID unit (Count >= 2), then an extra options group will be visible per Pn Tab (eg, the following is visible on the P1 Tab, towards the bottom of the page):



If the PID control block is no longer needed, it can be deleted using the "Delete Me" button.

NOTE:

If the PID block has been referenced in external files, eg Excel or PGM files, then these external references must be checked and corrected accordingly.

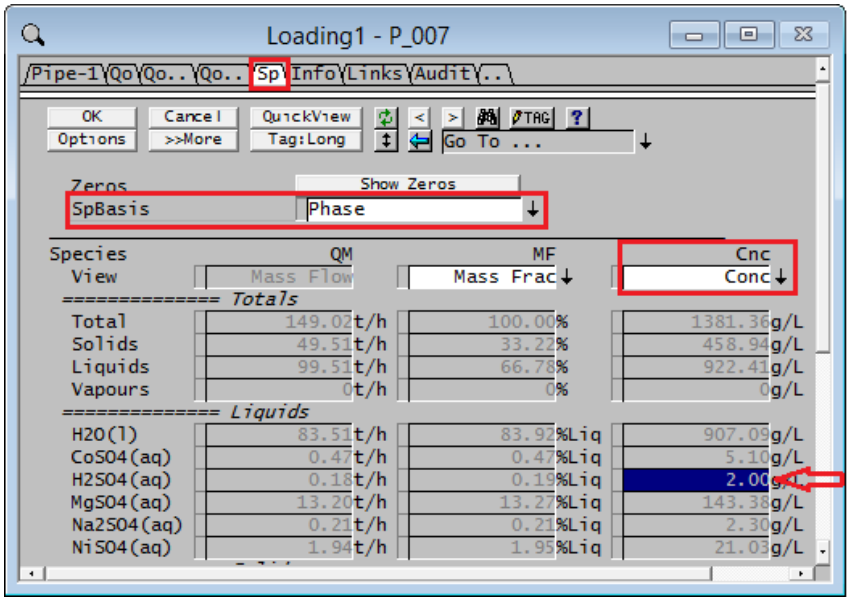
Exercise

Recall in the last section that the Reactions were starved of acid. As the feed conditions change, we will need to readjust the acid addition to ensure the reactions will go to completion. To control the acid, we will add another PID unit model.

➢ Add a second PID control unit (as demonstrated in section 6.3.2) to control the acid addition so that we have 2 g/L of acid left in the leached solution.

Hints:

- Set Point = 2 g/L H2SO4(aq) – this will represent the excess acid in Autoclave
- Output Tag = Feeder 'Conc_Acid' Mass Flow Required.
- Measured Tag = H2SO4(aq) concentration in the pipe out of the Autoclave



- This controller will be very sensitive. This is caused by:
  - There is interference from the steam controller; and
  - We are controlling the acid concentration in g/L by change the acid addition rate in t/h, therefore we need to make the changes very slowly.
- Increase the Proportional Band (PropBand) to slow down the control – keep increasing until the control stabilises.

➢ **Save** the project**.**

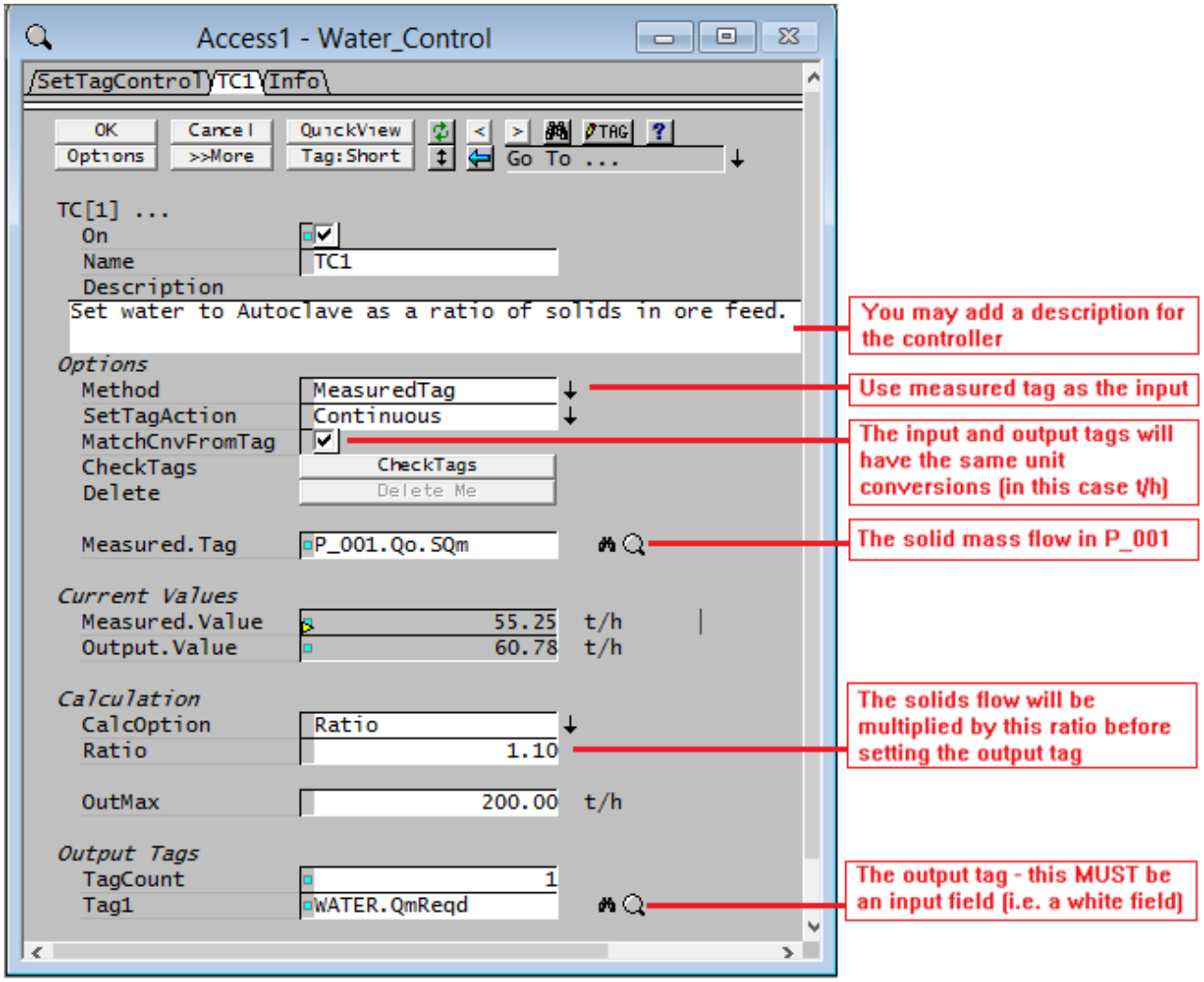
6.4. Adding Ratio controls using Set Tag Controller

For cases where a relationship can be defined, such as a ratio, then we will use Set Tag Controllers (Feed Forward Controllers) to do the control.

In this project, so far we have specified fixed flow rate for the water that will not vary with the amount of ore feed. We want to control the amount of water added to the ore as a ratio of the amount of solids entering the Autoclave. The Set Tag Controller unit will allow us to do this.

By Example

➢ Select the Graphics Window;
➢ Using Insert Unit, add in a Control - Set Tag Controller;
➢ Name the unit **Water_Control**;
➢ Right click on Set Tag Controller unit click on the **TC1** Tab;
➢ Enter the data as shown below:



Notes:

- Method:
  - *User Value* - This allows the user or another controller to enter a value;
  - *Measured Tag* - Measure the value of a tag in another unit.
- Set Tag Action:
  - *Continuous* - the output tag will be set whenever the input or ratio changes;
  - *Onceoff as Required* - the output tag is set once, when the 'Set Tags Now' button is pressed.
- **MatchCnvFromTag:** (Match Conversion from Tag) If this is enabled then the Measured and Output tags will always have exactly the same conversion units. In this case, the mass flow is shown in t/h. (Note: if this option is not selected, the measured & output values will not be assigned engineering units.)
- The **Meas.Tag** must be copied from the link connecting the ORE_FEED to TNK_001. In the above Access Window this link has the tag P_001, in your project the link tag may be different.
- **Current values:** No user input is required, as these show the current values of the Measured value and the Output value. These 2 values are useful for display purposes, and the user may copy them to the *Trend Window*.
- **CalcOption** (Calculation Options):
  - *'No Calculation'*, then Output value = Input Value.
  - *'Ratio'* – the user enters a Ratio and Output value = Input Value * Ratio.
  - *'Ratio and Offset'* – the user enters 2 values, a Ratio and an Offset and Output value = Input Value * Ratio + Offset.

- **OutMax:** The maximum value that can be sent to the Output tag.
- Output Tags:
  - The *Tag Count* is the number of tags to which the Output value must be written. In this case we will only write to 1 tag.
  - *Tag1* is the required tag to which we are writing the Output. In this case we send the value to the Feeder **WATER**. This tag must always be a writable (White) field.

6.4.1. Using the Set Tag Controller

- Copy the Current values to the *Trend Window*. These two values may be copied as a block, as for the PID controller.
- Solve the Project for a range of Ore Feed values and see how the measured and output values change.

6.4.2. Adding more controllers

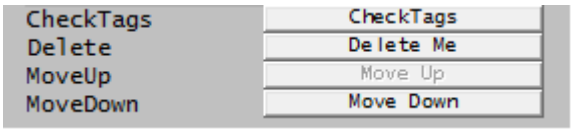
You can make adjustment to the number of controllers in the Water_Control model by typing in the number of controllers you need. Try and type in 2 in the **Count** text box found on the SetTagControl Tab page, and you will see an additional tab '*TC2*' becomes visible. You can now add a second ratio controller.

6.4.3. Disable the controller

You can disable all controllers in the Water_Control model by un-ticking the **On** check box just above the **Count** field near the top of the first tab page. Or you can disable the individual controllers by un-ticking the on check box just above the **Description** field.

6.4.4. Deleting the controller

If there is more than 1 TC control (Count >= 2) in the Set Tag Controller unit, then an extra group of tags will be visible per TC Tab (eg, the following is visible on the TC1 Tab, just above the Meas.Tag):



If the SetTag control block is no longer needed, it can be deleted using the “Delete Me” button.

NOTE:

If the Set Tag Control block has been referenced in external files, eg Excel or PGM files, then these external references must be checked and corrected accordingly.

6.5. Creating New Trend Windows (Optional)

Normally, a single *Trend Window* is opened when the project was first created.

Using File - New and selecting the Trend radio button you can add additional *Trend Window*s.

There is no limit to the number of *Trend Window*s added.

Note that if the Control Trend tick option is selected while adding a new *Trend Window*, the Controller *Trend Window* will be added. Keep in mind that only one Controller *Trend Window* is allowed per project.

Once a *Trend Window* is created, it can be renamed with the *File - Save/Rename Trend As* command, if the *Trend Window* is closed, it can be opened with the *File - Open File* command.

6.5.1. Trend graphics

As new values are calculated, the older values are scrolled to the left of the *Trend Window*. When the *Trend Window* is filled, the trend values are scrolled off the page and are no longer displayed. Using the following functions, it is possible to display more values on the screen, or move forwards and backwards through the *Trend Window*.

Note that if the Historian is off, then trend values are lost as soon as they move off the *Trend Window*.

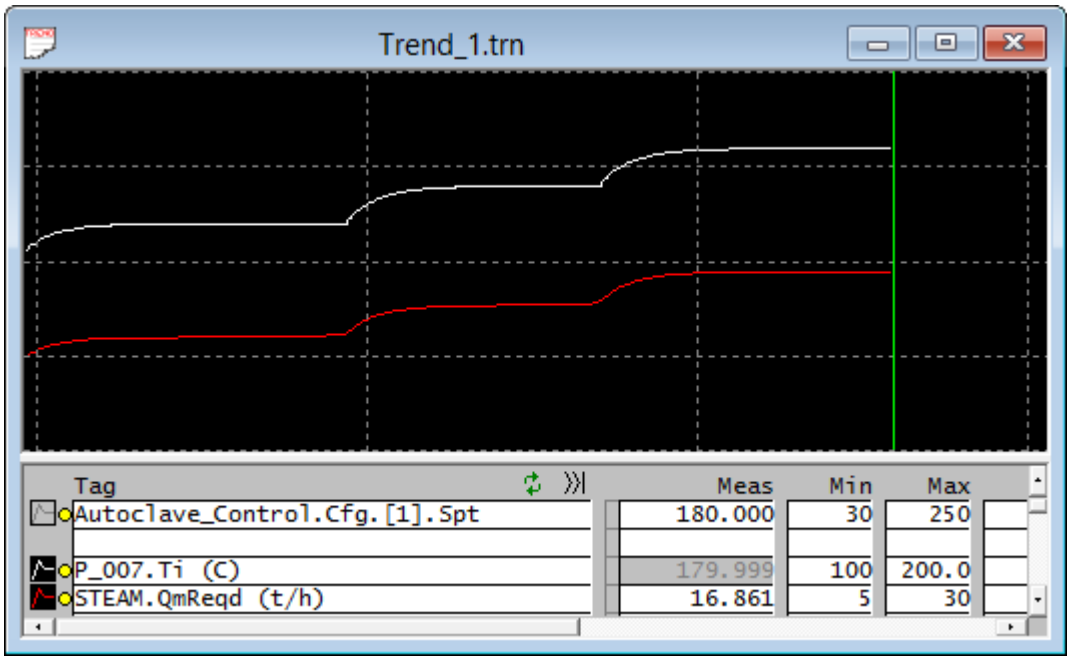
Trend Scroll

Use the Backward ( ), Forward ( ), Backward Fast ( ), Forward Fast ( ), and End ( ) buttons on the Trend toolbox to scroll the trends on the *Trend Window*.

Trend Zoom

Use the Zoom In ( ) and Zoom Out ( ) buttons to display trends of varying time spans, where the halves the view time span and the doubles the view time span.

6.5.2. Viewing Trends (Trend Line View)



The Trend Line View (top section with graphical lines) of the *Trend Window* will be updated to reflect changes made to the trend entries in the Trend List View (bottom section). A green vertical Time Line (representing the current SysCAD-Time 1) will be displayed and the most recent values of the trend line will be plotted to the left of the Time Line. Also, the scale of the trend line will be matched to the minimum and the maximum values as specified.

The trend time scale is displayed at the bottom centre of the Trend Line View, just above the section split in <hr:min:sec>. In a steady state model, this represents the time taken to solve the flowsheet.

[1] The SysCAD-Time does not equal to real present time. It starts at 0:00:00.0 hours on 1/1/1970 when the historian is first turned on for a new project. Thereafter, time is added to the historian time when solve or run is pressed.

As this example is normally solved within seconds, we need to zoom in to the section very close to the Green vertical time line to view the trends.

Zooming into a selection

To zoom in on a selected portion of the trend, you need to double click at two locations. The window will then zoom in to the area between the two selected locations.

Viewing Trend Line Data Over Time

Left Click on a trend line and hold down generates a trend information pop up window above the trend line view. It contains information (Tag, time, value) for the trend closest to the cursor. As you move the cursor across the *Trend Window*, the information displayed in the pop up window would be for the trend line that is closest to the cursor. To keep the focus on a selected trend line, use Shift + *Left click*.

6.5.3. Editing trend entries

The following popup menu options are available from right clicking on a trend entry (P_007.To)

- **Conversions** - Changing engineering units
- **Format** - Changing display format
- **Record in Historian** - Changing historian status
- **Show Trend** – Show / Hide Trend line
- **Colour** - Editing Trend Colour
- **Scale Trend** – Various options used to auto scale the trend
- **Other** – Various options
- **Clear -** You may clear single or multiple variables from the list at any time
- **Delete -** Trend entries can only be deleted if the project is not solving. You can delete multiple rows by highlighting them first.
- **Insert -** Rows can only be inserted if the project is not solving. You can insert multiple rows by highlighting them first.
- **Unit operation name | Access… –** opens the *Access Window* for P_007.
- **Unit operation name | Find… –** searches the graphics window for P_007.

6.5.4. Other Related Features

- **Changing the Column display width** - Dragging the column separation bar can change the column widths.
- **Record All** - To record all tags in the *Trend Window*(s), you can use the Record All option on the Trend menu.

6.6. Review

- Using the trend and historian options, process parameters can be closely monitored.
- The PID model is used to control the process using Feed Back control methodology.
- The Set Tag Controller is used to control a variable using Feed Forward control.
- The entries on a *Trend Window* can be modified to display customised information.

SECTION 7

7. Merging and Modifying Projects

7.1. Module overview

In this section, we will look at how to

- Open a project with an Alternate Configuration;
- Merge two projects together;
- Make modifications to a project and Connect flows between two graphics windows.

7.2. Open Project with Alternate Configuration

SysCAD has the ability to merge together two separate projects by importing a second project into one that is already opened.

In order for projects to merge, they **must** be using the same configuration file and saved using the same SysCAD version.

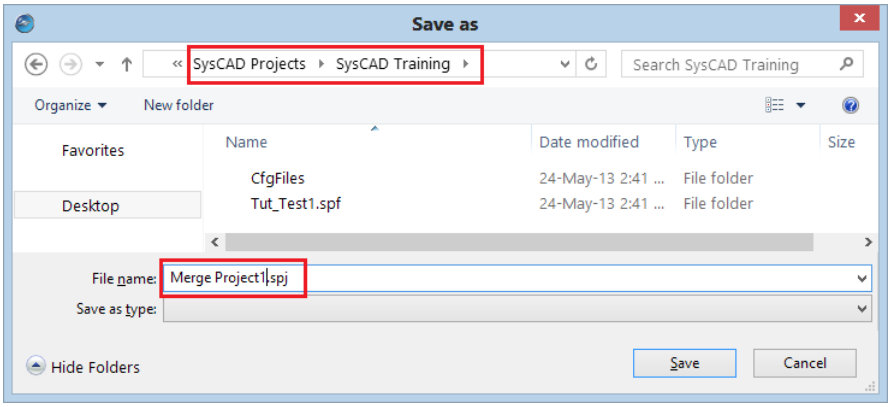
In this exercise, we will first open the second project (pre-configured) using the configuration file that we have been using and save the project. It will then be ready to merge with our project.

By Example

- Close and Save your project;
- *File - Open Project (Alternate Cfg).* (OR);
- Browse to: C:\SysCAD93\Tutorial\T1 Basic\Basic.07.1(CCD Circuit Only).spf
- Double click on the Project.spj file, or click Open;
- Click on the 'SysCAD Training' configuration in the Select Model Configuration dialog box;
- Press OK;

This project will open up using the Configuration file that we have been using so far in this Tutorial.

- *File - Save Project As ...* ;
- Browse to the folder C:\SysCAD Projects\SysCAD Training;
- Type in the name of the Project: **Merge Project 1**;
- Press Save.



This step is important as it ensures that:

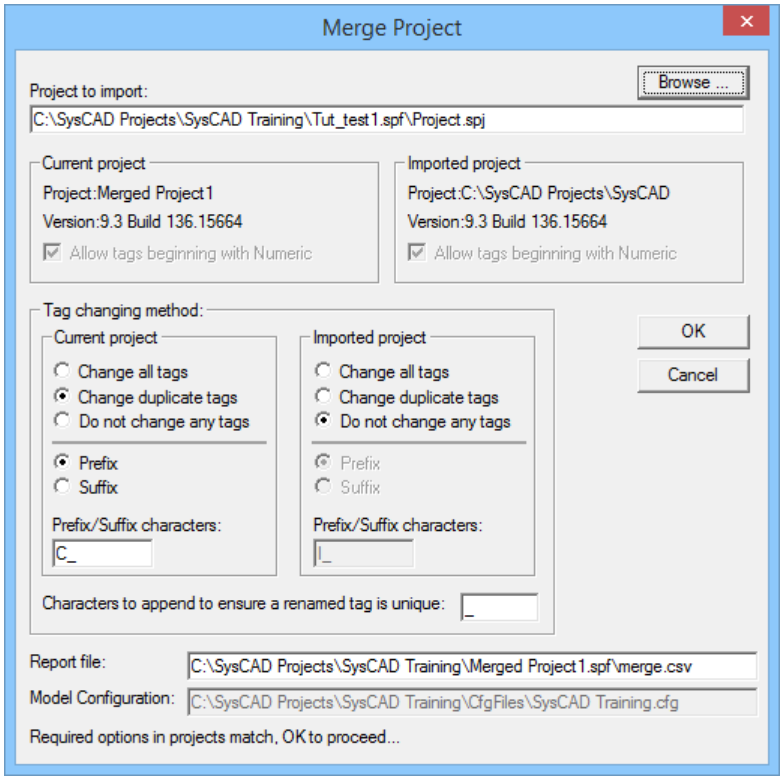
1. All projects using the 'SysCAD Training' configuration files are located in the same folder as the configuration files; and

2. The projects to be merged have been saved in the same version of SysCAD

7.3. Merging projects

With Merge Project 1 still open carry out the following exercise.

By Example

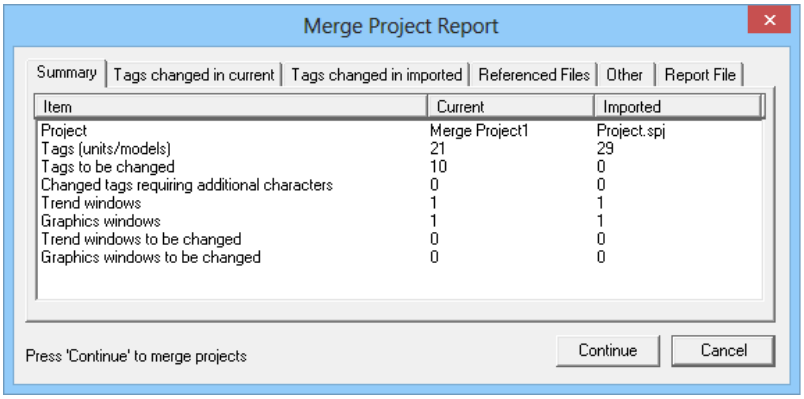


- *File - Merge Project*;
- Use Browse ... to find the project to Import. (This should be Tut_Test1.spf or the project that you have been working on);
- Under **Tag Changing Method**, choose Change Duplicate Tags for the **current project** and Do Not Change Any Tags for the **imported project**;
- Enter the preferred "Prefix" or "Suffix" for tag changing purposes, if duplicate tags are found.

  Note: As a general rule, the project being imported should always be the bigger project, with Tag change method set to *Do not change any tags for Imported project*.

- Press OK;

  SysCAD checks if the two projects can be merged together. If so, it gives a detailed report of all changes that will be implemented when the projects are merged.



- Press Continue to **Merge** of the two projects or Cancel to go back to the previous dialog window.

Hints:

- Both projects MUST have been saved in the same version of SysCAD. If one of the projects was saved in an older version, open it up in the newer version and save it before doing the Merge Projects.
- If you are merging two projects that contain the same reference file, merge report will prompt you with an error.
- Rename and reload the file in the master project.
- When you have fixed the problem, try merge again.
- Once you have merged the two projects, you can configure the feeder/cross page connectors to allow flow between pages.
- If a third project needs to be merged, make sure the current project is SAVED first. If not, you will end up with a corrupted project.

7.4. Using 'Save Project As' or 'Save Project Version'

Before we make major changes to a project (or when we want to keep a copy of the base case model), it is recommended to save the project with another name so that we have a version for backup.

To save the project with a new name, we can use either **Save Project As** or **Save Project Version.**

By Example

- *File - Save Project Version*;
- Leave **comment** text box blank and press OK.

  Your new project will be saved in a folder called **Merge Project 1-00.spf**. If this is saved again with Save Project Version… the new project will be called **Merged Project 1-01.spf**.

  Alternatively, you can type in a description in the **comment** box, e.g., Leach and CCD. The New Project will be saved in a folder **Merge Project 1(Leach and CCD)-01.spf**

7.5. Modifying the Project

This project now has two flowsheets. The second flowsheet requires a number of modifications. The modifications will be explained here.

From the list of figures in Section 1, **Figure 2** is the starting point for the current project and we wish to edit the project to make it look like **Figure 3.**

Overview of changes to be made: (these are explained step by step in the following sections)

1. Change the Cooler model type from a Shell and Tube Heat Exchanger to a Simple Heat Exchanger.
2. Add a Washer unit model between the two existing stages – first delete links P_011 and P_014, then insert the washer unit model and connect links.
3. Some other cosmetic changes using commands such as Change Tags, Change Symbol and Redraw Link.

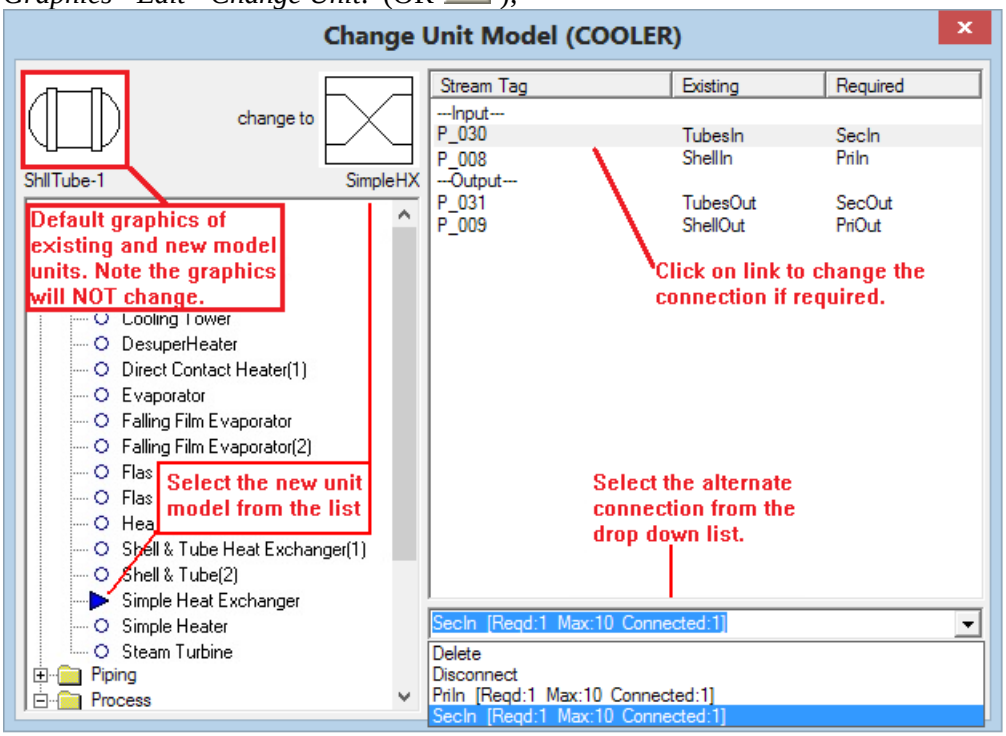
7.5.1. Change Unit

The Change Unit command allows the user to swap an existing unit operation model with a new one. This option does the following:

1) Delete the existing mathematical model, but leaving the graphics in place
2) Attaches the existing graphics to the newly selected model.
3) Re-connect any existing pipes the current model has
4) Delete any extra pipes if they are not needed.

By Example

- *Graphics - Edit - Change Unit.* (OR );



- Click on the 'Cooler' unit;
- In the left hand side of the dialog box, select the **Simple Heat Exchanger** model;
- In the right hand side of the dialog box, Select P_030 (defaults to PriIn) and use the editing panel on the bottom right hand corner to select SecIn;
- Select P_008 (defaults to SecIn) and use the editing panel on the bottom right hand corner to select PriIn;
- Select P_031 (defaults to PriOut) and use the editing panel on the bottom right hand corner to select SecOut;
- Select P_009 (defaults to SecOut) and use the editing panel on the bottom right hand corner to select PriOut;
- Press the OK button to confirm the change.

Please note that the Change unit will not change the graphics symbol. If the graphics symbol needs to be replaced, we can use the change symbol command as shown in a later section.

<u>Configuration of Simple Heat Exchanger:</u>

- Right click on the Cooler;
- Leave the default options of SideDefinition = **Primary;**
- Leave Method = **ProductT;**
- Set **TReqd** = **50** deg C.

7.5.2. Deleting Graphics

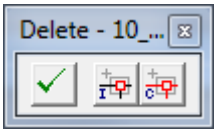
To remove the graphics symbols (and their associated mathematical model) from the *Graphics Window*, use the Delete Graphics Command.

Deleting a Graphics Symbol by left clicking to select

By Example

- *Graphics - Delete - Delete*. (OR  OR <Ctrl>+<D>)

  SysCAD displays the Delete toolbar:

- Single left click on the P_011, P_014 graphics symbols;

  The links will turn magenta; if the selection did not work as required, close the Delete toolbar.

- Click the done button  on the Delete toolbar to remove the selected graphics and associated mathematical models.

Deleting a group of models

By Example

- *Graphics - Delete - Delete*. (OR  OR <Ctrl>+<D>)
- Click on the In-Window  or Cross-Window  buttons;
- Draw a box around the models you wish to delete, all selected models will turn magenta;
- Click the done button  on the Delete toolbar to delete the models.

Deleting an entire flowsheet

By Example

- *File - Delete/Close Active Graphic*;

  If you want to remove the flowsheet and all the units on it then Click 'Delete'.

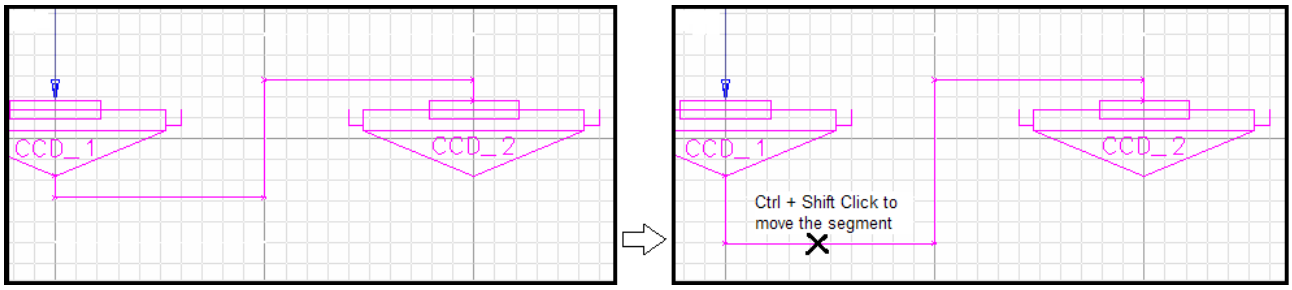
- Click 'Cancel' to cancel the command.

(The 'Close' button will close the flowsheet without removing the models – this is not generally recommended)

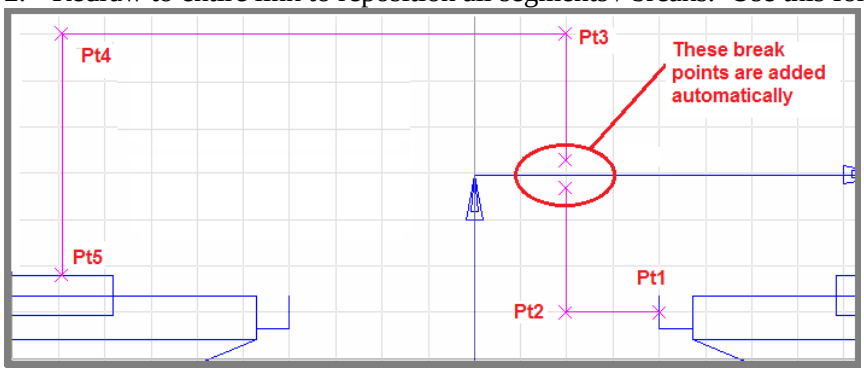
7.5.3. Fine Tune Insert Link Graphics

When Inserting the Link, sometimes the default link graphics may not be exactly what we want, we can "fine tune" the graphics using the following methods:

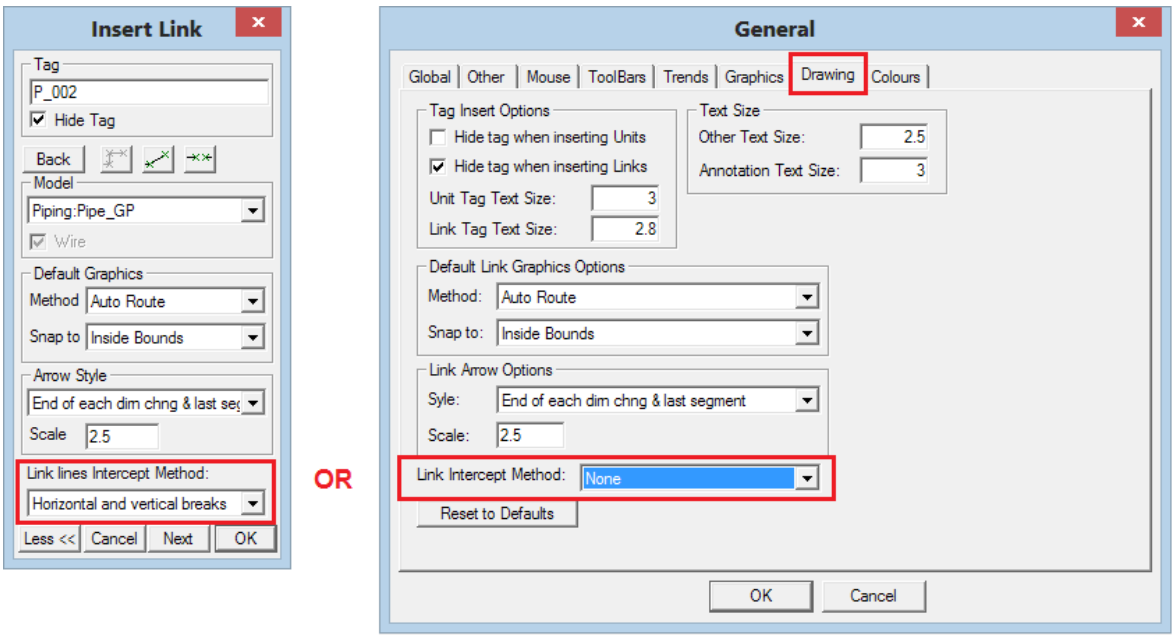
1. Use "Shift+Ctrl+Left Click" to do slight adjustments to Start/End points and segments. Use this for the Underflow lines.



2. Redraw to entire link to reposition all segments / breaks. Use this for the overflow lines.



3. To draw lines without breaks, either change the **Link Lines Intercept Method** to **None** or press **Shift+Click** when drawing the segment.



HINT: User can set the **Link Lines Intercept Method** to **None** while building the flowsheet, and ignore any manual line breaks. When the flowsheet is finished, simply use ***Graphics | Display | Vertical*** (or Horizontal) ***Link Breaks at Intercept*** to auto-correct all link breaks.

Review Exercise

- Rename CCD_2 to CCD_3;
- Insert a new **Washer** CCD_2;
- Insert the new connections as per Figure 3. See the tables on the next page if you need help with washer IO connections.
- Insert links P_011, P_012, P_013, P_014 using Figure 3 as a guide.

NOTE: A list of all the models and links used in this flowsheet are presented below:

Type	**Graphics Symbol used**	**Tag**	**Scale(%)**		**Rotation**
			X	Y	
Process – Feeder/Sink/ CrossPage	Feed | Feeder04_TagTopLeft	Leach_Solution	100	100	0
	Feed | Feeder04_TagTopLeft	Cooling_Water_In	100	100	0
	Feed | Feeder04_TagTopLeft	Cooling_Water_Out	100	100	0
	Feed | Feeder04_TagTopLeft	Wash_Solution	100	100	0
	Feed | Feeder04_TagTopLeft	Clarified_Solution	100	100	0
	Feed | Feeder04_TagTopLeft	To_Tailings	100	100	0
Separation – Thickener - Washer	WasherDecanter | Default	CCD_1	120	120	0
	WasherDecanter | Default	CCD_2	120	120	0
	WasherDecanter | Default	CCD_3	120	120	0
Process – Tank(1)	Tank | Agitated2	Tailings_Tank	100	100	0
Heat Transfer – Simple Heat Exchanger	HeatExchange | HX	Cooler	100	100	0

Tag	**Source unit**	**Source IOTag**	**Destination unit**	**Destination IOTag**
P_008	Leach_Solution	-	Cooler	PriIn
P_009	Cooler	PriOut	CCD_1	Washer_Feed
P_010	CCD_1	Washer Overflow	Clarified_Solution	-
P_011	CCD_1	Washer_Underflow	CCD_2	Washer_Feed
P_012	CCD_2	Washer Overflow	CCD_1	Washer Input
P_013	CCD_2	Washer_Underflow	CCD_3	Washer_Feed
P_014	CCD_3	Washer Overflow	CCD_2	Washer Input
P_015	CCD_3	Washer_Underflow	Tailings_Tank	Input
P_016	Tailings_Tank	Output	To_Tailings	-
P_017	Wash_Solution	-	CCD_3	Washer Input
P_030	Cooling_Water_In	-	Cooler	SecIn
P_031	Cooler	SecOut	Cooling_Water_Out	-

We now need to move and rotate the Feeder, Cooling_Water_Out, so that it leaves the flowsheet on the right hand side and redraw the link P_031.

These commands will be explained in the following headings.

7.5.4. Scale / Rotate Graphics Entities

First we need to rotate the **Cooling_Water_Out** graphics symbol.

Rotate a Single Graphics Symbol

By Example

- *Graphics - Edit - Scale/Rotate*. (OR)

  You will be presented with the Alter Entity toolbar:



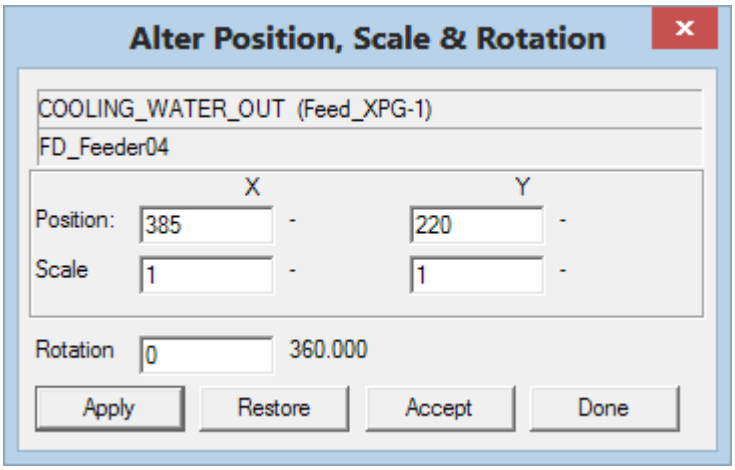
- Move the cursor over the *Graphics Window*. The cursor will change to the GRF pointer;
- Select **Cooling_Water_Out** by clicking on it once;
- Click on the Rotate+ ( ) button as many times as necessary to rotate the graphics to the desired angle. Note that SysCAD only rotates the graphics entity 45 degrees at a time;
- Click on the to close the window, click on the next unit to continue changing graphics.

Note: Single click on the background will cancel the selected graphics ready for a new selection. This is useful when the wrong piece of graphics is selected.

Hint: You may scale and rotate multiple symbols at any one time, just use the and buttons.

Using the Customised Scale Up factor

Another option is to use the customised scale-up/rotation-angle dialog box. Select the graphics symbol, click on the Alter Entity toolbar, and change the X and Y Scale or Rotation fields to the desired values.



You can now **Apply** the changes. To accept the change, click **Accept** or press **Restore** to retain the original setting.

Note:

You can use a negative number (-1) in the X-Scale box to mirror the graphics symbol along the x-axis. Similarly a value of -1 in the Y-Scale box will mirror the symbol along the y-axis.

Using the Keyboard Arrow Keys

While the Alter Entity toolbar is open, user can move/scale/rotate the currently selected objects using keyboard arrow keys. Please see next section Moving Graphics for more information.

7.5.5. Moving Graphics

Next we need to move the **Cooling_Water_Out** to the right hand side of the graphics page.

By Example

- *Graphics - Edit - Move*. (OR MOV) opens the Move Entity toolbar.



Move Graphics Symbol using Drag and Drop

- Move the cursor over the *Graphics Window*. The cursor will change to the *GRF* pointer;
- Select **Cooling_Water_Out** by clicking on it once. The cursor will change to the *POS* pointer;
- Drag the selected object and drop it in the new location.
  Use this when the graphics object needs to be moved far away from its original position.

Move Graphics Symbol using Keyboard Arrow Keys

While the Move Entity toolbar is active, the selected object(s) can be moved/scaled/rotated using the keyboard arrow keys. (The mouse cursor should display *POS*, if not; select the object(s) first.)

- Pressing ↑ ← ↓ → will move the objects left/right/up/down.
- Pressing Shift + ↑ ← ↓ → will move the objects in larger steps.
- Pressing Ctrl + ← → will rotate the objects clockwise and anticlockwise.
- Pressing Shift + Ctrl + ← → will rotate the objects in larger steps.
- Pressing Ctrl + ↑ ↓ will scale the objects up and down.
- Pressing Shift + Ctrl + ↑ ↓ will scale the objects in larger steps.

To move another piece of graphics, click anywhere on the graphics window once to de-select the currently selected object. The cursor will change to the GRF pointer, select the new graphics by clicking on it and then repeat the process.

To move multiple objects, use the or button to draw a box around the graphics symbols to select them, then position them the same way as per single graphic selection.

Using Snap to Grid Buttons

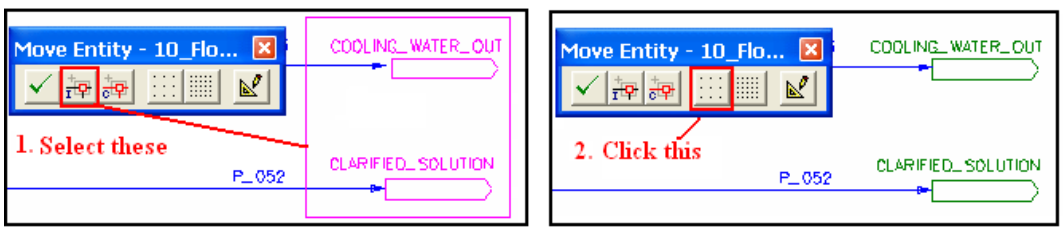
When the graphics symbols are moved, they are snapped to the small grid.

If you wish to snap the graphics objects to the big grid, select the graphics objects first, then press the (Big Grid) button to snap them to the big grid.

If you wish to align models horizontally (e.g. row of tanks) or vertically (e.g. multiple feeders), use the or button to select multiple units, then press the Big Grid button. All selected units will be snapped to its nearest grid. This is best used to align multiple units that are just slightly off-alignment. The grid size can be changed in *Tools - General Options - Graphics Tab*.

By Example

To align two feeders using snap to grid button – with Big Grid set to 5:



You can also click on the snap to grid buttons with a single object selected, this is recommended after a manual move to make sure the graphics is snapped to the grid.

7.5.6. Redrawing Links

The link P_031 is now out of place, can it be redrawn without having to delete the link since its connection is still correct?

The command for changing the graphical appearance of links is **Redraw Link**.

Note:

It is important to note that the connectivity of the mathematical model is NOT changed. That is, the source and destination information will remain unchanged once the pipe is inserted. All that can be changed is the appearance of the pipe on the *Graphics Window*. If the Link connections need to be changed, then use **Delete** and **Insert Link** or **Disconnect Link** and **Connect Link**.

By Example

- *Graphics - Edit - Redraw Link*. (OR );
- Move the cursor over the *Graphics Window*. The cursor will change to the LINK pointer;
- Click on the pipe P_031;
  The selected link will turn magenta and the Connected Unit Operations will be marked Brown (default colour).
  This will load up the Redraw Link dialogue box which allows the user to change the arrow style or scale if required.
  The cursor will change to the POINT pointer.
- User can either Redraw the link by clicking in new starting, direction change and end points (exactly as with drawing the link) OR
- Fine tune by using < Ctrl + Shift +left clicks> to reposition the Start/End point or existing segment positions. NOTE fine tune cannot add or remove segments, if the number of segments is incorrect, re-draw the link completely.
- Press OK.

7.5.7. Disconnect/Connect Link

You can disconnect a link from a unit using the *Graphics - Edit - Disconnect Link* command. Choose the link and then choose which end to disconnect.

You can connect a link to a unit using the *Graphics - Edit - Connect Link* command.

Choose the link and then choose which end to connect. Links may need to be connected if the unit they were connected to has been deleted.

If one end of link is connected to the wrong unit or to the wrong connection point:

- Use the **Disconnect Link** command first to disconnect the incorrectly connected end;
- Use the **Connect Link** command to connect it to the correct unit or correct connection point.

Note: the SysCAD model will not run if both ends of any link are not connected.

7.5.8. Change Symbol

The final cosmetic change is to change the graphical symbol of the Tailings_Tank using the Change Symbol command.

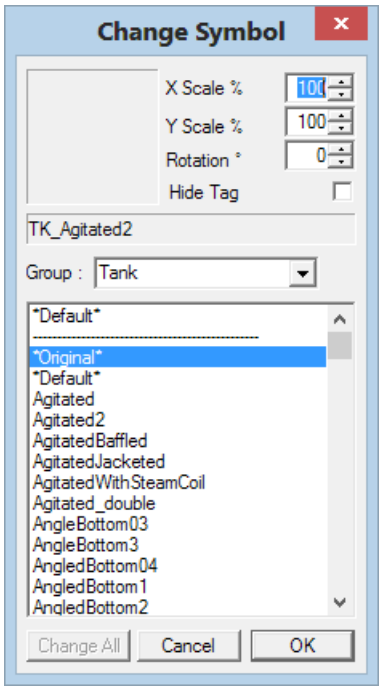
The command is **Change Symbol**.

Notes:

1. The unit operation as it appears on the *Graphics Window* is only a graphical representation of the mathematical model. Therefore, it is possible to change the appearance of the drawing symbol without deleting the unit operation.
2. It is important to note that the mathematical model cannot be changed this way. That is, a tank will remain as a tank; all that can be changed is the appearance of the unit operation on the *Graphics Window*.

By Example

- *Graphics - Edit - Change Symbol* (OR );
- Place the mouse cursor on the *Graphics Window*, the cursor will read **+unit**;
- Click on the Tailings_Tank - the **Change Symbol** dialog box will be displayed:



The symbol currently being used is represented by the word *original*, *default* means the default SysCAD symbol. Any symbols that have been used in the project will be added above the line (this can be treated as the most recently used symbol list).

After selecting a new symbol from the list, you may adjust the **X** and **Y** scale as well as **Rotation** before pressing OK to confirm change. Pressing Cancel or selecting *original* the graphics symbol will remain unchanged.

- Choose the **Agitated2** symbol from the list;
- Press OK.

If another Symbol change is required, simply repeat the above steps.

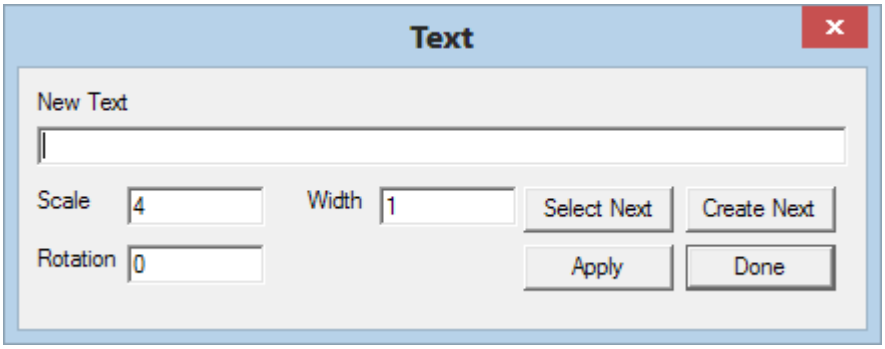
7.5.9. Insert Text

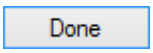
You can insert text into your *Graphics Window* to display Title blocks, Equipment Description, comments and so on.

By Example

- *Graphics* - *Insert* - *Text* (OR )

  The text dialog box will appear as shown below:



- Enter the required Text;
- Change the **scale, width** and **rotation,** if required**;**
- Click at the desired location on the *Graphics Window* to place the Text;
- You can move its location at this point by clicking on a new location or use the arrow keys  to move the text left/right/up/down;
- Press  to add the next Text String or press the  button to close the window.

7.6. Configure the unit operations using Data Transfer

7.6.1. Washer

The help on the washer model can be found on Help – Models – Mass Separation Models – Washer (or http://help.syscad.net/index.php/Washer).

You must specify the Mixing Efficiency, underflow (UF) and overflow (OF) solids concentration for the washer.

Note that SysCAD does start with some default values, but you should always ensure that the correct values are used for your project.

For the counter current washer circuit, another important factor is how much wash water should be added. We will revisit this issue in the next section.

The two existing washers have been configured. We want the third washer that we have added to have the same configuration as these washers. We can either enter the values manually, or we can use data transfer to copy the values across.

Hint:

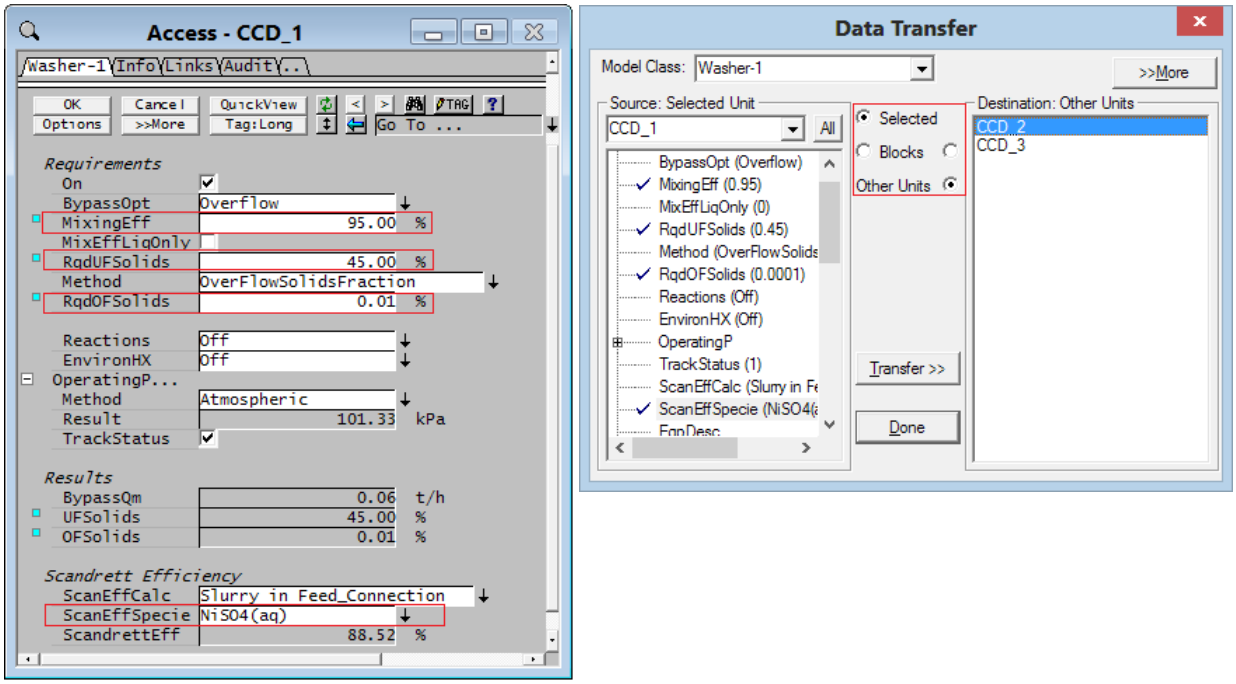
If you have connected the washer feed/input streams incorrectly, you can correct it by simply using the Change Unit option, you don't have to change the unit type, just change the connections on the right hand side of the Change Unit dialog box.

7.6.2. Using Data Transfer

By Example

- Right click on CCD_1;

  The configuration of CCD_1 is shown in the figure below. The fields highlighted are the ones we wish to transfer to CCD_2.



- Click on the Options button;
- Choose **Data Transfer…** from the top of the list;
- Make sure the options chosen are as per the right figure above, marked within the red box:
- Select data to be copied (shown by the blue ticks), on the left hand side of the Data Transfer dialog box, or you may press All next to the Source;
- Select CCD_2 on the right hand side of the dialog box (Left click – hold & drag will select multiple unit operations.);
- Press Transfer >>;

  When SysCAD is busy with data transfer, the cursor will change into the busy symbol, when it is finished, the cursor will return to normal.

- Press Done.

  The configuration of CCD_1 has now been copied over to CCD_2.

- Right click on CCD_2 to check the result of data transfer.

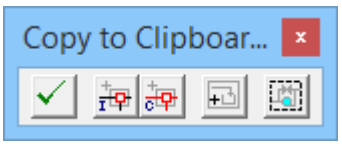
7.7. Extend Washing Circuit using Copy & Paste

We would like to extend the washing circuit to 6 stages, we can use Graphics - Copy & Paste to make a copy of the first 3 stages we have just drawn.

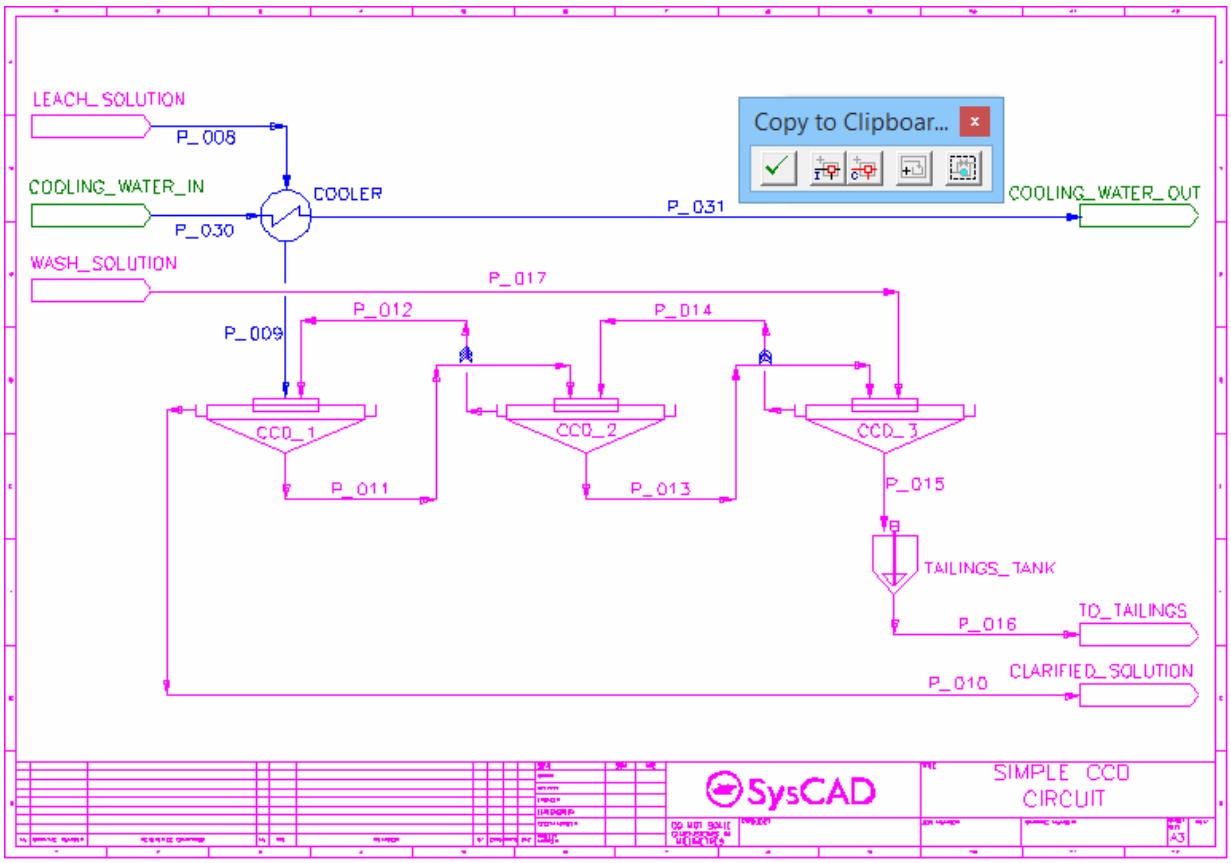
In the follow section we will only touch on the basics of Graphics Copy & Paste feature, for detailed help on this functionality, please see http://help.syscad.net/index.php/Graphics_Copy_and_Paste.

7.7.1. Copy Models/Graphics

- Select the **10_Flowsheet.scg** *Graphics Window*;
- *Graphics – Copy&Paste - Copy* (OR Ctrl+C);
- The copy toolbar will be visible:



- Select the models and graphics/text to be copied as shown below:



Hint, you can use the cross window button ( ) to select everything, then click on the units you don't want to copy to de-select them.

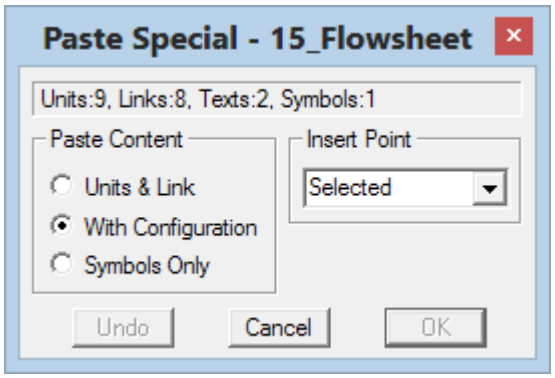
- Click on the button and choose the bottom left hand corner as the insertion point. (Grid count 0,0)
- Click the button to finish the Copy process.

SysCAD will make a copy of all the models and graphics selected on the clipboard. Note that all the copied units are highlighted in bright green.

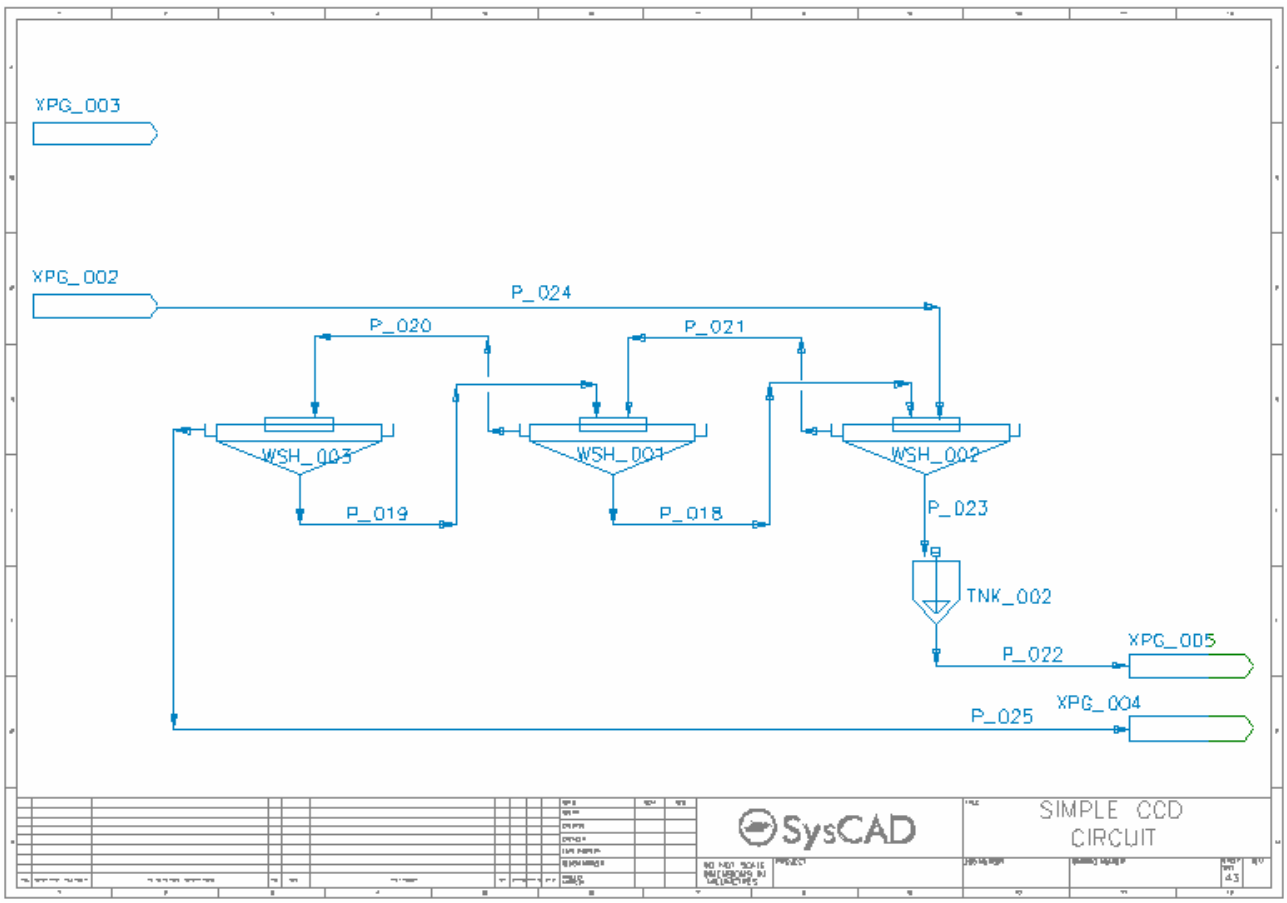
7.7.2. Paste Models/Graphics

To paste the contents of the clipboard into SysCAD, we will do the following:

- Create a New Graphics Window: *File – New File - Graphics* (**15_Flowsheet.scg)**
- *Graphics – Copy&Paste - Paste* (OR Ctrl+V);
- The paste Special Dialog box will be visible:



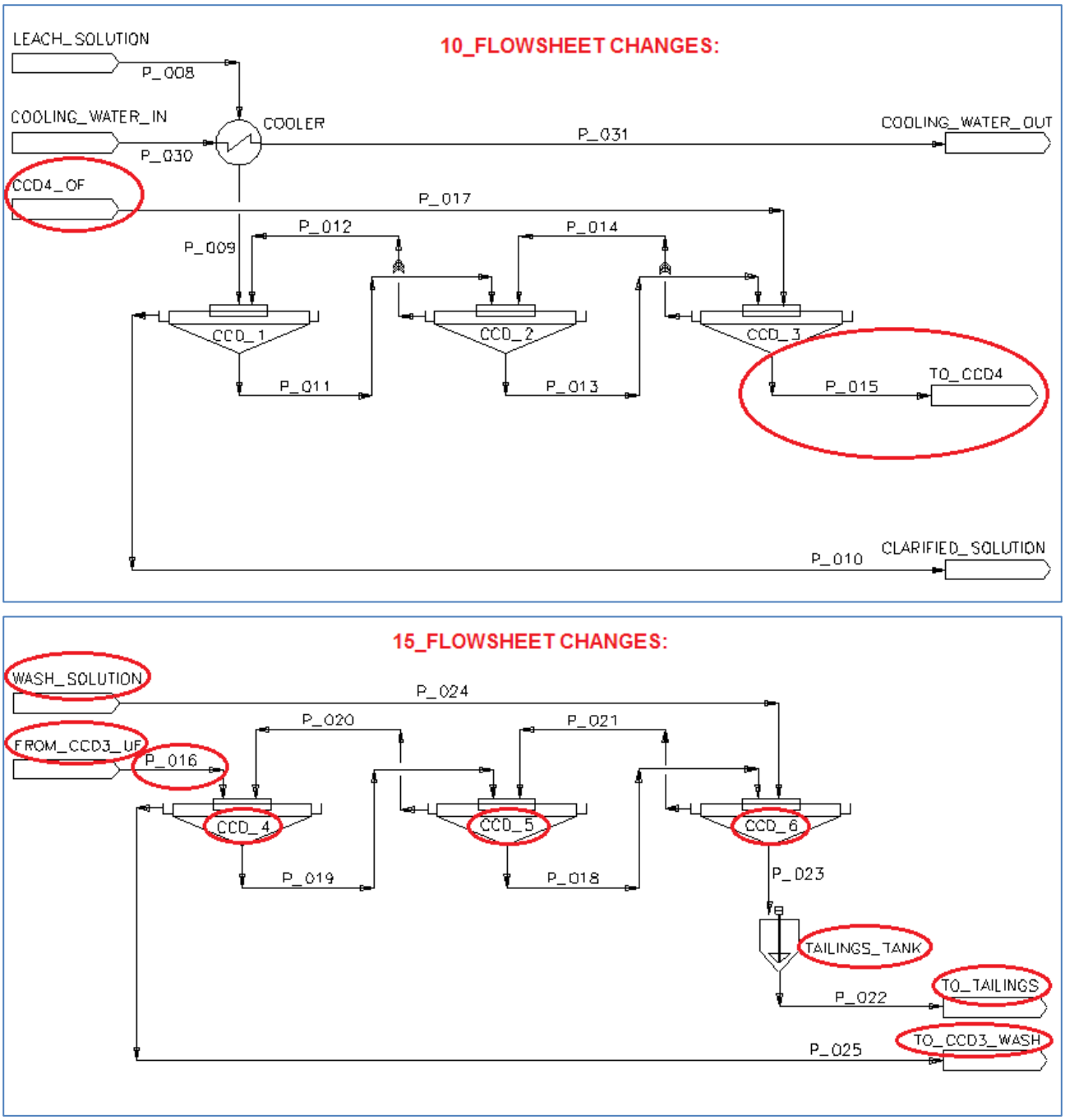
- We will use the option *With Configuration*
- Move the mouse cursor to the bottom left hand corner (this was our selected insertion point in the last step), left click once to paste the units and graphics.
- Press OK to accept the paste.



SysCAD will create a new set of models based on the copied units and insert them on this new flowsheet. All unit operations / links will have new names; user will need to make some minor changes to this flowsheet to complete the 6 stage CCD circuit.

7.7.3. Modify the CCD circuit

We will make changes to both flowsheets 10 & 15.
The suggested changes are as shown in the following picture:



For 10_Flowsheet:

- Rename two feeders, delete Tailing Tank and P_016. Reconnect and redraw link P_015.

For 15_Flowsheet:

- Rename the unit operations (Feeders and washers).
- Move and rename Feeder (XPG_003).
- Insert Link P_016 to connect CCD 3 underflow to CCD 4 Washer Feed.

7.8. Controlling the Wash Solution to the CCD Circuit

The mass flow of the wash solution to the CCD circuit must be twice the solids mass flow to the circuit, i.e. Wash Solution = 2 * Solids mass flow.

Review Exercise

We will use a *Set Tag Controller* unit to control the **Wash_Solution** to Washer number 6. (See Section 6.4, for a detailed description of the setup of this unit)

- Using **Insert** Unit, add a **Control - Set Tag Controller**, with a Tag name '**WashSolution_Control'**
- The measured tag (Meas.Tag) is the Solids flow in pipe P_008 (CCD_1 feed).
- The Output Tag (Tag1) is the Required Mass Flow in the Wash_Solution Feeder (this MUST be a WHITE field)
- The Ratio = **2**.
- **Solve** the project.

7.9. Connecting flows between two Graphics Window

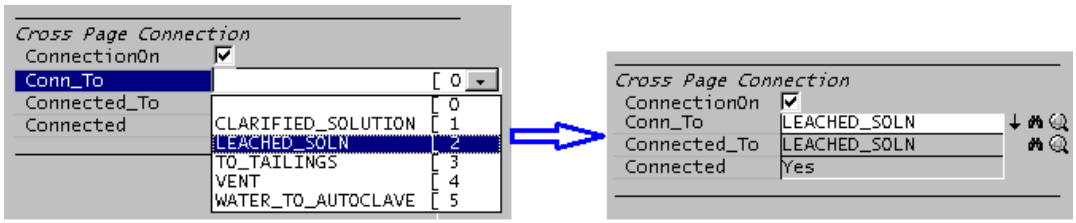
A *Graphics Window* can be connected to allow 'flow' of material between pages. There is no restriction on how many *Graphics Windows* are connected or whether they are connected at all. Connections between *Graphics Windows* are done via the Feeder/Cross-Page Connector.

Note: The cross page connection can only be set via the Feeder unit operation (feed entering the page), it cannot be set via the sink unit operation (product leaving the page).

We want to connect the Leached_Soln Feeder/XPG from the '05_Flowsheet' to the Leach_Solution Feeder/XPG on the '10_Flowsheet'.

By Example

- Select the **10_Flowsheet.scg** *Graphics Window*;
- Right click on **Leach_Solution** Feeder, (this is the leach solution entering the CCD flowsheet);
- Select the **FeederSink** tab on the *Access Window*, click the List box on the **Conn_To** text box, SysCAD will list all the available unit operations for cross page connection;
- Select **Leached_Soln** (this is the leach solution leaving the autoclave flowsheet), SysCAD will make the connection and display its status as follows:



Hints:

1. If you uncheck the ConnectionOn option, you can disconnect the connection.
2. You can click on the binoculars or magnifying glass symbol to the right of the Conn_To box to jump to the connected cross page connector.
3. From the Graphics Window, double clicking on a connected Feeder/Sink/CrossPageConnector graphics symbol will jump to the connected unit.

Exercise

Make Cross page connection for Feeders: *CCD4_OF* and *From_CCD3_UF*.

- **Save** and **Solve** the project.

7.10. Review

In this module, we have learned how to merge projects as well as modify an existing project.

We have also looked at how to connect up two flowsheets using the cross page connection option on the Feeder.

SECTION 8

8. General Controllers

8.1. Module overview

So far we have looked at two types of controllers in SysCAD: PID and Ratio (SetTag) Controllers.

In this module you will learn how to control the process with the use of a General Controller, which reads a PGM file. (PGM is a built-in language used to extend the functionality of the models. Its purpose is similar to Visual Basic for MS Excel.)

With a PGM file, you can input customised logic into the model. Examples of this are:

- A simple relationship control for variables based on user defined functions, or
- A simple calculation for product recovery; or
- A complex control system used to control the whole plant.

Tasks:

1. We will add in a simple user function to change the reaction extent for Cobalt based on the Autoclave temperature; and
2. We will calculate the Overall Nickel Recovery.

To complete the above tasks, we first need to add in a General controller.

Please continue with the project that you merged in Section 7(Merge Project 1), or open Tutorial\T1 Basic\ Basic.07.3(Copy 6 CCD).spf

8.2. Insert a General Controller

- Select the 05_Flowsheet *Graphics Window*;
- Using **Insert** Unit, add a **Control - General** unit;
- Rename this unit to **Plant_Control;**
- Right click on the General Controller unit;
- Click Edit_PGM - this will create and open up a PGM **template** using the default Text editor.

Notes:

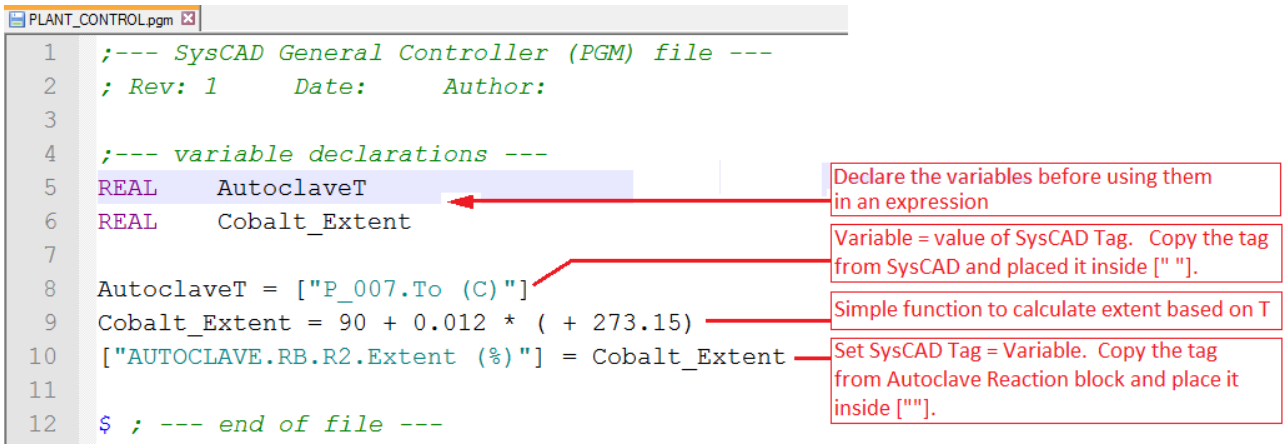
1. The PGM file will have the same name as the General Controller unit, in this case 'Plant_Control.pgm'.
2. We recommend using the 'NotePad++' text editor. The install file for this software is distributed with SysCAD in the ..\SysCAD93\Setup\Notepad++ folder. Before installing Notepad++, please see http://help.syscad.net/index.php/Using_Notepad++ in the online documentation.
3. The PGM template gives a summary of the PGM syntax required when declaring variables.
4. A brief summary can also be found at the end of this section.

8.3. Write a PGM Control File

We will first create a very simple PGM file, which will do the following:

1. Get the current autoclave temperature – we will measure the temperature in the slurry line exiting the Autoclave;
2. Calculate the reaction extent for cobalt as a function of the autoclave temperature (we are using a very simple linear relationship – this can be as complex as required);
3. Set the Reaction extent for cobalt.

The following control file will accomplish these tasks (this file was created using Notepad++):



➢ Please set up your PGM file based on the one above.

Additional Notes:

Lines	Description
1, 2 & 4	These are all comments – anything written after a semicolon is ignored by SysCAD
8 & 10	[“ ”] is reserved for getting/setting values from/to SysCAD.
12	All PGM files MUST end with a **$**. This tells SysCAD that this is the end of the file and anything after the **$** will be IGNORED.

➢ **Save** the PGM file;
➢ Return to SysCAD;

Notes:

1. This PGM file is created and modified using a text editor (the Microsoft default is Notepad, but in this case we have used NotePad++). Therefore any change to the file must be reloaded into SysCAD.
2. The automatic PGM reload functionality is enabled by default and hence SysCAD will reload the PGM file automatically when it recognises a change in the file.
3. Once the PGM is reloaded (automatically, or manually by clicking on the ‘Reload PGM’ button), SysCAD will check the commands in the file for errors.

➢ Click on the **Plant_Control** unit and check the access window for errors;

If the file is identical to the one shown above, SysCAD will report no errors and will display OK in the State text box.

If you have made a typing error, then the Status will be ‘W: Reload required’ and the General Controller will display which line contains an error. Fix any errors before continuing.

➢ **Solve** the project and note the following:

The calculated Cobalt reaction extent is 95.08%.

8.3.1. Display Calculated Variables in the Access Window

The PGM code allows users to display variables in the access window. These can then be manipulated in the same way as other SysCAD tags.

The following parameters are useful when declaring a variable to make it visible in the Access window and to display conversion units:

- @ - adding this makes the variable visible with read access only - displayed as a grey field;
- Engineering units, such as t/h, C, m^3/h, format is ("Family", "engineering units"); these are CASE sensitive.

The PGM file below shows the changes required to display the variables in the Access window:

➢ Make these changes to your file and save it.

PLANT_CONTROL.pgm

```
1  ;--- SysCAD General Controller (PGM) file ---
2  ; Rev: 1      Date:      Author:
3
4  ;--- variable declarations ---
5  REAL     AutoclaveT@("T","C")
6  REAL     Cobalt_Extent@("Frac","%")
7
8  AutoclaveT = ["P_007.To (C)"]
9  Cobalt_Extent = 90 + 0.012 * ( + 273.15)
10 ["AUTOCLAVE.RB.R2.Extent (%)"] = Cobalt_Extent
11
12 $ ; --- end of file ---
```

The @ symbol makes the variable visible in the Controller acess window.
Conversion units are useful when variables are displayed.

NOTE: The conversion units specified MUST match the conversion units in the code. For Example - AutoclaveT is declared as T (temperature) with units C, and the tag reads the temperature in P_007 also in C.

➢ Click on the **Plant_Control** unit and check the access window for errors;
➢ **Solve** the project and check the results in the Plant_Control *Access Window*.

8.3.2. Writable Variables and Text in the Access Window

It is NEVER a good idea to 'hard-wire' values in the PGM file, such as the constants used in the linear relationship. It is strongly recommended that you allow the user to enter and change these values from the *Access Window*.

The following parameters are useful when declaring a writable variable to make it visible in the Access window and to display an input range:

- * - adding this makes the variable visible with read/write access - displayed as a white field;
- Input ranges <min, max> for writeable variable;
    - You may also add Text or a new Page to the Access Window as shown in the following PGM file:

    -

PLANT_CONTROL.pgm

```
1  ;--- SysCAD General Controller (PGM) file ---
2  ; Revision: 1     Date:     Author:
3
4  ;--- variable declarations ---
5  PageLabel(AutoClave)
6      TextLabel(, "---Reaction Extent---", "   Cobalt extent = A + B*T(K)")
7      REAL     A*("Frac", "%")<80,95>
8      REAL     B*<0.005, 0.015>
9      REAL     AutoclaveT@("T", "C")
10     REAL     Cobalt_Extent@("Frac", "%")
11
12     ;--- Cobalt Extent as a function of Autoclave Temperature ---
13     AutoclaveT = ["P_007.To (C)"]
14     Cobalt_Extent = A + B * (AutoclaveT + 273.15)
15     ;Apply Limits: Cobalt Extent must be a value between 0 and 100
16     Cobalt_Extent = Range(0, Cobalt_Extent, 100)
17     ["AUTOCLAVE.RB.R2.Extent (%)"] = Cobalt_Extent
18
19 $ ; --- end of file ---
```

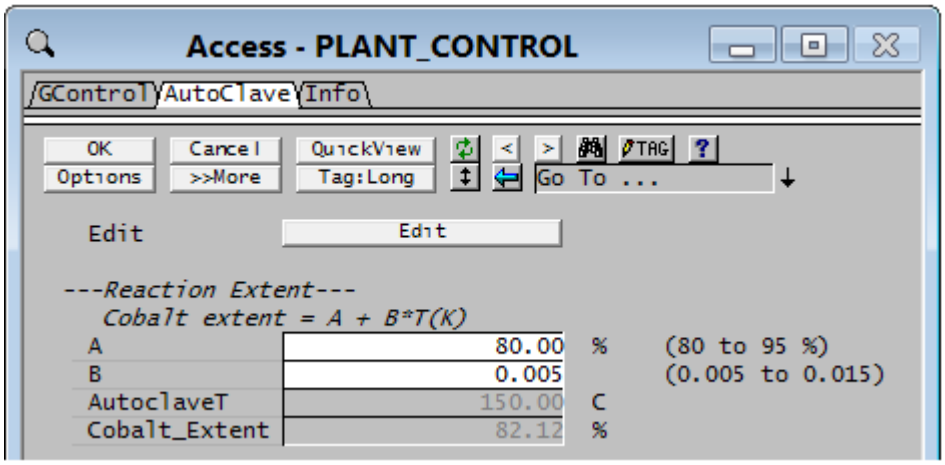
Creates a new Tab page called 'Autoclave' in the controller access window.

Creates Text in the Controller access window.
The first comma creates a blank line, the second comma starts a new line.

A and B have input ranges, specified within angle brackets <>.
The valid range will be displayed to the right of the variable field on the access window. User specified values will be limited to this range.
NOTE: The range only applies to writeable variables.

The Range(Min, Value, Max) Function forces the result to be within the Min and Max range.
In this case Min = 0 and Max = 100

- Make these changes to your file and save it;
- Check the results in the Plant_Control *Access Window*.



Additional Notes:

1. All the variables are now visible in the *Access Window* of the General Controller.
2. The constants *A* and *B* have replaced the hard-wired values of 90 and 0.012 used previously. These are writable variables (white field) and may be changed by the user.
3. All reaction extent and temperature variables have engineering units defined:
   a. Engineering units are case sensitive.
   b. After the engineering units are assigned, you may change the displayed engineering units on the access window without affecting the calculations in the PGM code.
4. These variables may be added to a Trend Window for monitoring purposes, they may also be reported, or set via Excel.

- Change the value of *A* in the *Access Window* to **95**;
- Change the value of *B* in the *Access Window* to **0.015;**
- **Solve** the project.

Note that the Cobalt Extent is set to 100, instead of the calculated 101.35%. This is due to range limit being imposed on Line 16 in the PGM file.

Exercise

- Add a calculation to the PGM file to obtain the overall Nickel Recovery = Aqueous Nickel in CCD 1 Overflow / Total Nickel in Ore. Try and add this to your existing PGM file on your own.

You may use the following PGM file as a guide if you need assistance.

PLANT_CONTROL.pgm

```
4   ;--- variable declarations ---
5   PageLabel(AutoClave)
6       TextLabel(, "---Reaction Extent---", "   Cobalt extent = A + B*T(K)")
7       REAL    A*("Frac", "%")<80,95>
8       REAL    B*<0.005, 0.015>
9       REAL    AutoclaveT@("T", "C")
10      REAL    Cobalt_Extent@("Frac", "%")
11
12  PageLabel(Recovery)
13      TextLabel(, "---Nickel Recovery---")
14      REAL    NickelRecovery@("Frac", "%")
15      REAL    NickelInOre, NickelInCCD
16
17      ;--- Cobalt Extent as a function of Autoclave Temperature ---
18      AutoclaveT = ["P_007.To (C)"]
19      Cobalt_Extent = A + B * (AutoclaveT + 273.15)
20      ;Apply Limits: Cobalt Extent must be a value between 0 and 100
21      Cobalt_Extent = Range(0, Cobalt_Extent, 100)
22      ["AUTOCLAVE.RB.R2.Extent (%)"] = Cobalt_Extent
23
24      ;---Nickel Recovery---
25      NickelInOre = ["P_001.Qo.QEl.Ni (t/h)"]
26      NickelInCCD = ["P_010.Qo.QEl.Ni (t/h)"]
27      ;Check that NickelInOre is larger than some small value - to avoid dividing by zero
28      If (NickelInOre > 0.0001)
29          NickelRecovery = NickelInCCD/NickelInOre * 100
30      Else
31          NickelRecovery = 0
32      Endif
33  $ ; --- end of file ---
```

Notes:

1. You may create as many new Tabs in the Access Window as desired.
2. It is always a good idea to add comments to your code, as it makes it much easier to follow.
3. The variables 'NickelInOre' and 'NickelInCCD' are NOT displayed in the access window.
4. Line 28 checks if the value in 'NickelInOre' is greater than 0.0001 (you may use any small value):
   a. If NickelInOre > 0.0001 is True, then line 29 is executed;
   b. If NickelInOre > 0.0001 is False, i.e. NickelInOre is very small or zero, then line 31 is executed.
   c. This code is required to prevent a 'Divide by Zero' error – if you are going to divide by a value, always check that it is not zero (greater than some small value) before you use it. Please also see http://help.syscad.net/index.php/Frequently_Asked_Questions#How_do_I_avoid_a_.27Divide_by_Zero.27_error.3F in the online documentation.
5. You may replace Lines 28 to 32 with a single iif function:
   NickelRecovery = iif(NickelInOre > 0.0001, NickelInCCD/NickelInOre * 100, 0) (this is exactly the same as the IF function in Visual Basic)

8.4. Review

In general, any (simple or complex) control strategies can be added by writing code in a PGM file. This can range from setting a simple flow ratio to writing a full plant control strategy. Help on the PGM language can be found at http://help.syscad.net/index.php/PGMs .

PGM Quick Help:

- Any text after a **semicolon (;)** is ignored by the compiler and treated as comments only.
- Real is used to define any real number.
- Integer is used to define an integer.
- The **dollar sign ($)** marks the end of file and must be present.
- When declaring a variable, you can add a ***** to make it visible and writable on the General Controller's Access Window.
- You can declare a read only variable by adding **@** after declaring the variable.
- You can assign an engineering unit to a variable when you declare it. The engineering units are Case Sensitive. The format is: variable ("Dimension", "Engineering Unit")
- When a new variable is defined, an initialisation value can be assigned to the variable by enclosing the value in << >>. This value is only used once as the variable is loaded for the first time.
- You can assign a range to a variable when you declare it. The available formats are:
  - Variable <min value, Max Value>
  - Variable<Min value, >
  - Variable <, Max Value>
- You can add a new Tab to the Access window by using the PageLabel("Text") function. Note: It is a good idea to use a short Page name.
- You can add a text line to the Access window by using TextLabel("Text") function.
- You can add a blank line to the Access window by using TextLabel() or TextLabel(, Text)
- Once you have declared a variable, you can use it in calculations.
  - For Example: WashWaterReqd = SolidsIn * Ratio
- Use ["…"] OR the function GetTag("....") to retrieve information from SysCAD.

  For example:
  - Ni_in_CCD1_OF = ["P_010.Qo.QEl.Ni (kg/h)"] ;*OR alternatively*
  - Ni_in_CCD1_OF = GetTag("P_010.Qo.QEl.Ni (kg/h)")
- Use ["…"] OR the function SetTag(".....", Value) to set calculated or required values into SysCAD.

  For example:
  - ["AUTOCLAVE.RB.R2.Extent (%)"] = Cobalt_Extent ;*OR alternatively*
  - SetTag("AUTOCLAVE.RB.R2.Extent (%)", Cobalt_Extent)
- You can copy and paste tags from SysCAD to the text editor, using <CTRL+T> to Copy Full Tag and <CTRL+ V> to paste.

SECTION 9

9. Makeup and Environmental Heat Exchanger

9.1. Module overview

In this model, we will introduce two other sub models:

- Using Makeup Source and Makeup Block to neutralise the acid in the tailing tank;
- Adding heat loss to the washer tanks using Environmental Heat Exchanger (EHX);

9.2. Adding MakeUp Blocks and Sources

The Makeup Block can be added to a number of models, such as the Tie, Tank, Feeder, etc. By enabling Makeup Block within a unit, you may add flow to the unit in a controlled fashion.

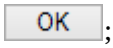
Note: The Makeup Block gets the flow from the Makeup Source, so this unit must be inserted prior to enabling the Makeup Block in a unit.

Please continue with the project you are working on (Merge Project 1), or open Tutorial\T1 Basic\Basic.08(PGM Control).spf.

9.2.1. Adding a Makeup Source

We will first add a Makeup Source to the project.

By Example

- With 15_ Flowsheet active
- *Graphics - Models - Insert Unit*, OR , OR <Ctrl+U>;
- Select "**Makeup Source**" in the Process group;
- Position the Makeup Source on the Graphics;
- Click 

;
- Rename the unit "NaOH_MakeUp".

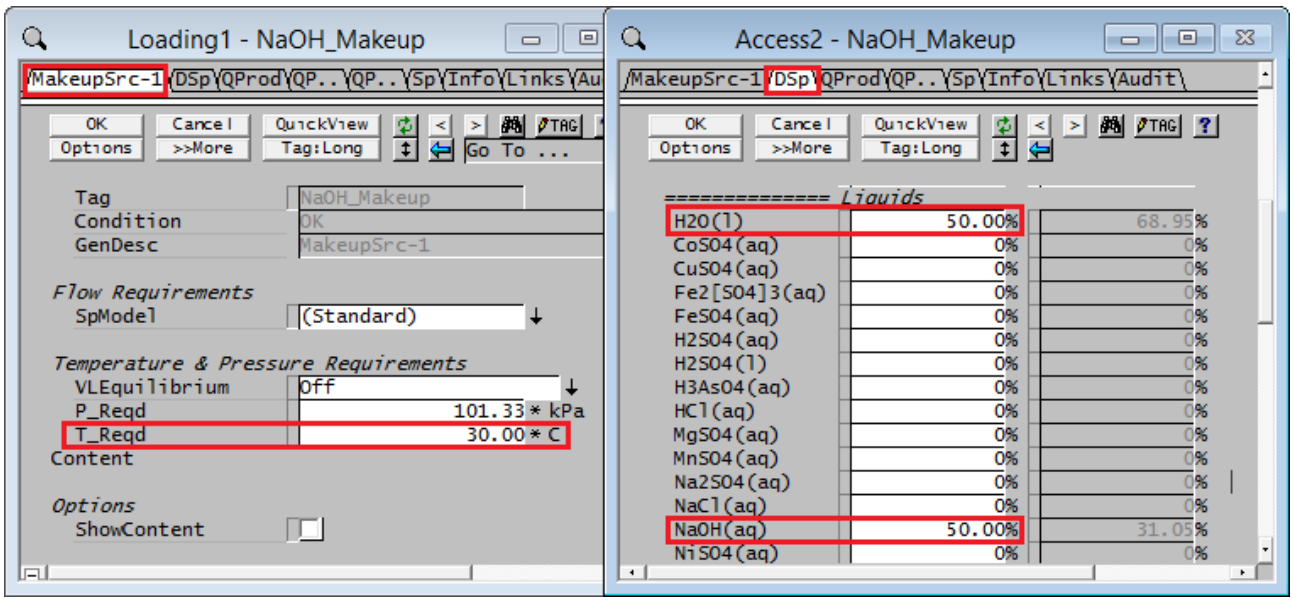
9.2.2. Configuring the Makeup Source

A Makeup Source is basically a Feeder with an infinite capacity – it will supply as much material as required.

The Makeup Source must be configured in the same way as a Feeder, except the flow is not specified. So, you must set the Temperature, Pressure and Composition of the unit.

By Example

- Right click on the makeup source;
- Set the T_Reqd = **30**°C;
- Click on the D**Sp** tab;
- Change the composition to be **50% H2O(l)** and **50% NaOH(aq)** by mass. See completed *Access Window* below;
- Press OK.

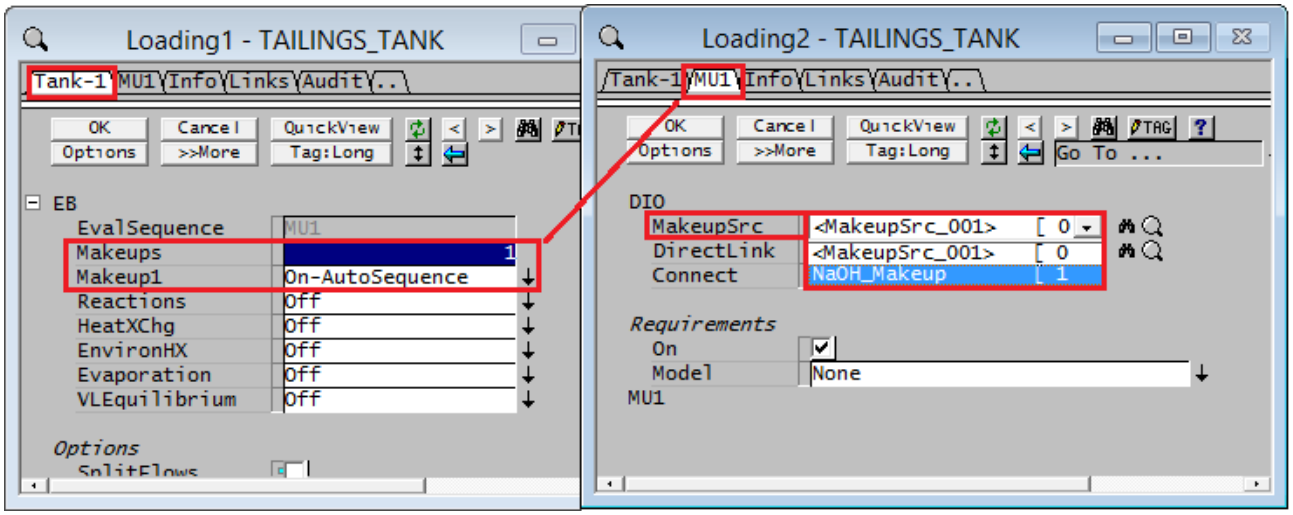


9.2.3. Adding Makeup Block (MU) to Process Units

- Right click on the Tailings_Tank;
- Go to the Tank-1 Tab of the *Access Window;*
- Type "**1**" next to Makeups in the EB block.

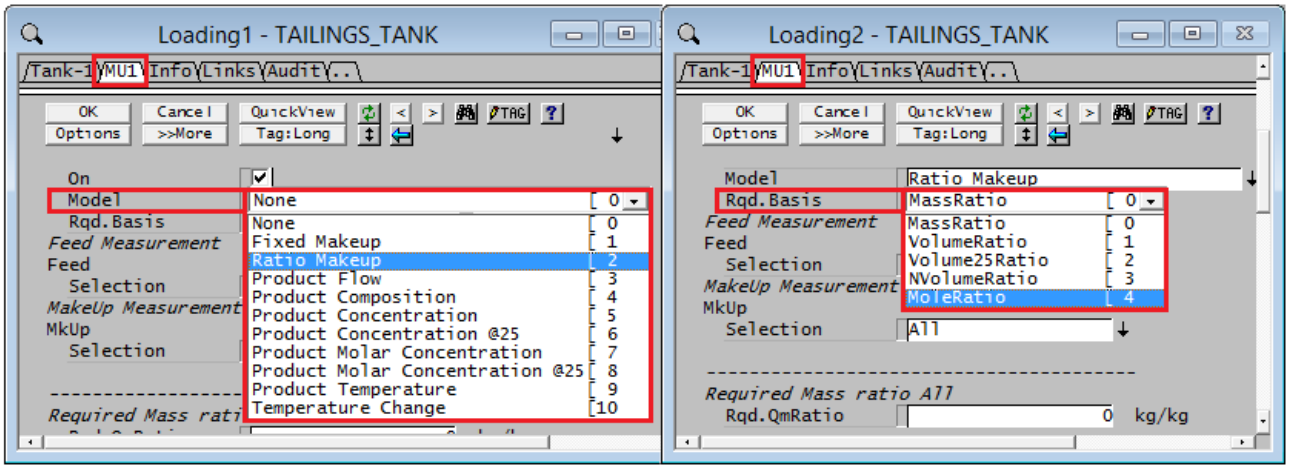
Note: The user may enable more than one Makeup Block per unit, by entering 2, 3, etc. The unit will then have the appropriate number of Tabs: MU1, MU2, MU3, etc. The user must then configure all the MU tabs. The MU blocks are evaluated sequentially during project solve.

- Go to the MU1 tab;
- Select "NaOH_MakeUp" from the drop down list for *MakeupSrc;*



The Makeup Block may then be configured as in a number of ways.

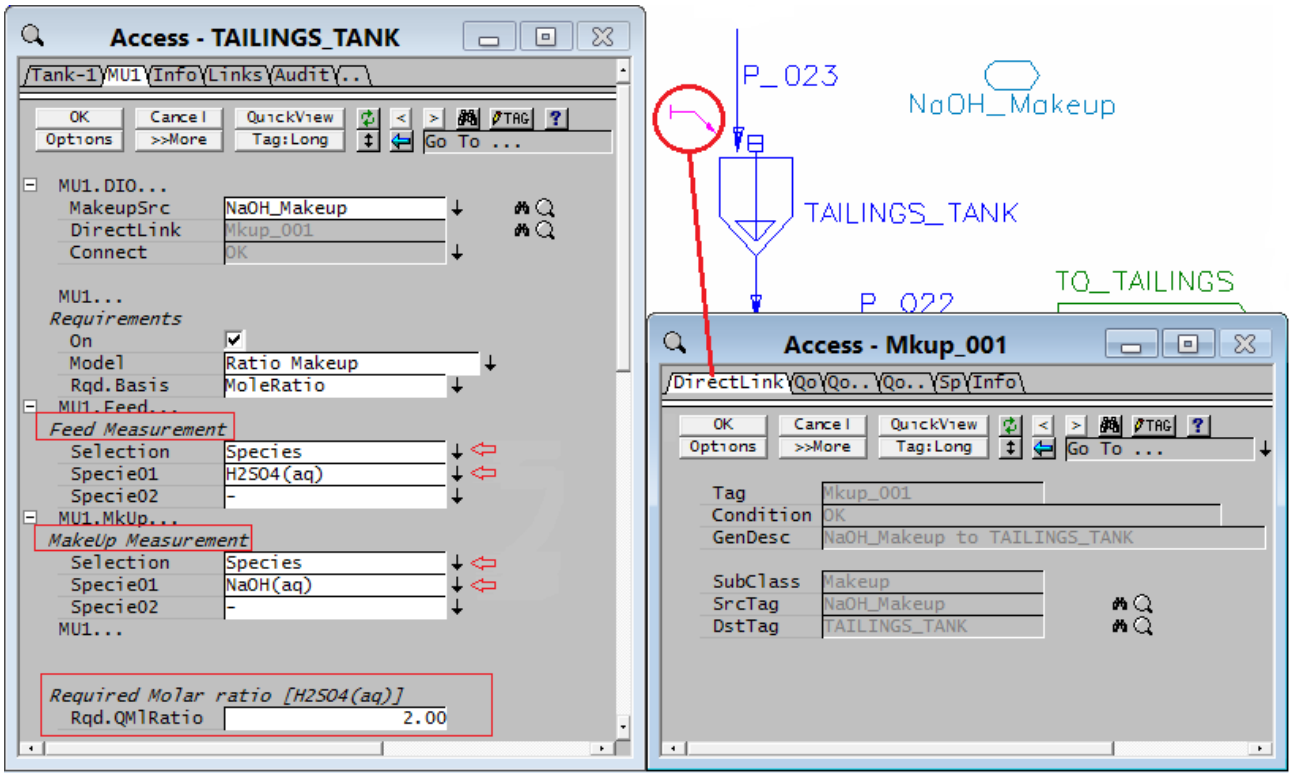
- Choose “Ratio Makeup” from the *Model* drop down list;
- Choose “MoleRatio” from the *Rqd.Basis* drop down list;



HINT: The neutralisation reaction we will be adding is

$$H2SO4(aq) + 2\ NaOH(aq) = 2\ H2O(l) + Na2SO4(aq)$$

Based on this, we will need to add 2 moles of NaOH for every 1 mole of H2SO4. Therefore, we will set up the ratio controller as shown below:



- Choose ‘Species’ from the Feed Measurement *Selection* drop down list;
- Choose ‘H2SO4(aq)’ from the list of species;
- Choose ‘Species’ from the Makeup Measurement *Selection* drop down list;
- Choose ‘NaOH(aq)’ from the list of species;
- Type **2** into the Rqd.QMlRatio field;
- Press OK.

A graphic symbol will appear next to the tailings tank. This is the direct link used to represent a makeup flow from NaOH MakeUp Source to Tailings Tank.

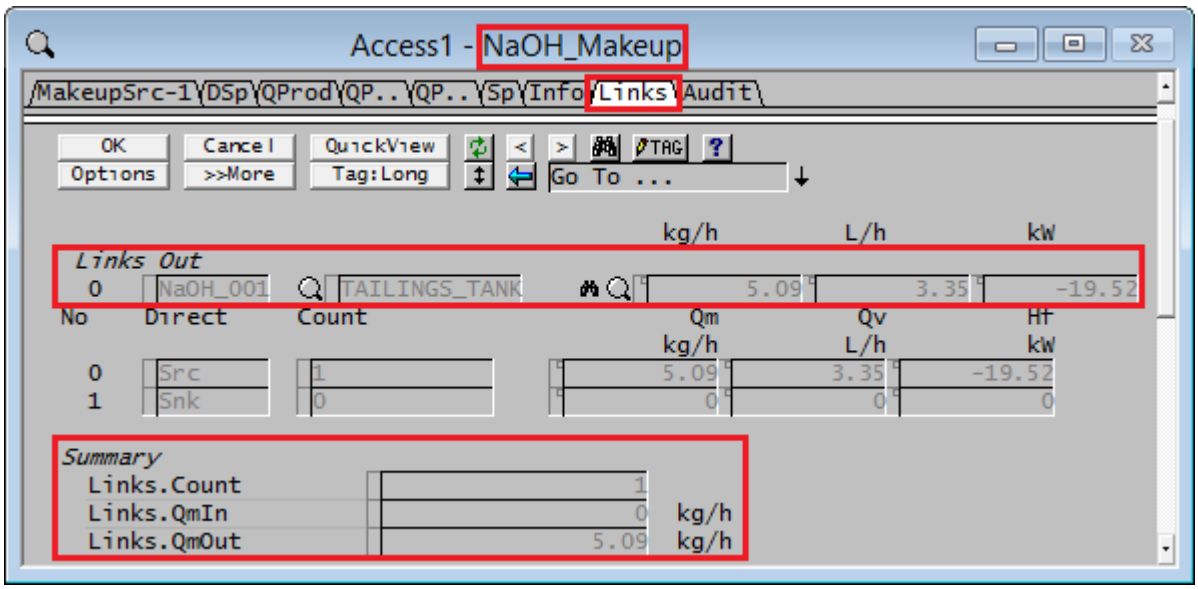
Review Exercise:

- Add a **Reaction** to the Tailings_tank using the neutralisation reaction listed above;
- **Solve** the project;
- Check the flows around the Tailings_tank and you will see that the makeup source is adding just enough NaOH(aq) to neutralise all of the H2SO4(aq).

9.2.4. Displaying the Total Makeup required

- Right click on **NaOH_MakeUp;**
- Go to the **Links** Tab and review the flows on this tab.

This tab will summarise and show each makeup connected to the makeup source, their individual flows as well as the total (Links.QmOut). This is a very useful feature for adding reagents and utilities.



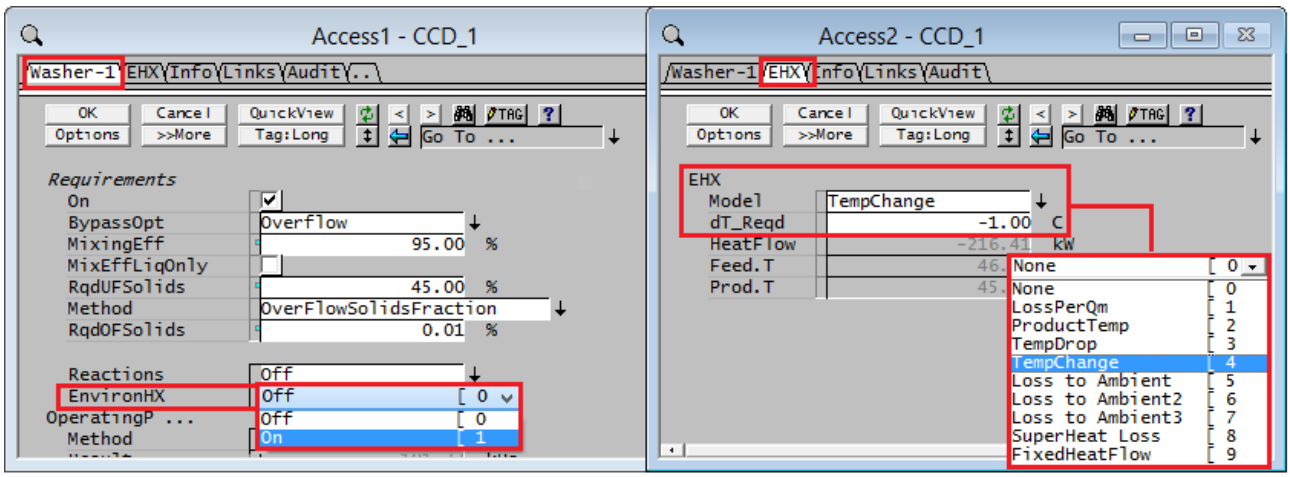
9.3. Adding Heat Loss or Emulating Temperature Control

Next we will look at how to adding heat loss values for the Washers. We can accomplish this by using the EnvironHX sub model.

Using the current project, we will add an Environmental Heat Exchange sub-model to the first washer.

By Example – Heat Loss

- Right click on CCD_1;
- Select "**On**" for **EnvironHX;**
- Go to the new tab "**EHX**" (see *Access Window* below);
- Choose **TempChange** method from the **Model** list box;
- Type **-1**°C into the **TempChange** Field;
- Press OK.



- Solve the model and observe the results.

The EHX tab will display the amount of energy that was removed to achieve the desired temperature drop (HeatFlow field).

Exercise 1 – Temperature Control

- Right click on CCD_1;
- Go to the "**EHX**" tab;
- Change the Model type to '**ProductTemp**';
- Set the required temperature = **35°C**;
- **Solve** the model and observe the results.

The EHX tab will display the amount of energy that was added or removed to achieve the desired final temperature.

This is a very useful feature to ensure that units run at a required temperature.

Exercise 2 – Fixed Energy Flow

- Right click on CCD_1;
- Go to the "**EHX**" tab;
- Change the Model type to '**FixedHeatFlow**';
- Set the required heat flow = **-20kW**;
- **Solve** the model and observe the results.

The EHX tab will display the final temperature once the required amount of energy has been removed.

9.4. Review

In this module, you have learned how to:

- Add and configure makeup blocks
- Add and configure makeup sources
- Add and configure environmental heat exchange (EHX)

What's to come in the following modules..

In the following modules, we will look at some more SysCAD graphical features and Excel Reporting.

SECTION 10

10. Graphics Window & Bulk Tag Change

10.1. Module overview

In this module, we will look at a two useful SysCAD features, these are:

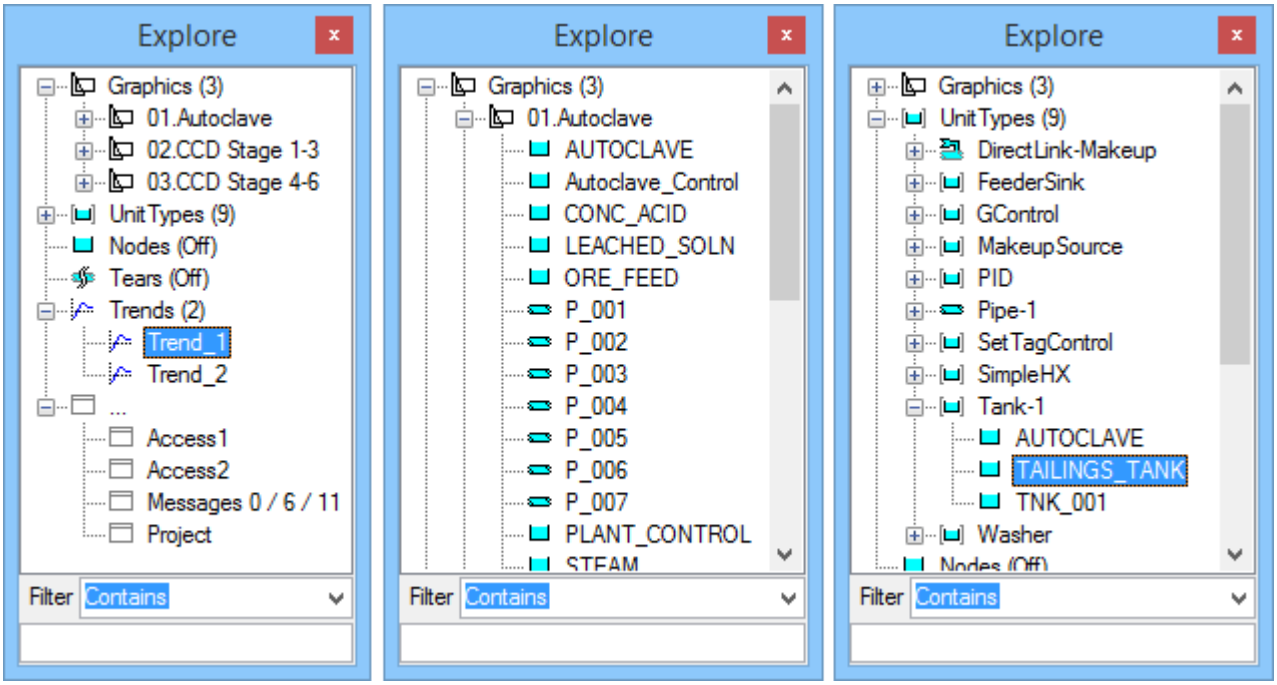
- Graphics Window Options and
- Bulk Tag Change

10.2. Working with Graphics Windows

10.2.1. Navigating the Project & Locating Graphics Objects

The Explorer Window allows you to navigate the project and locate the unit operation on any of the *Graphics Window*s with ease.

By Example



The above picture shows (from left to right):

- You can switch between graphics and trend windows using the Explorer window
- By opening the Graphics window tree, you can see all the models on the graphics page, clicking on a selected graphics unit name will highlight the selection on the graphics page.
- By opening the Unit Types tree, you can see the unit operation by type, in this case, there are three tank models in the project.

You can also input some filter options to shorten the lists, if required. The options are:

- Off – no filter;
- Contains – e.g., type in P_ to display all pipe tags only;
- Wildcards –Part of the tag name can be entered e.g. : P*; and
- Regular Expressions – similar to wildcards.

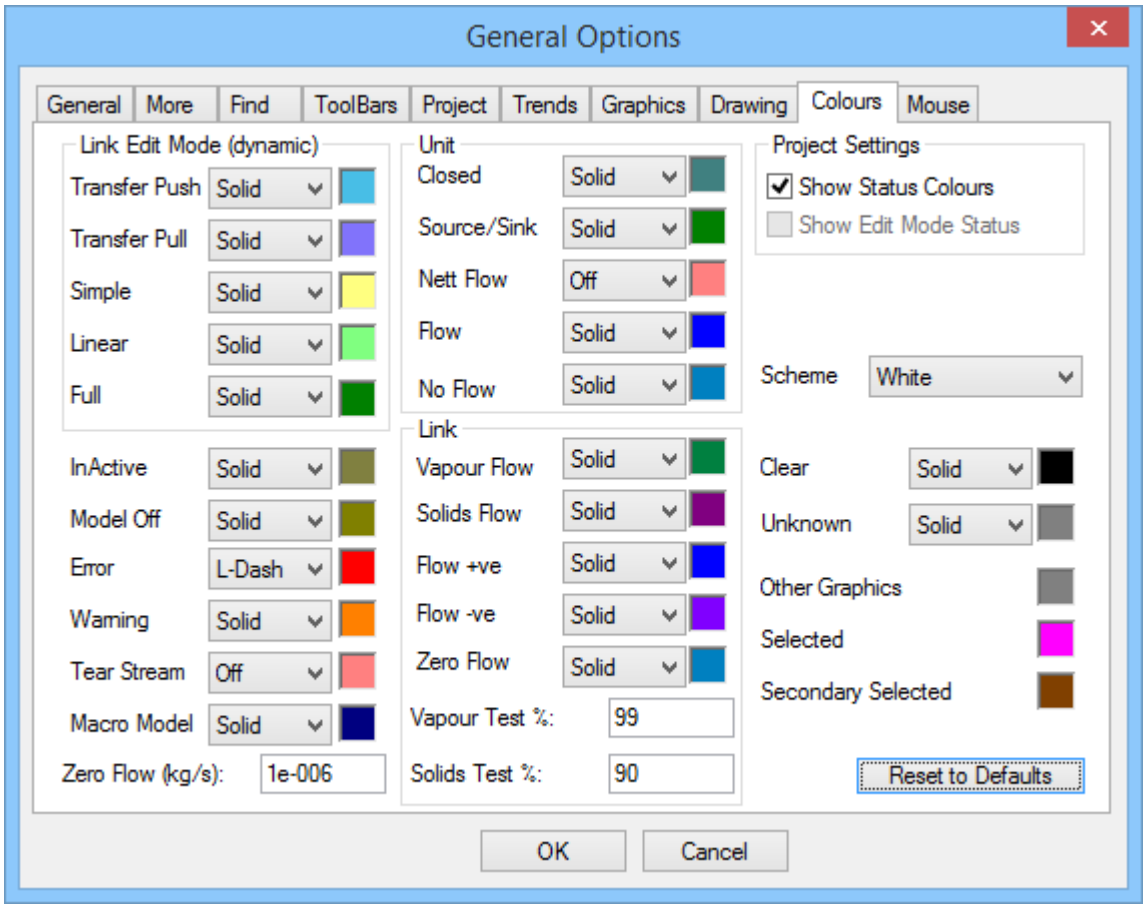
10.2.2. Graphics Symbols Display Colours

You may use the Graphics Symbols Display Colours to help identify the current state of the project.

By Example

Open the project you have been working on (Merge Project1), or Tutorial\T1 Basic\Basic.09(MakeUp and EHX).spf.

➢ *Tools - General - Colours Tab* (OR  OR CTRL+A)



Note the colour setting for the different conditions. You may change the colours by clicking on each individual colour boxes. However, for the purpose of this exercise, we will leave them as default colours.

These colour settings allow the user to quickly assess the condition of the flowsheet – the colours indicate if there is flow, and if it is a slurry, vapour or mainly solids.

➢ Press the Reset to Default button to return to the original colour settings.

10.2.3. Background Colour, Copy Bitmap, Printing and Behaviour

Background Colour:

- *Graphics - Colour Scheme*.

You may select one of the pre-defined background colours.

Copy flowsheet as Bitmap for reports:

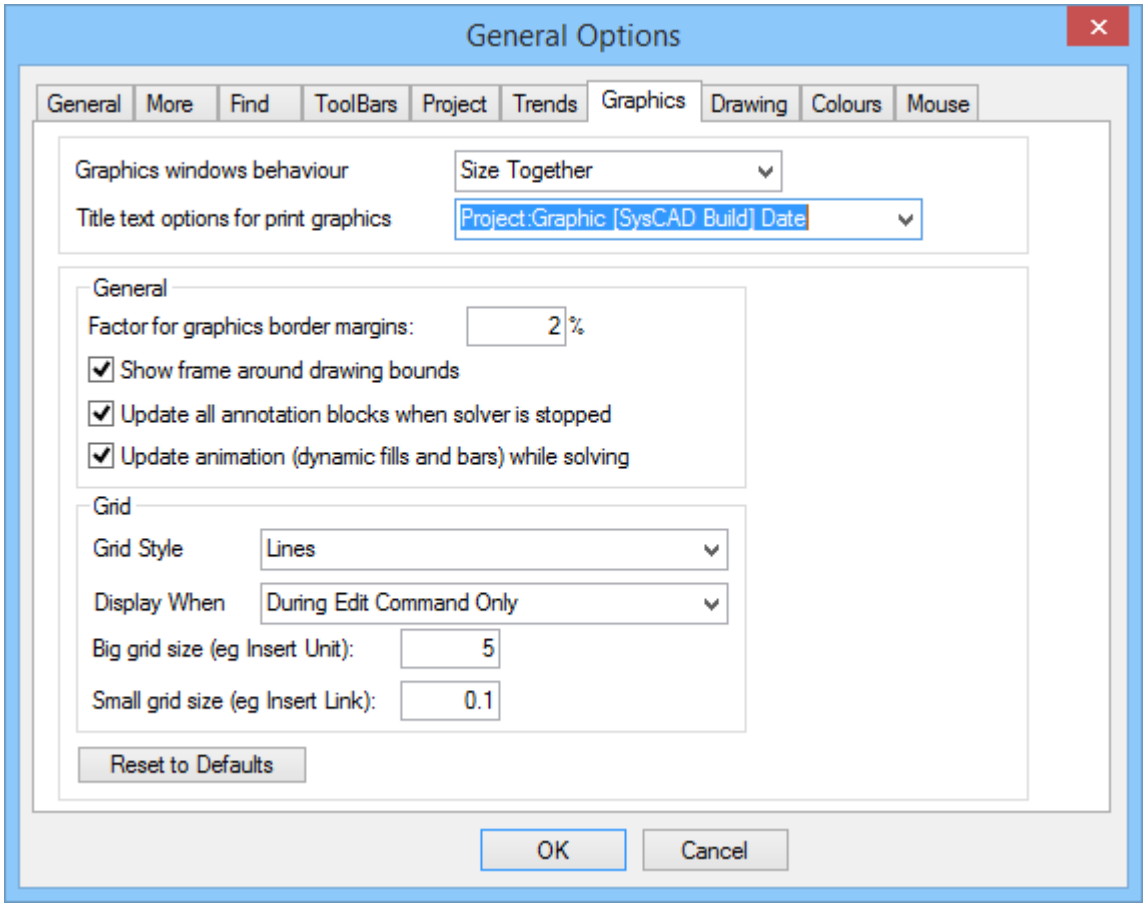
- *Graphics - Copy Bitmap*.

The copy Bitmap option will copy a Black (lines) and White (background) bitmap to the clipboard. You may then paste the picture either directly into a MS Excel or Word report or to a Graphics Editor for tidy ups before inserting into the report file as a picture.

Printing flowsheet(s):

- *File - Print OR Print Multiple*.

The printed Flowsheet is defaulted to landscape, with black lines and white background.
You may also select the required Printing Header from **Tools | General | Graphics Tab:**



It is recommended to set the Factor for graphics border Margins to 2% to allow space for the Header (if Title text is used).

Graphics Window Behaviour:

From the above Dialog box, you can also set how the *Graphics Windows* (if more than one) should behave when it is sized, as well as other settings such as Grid snaps.

10.2.4. Renaming Graphics Window

By Example

- *View - Explorer* (OR  OR <Ctrl+E>);
- Right click on *Graphics Window* **10_Flowsheet** and select Rename;
- Rename the flowsheet **02.CCD Stage 1-3;**
- Press .

- **Save** the project.

Alternatively, you can rename the graphics window from the menu commands:

- Click on the **05_Flowsheet.scg** *Graphics Window*;
- *File – File - Save / Rename Graphics As…* .(OR <Ctrl+Shift+A>);;
- Rename the flowsheet **01.Autoclave;**
- Save.

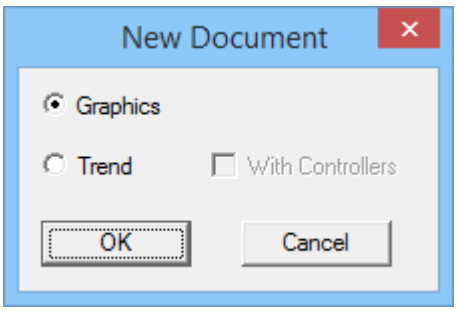
The name of the *Graphics Window* has been changed to 01.Autoclave and two new files (01.Autoclave.scg and 01.Autoclave.dxf) have been created in the project folder.

The old graphics files (05_Flowsheet.scg and 05_Flowsheet.dxf) still exist in the project folder. These files can be deleted from the project folder using Windows Explorer.

10.2.5. Creating a New Graphics Window

Within a project, you can create any number of separate *Graphics Window*s.

- *File – File – New File*. (or <Ctrl>+<N>)



- Select Graphics;
- Press OK.

SysCAD creates and opens a new *Graphics Window* with a default name of xx_Flowsheet.scg where the xx is a multiple of 5.

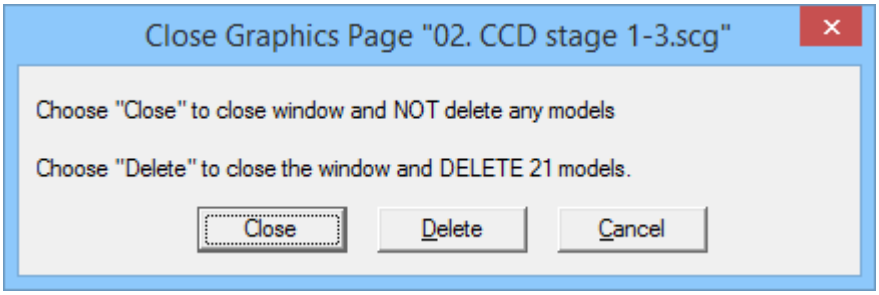
10.2.6. Deleting Graphics Windows

Before we practise this option, lets save the project as something else so we don't lose any data.

- *File - Save As*;
- Save this project as Merge Project 1(test delete).spf;
- Click on **02.CCD Stage 1-3**;
- *File – File – Delete/Close Active Graphics*.

SysCAD will prompt for confirmation of the closing or deleting of the window

- Press **Delete**.



NOTE: Selecting Delete will delete all the SysCAD models on the graphics page you are closing, thus removing them from the database. You must exercise care when closing the window to avoid data loss.

If the project is saved now, all the unit operation on 02.CCD Stage 1-3.scg will be removed. If this is not intended, you can close the project without saving to go back to the original project.

10.2.7. Graphics Window Zoom

The Graphics Window zooming and panning can be done by either the Mouse Wheel or Zoom tool Bar:

Zoom/Pan with Mouse Wheel:

Using the **mouse wheel** to zoom and pan around the graphics window.

Zoom in/out of the graphics window:

- Pressing Ctrl while turning the mouse wheel will zoom in/out of the graphics window with the focus point being the mouse cursor.

Panning of the graphics window:

- Press and hold the wheel and drag the graphics page will pan the graphics window.
- Turning the mouse wheel up/down will also pan the window up/down.

If the mouse wheel is not available, user can use Zoom Tool bar.

Zoom/Pan with Zoom Tool Bar

- The (Zoom to selection) allows the user to zoom into a selected group of graphics;
- The (Zoom All) button will show the full graphics window; and
- The button will open the Zoom Floating toolbar.



Zoom in ( ) and Zoom out ( ) keeps the centre of the *Graphics Window* as the centre point.

Move Left ( ), Move Right ( ), Move Up ( ) and Move Down ( ) glide across the page with the same magnification.

Zoom all ( ) returns the *Graphics Window* to the full page view.

Note that clicking on the background while the zoom toolbar is opened will have the same effect as pressing the button.

Click on the Zoom toolbar to close it.

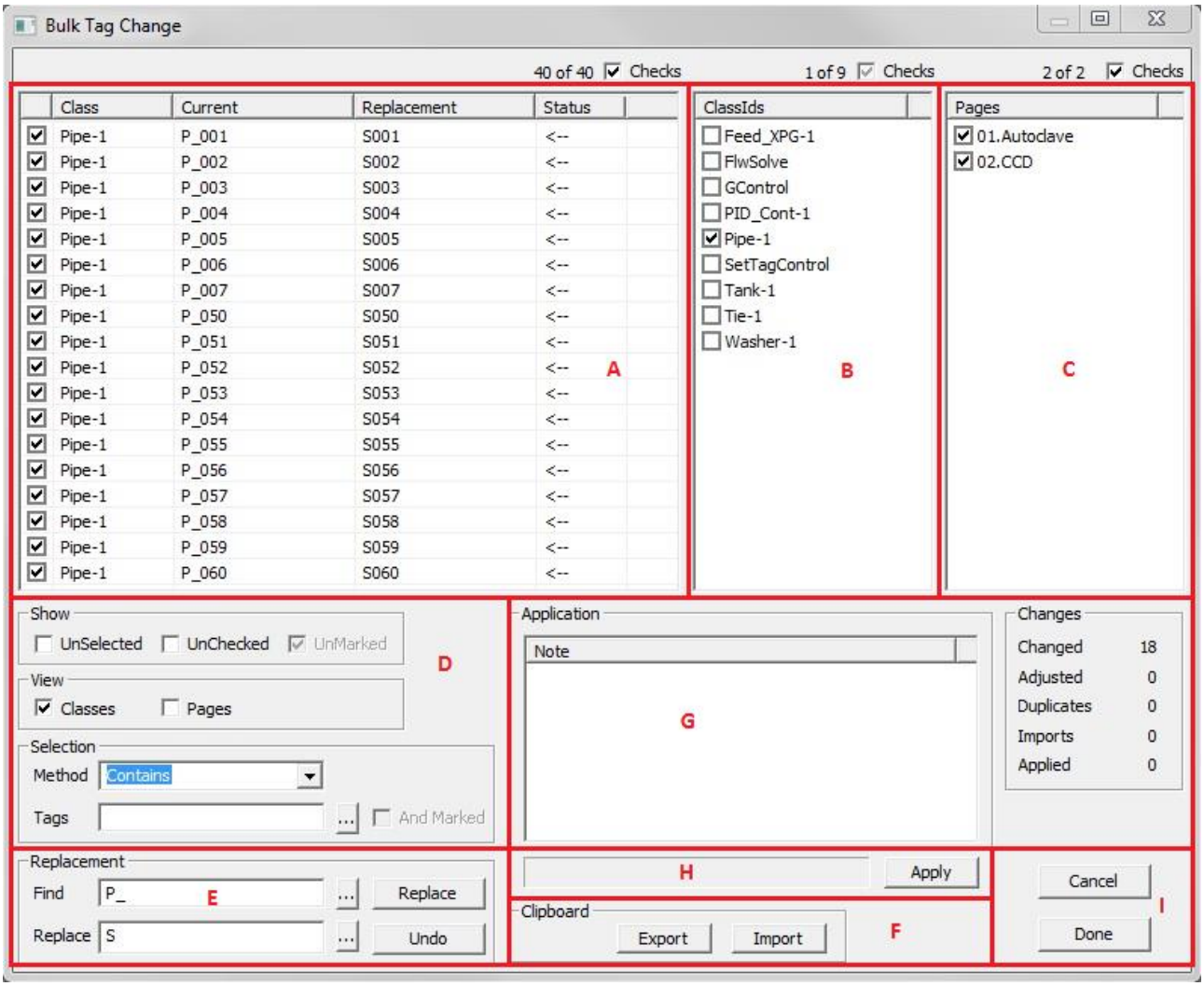
10.3. Bulk Tag Change

You may use the Bulk Tag Change function to quickly and easily change a large number of Tags.

By Example

- Open the project you have been working on before the delete graphics page (Merge Project 1) or Tutorial\T1 Basic\Basic.09(MakeUp and EHX).spf.;
- *Edit - Bulk Change Tag*;

You may use this dialogue box to quickly change multiple tags.



The workflow of how to use the bulk change tag is explained below:

1. It is often more manageable to change tag names on a per graphics page basis. Use section **(C)** to select the required graphics page.
2. You may want to use section (B) to select the required unit type for tag change. For example, we would like to rename all the pipes only.
3. Use section (E) to find and replace a group of tags. In this example, we will request to replace all tags that start with P_ to S. Press the Replace button after we have filled in the information in the Find and Replace boxes.
4. NOTE: The Replace button will act as a request to change tags only - it does not actually change the tags in the database. After the Replace button is pressed, SysCAD will do a check on the tag change requests and fill in the status column, tags ok to change will be marked with ← and duplicate tags will

be marked x Duplicate/s. You can elect to undo the change requests by pressing the Undo button and try again or change the duplicate ones manually. Once all errors are fixed, the Apply Button in Section (H) will become available.

5. Section (A) displays the current status of the tag change operation. You can also use this section to manually change tags. To do so, double click on the tag(s) on the Replacement column, then type in a new name. NOTE that when manually changing tags, it is possible to create duplicate tags, but SysCAD will give you a warning with regards to the duplicate tag, and you must fix the duplicate tag problem before the actual tag changing can proceed.
6. Once all the new tag names have been inputted to the Replacement column correctly, press the Apply button in Section (H).
7. NOTE: The APPLY button will only become available if tag change requests are present with no duplicate tags. Once you have pressed the APPLY button, the SysCAD tags will be changed.
8. NOTE: There is NO undo option after the tag changes are applied. You may only return to the previous version of the tags by exiting and not saving the project.
9. SysCAD will provide feedback information in section (G).
10. Press Done (I) when finished.

The full explanation of the dialogue box is presented in the User Guide, on the Edit Commands page (see http://help.syscad.net/index.php/Edit_Commands#Bulk_Change_Tag).

10.4. Review

In this module we have learnt about:

- graphics windows
- bulk tag change

What's to come in the following modules..

In the next section, we will look reports.

SECTION 11

11. Excel Reports and Quick View

11.1. Module overview

SysCAD reporting is done via MS Excel. SysCAD can send and receive information from Excel. There are many different types of SysCAD reports. In this section we will cover some basic reports.

For more help on SysCAD Reports, please see the online help file:

http://help.syscad.net/index.php/Excel_Reports

Basic workflow in creating a Report

- Create or Open an Excel workbook;
- Add SysCAD reporting format to a worksheet;
- Save the workbook;
- Switch to SysCAD and open the Excel Automation Dialog box;
- Add the report path, report name and generate the report;
- Wait for SysCAD to write the data to MS Excel;
- Review report and format as required; and
- Save the report.

The basic types of report covered in this module are:

- Report selected variables as a list. (e.g. production, recovery)
- Report values as a table (e.g. stream data table)
- Report values based on some filter.
- Read in data from Excel as a list or Table. (e.g. Feed, setpoints)

11.2. Reporting SysCAD Values to Excel as a List

11.2.1. Setting up the SysCAD Tag List Report Format in Excel

The Tag List Report is especially useful for reporting of specific important variables, such as model criteria.

By Example

We would like to create this report: We enter data in Column A, SysCAD enters data in Column B.

	A	B
1	**SysCAD_TagList(Report1,V,5)**	
2	PlantModel.System.Version	*This cell should report the SysCAD Version*
3	PlantModel.System.PrjName	*This cell should report the project name*
4	PlantModel.System.DateAndTime	*This cell should report the Date and Time*
5	P_007.Qm (t/h)	*This cell should report the Mass flow for P_007*
6	P_007.To (C)	*This cell should report the Temperature for P_007*

To do this, we will start by creating a MS Excel workbook.

- Start MS Excel on your computer;
- Open a New spreadsheet;
- Enter the following text string in Cell A1:

SysCAD_TagList(Report1,V,5)

- The first part of this string **SysCAD_TagList** is a report keyword, which SysCAD will search for during a report generation. If this keyword is found, SysCAD will generate a report if a valid report name and valid tags are found.
- The "**Report1**" part of the string is the name of the SysCAD report. (Please do not confuse this with the Excel file name, as each excel file may contain many SysCAD reports.)
  NOTE: You may create multiple reports with the same name; this will allow you to generate these reports at the same time.
- The **V** part of the string denotes the tag names are in the **Vertical** plane (thus row headings). Another valid option is **H** for **Horizontal**, where the tag names will be column headings.
- The next number is the search length or maximum column/row size of the Get Tag reports. In the example given, the search is **5** rows long.

NOTE: If you only have one report per worksheet, then you may define the search area to be much bigger than required. However, if you have multiple reports like we will in this section, you must give it the "correct" size to avoid data being overridden by other reports.

Now we need copy in some SysCAD tags to be reported in the five cells immediately under cell A1:

- Return to SysCAD;
- *View - Plant Model* and click on the System tab;
- Click on "*Version*" and press <CTRL+T> or right mouse click, Copy Full Tag;
- Return to Excel;
- Paste the tag into cell A2.
- Repeat for the tag "*PrjName*" and "*DateAndTime*" and paste these tags into cells A3 and A4, respectively.
  - For the remaining two cells (A5 and A6), we are going to report some stream information:

- Return to SysCAD;
- Right click on P_007, the Leached Solution from the autoclave;
- On the Pipe-1 tab and click on "*Qm*", the mass flow;
- Press <CTRL+T> or right mouse click and select Copy Full Tag;
- Return to Excel;
- Paste the tag into cell A5;
- Repeat for the tag "*To*" (TemperatureOut) and paste this tag into cell A6;
- Save the file in a subfolder of the current project called "Reports".

|__ ***Merge Project 1.spf***

|__ *Controls*

|__ *Reactions*

|__ ***Reports*** *(Create this folder and save the MS Excel Report here)*

Hints on building a report:

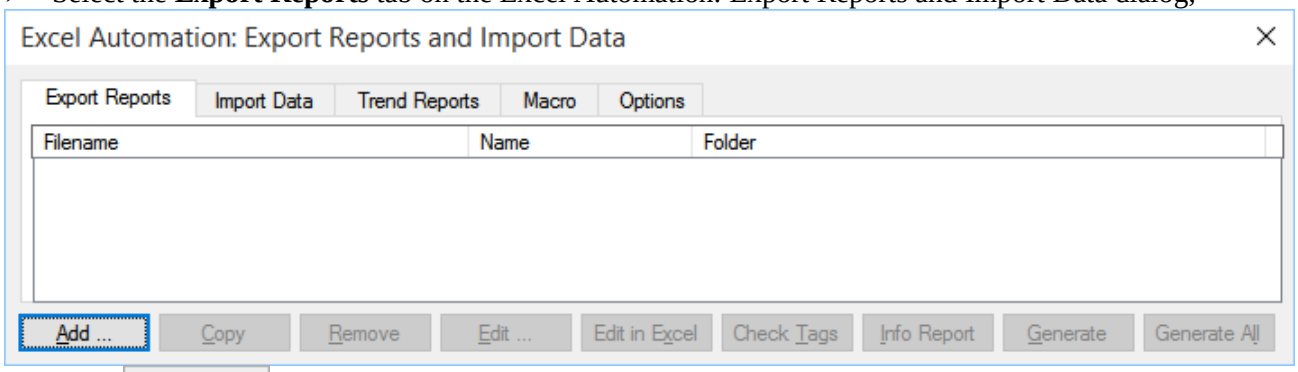
- The easiest way to add tags to the report is by copying it from the SysCAD *Access Window*. You may copy multiple tags from SysCAD and paste them into the Excel workbook.
- For more help or detailed description of the report format, please refer to http://help.syscad.net/index.php/Excel_Reports
- Tags can be manually typed in, but this is not recommended as it is easy to make a spelling mistake. Also, keep in mind that there must be a space between the tag and the engineering units, i.e. "Qm (kg/s)" and not "Qm(kg/s)".
- Engineering units are case sensitive. When copied from SysCAD, the engineering unit is pasted along with the tag. However, if manually typed in, please check the engineering units' format in SysCAD when in doubt. If no engineering units are entered, default SI units will be used.

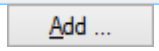
11.2.2. Sending Data from SysCAD to Excel

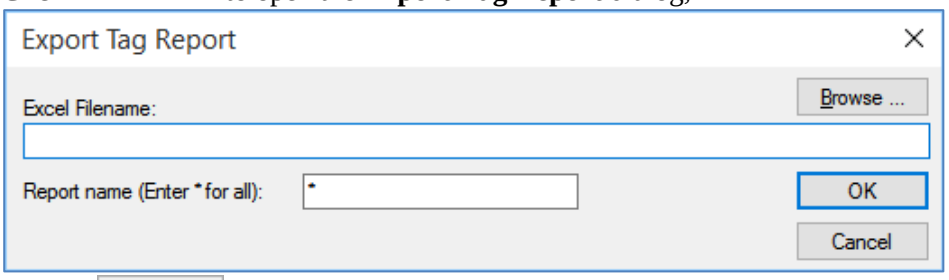
Once a SysCAD report format is created and saved, SysCAD can report the data. To do this, we will switch to SysCAD and open the Excel Automation Dialog box.

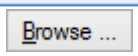
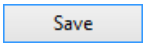
By Example

- Open the current project (Merge Project 1) or Tutorial\T1 Basic\Basic.09(MakeUp and EHX).spf;
- *Tools - Reports…* (OR  OR <CTRL+R>);
- Select the **Export Reports** tab on the Excel Automation: Export Reports and Import Data dialog;

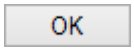
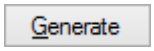


- Click  to open the **Export Tag Report** dialog;



- Use the  button to locate the Excel file that you just created and click the  button.

  You will be returned to the Export Tag Report dialog box with the full filename entered into the Excel Filename text box.

- Type **Report1** into the Report name text box. [The word *Report1* comes from the Keyword we have put into the Excel workbook earlier, recall the keyword was: SysCAD_TagList(***Report1***,V,5)]
- Click  to return to the Excel Automation dialog box.
- Select this entry and press the  button to create the Report.

  You will see Microsoft Excel open the report and display the message:

  ----- Please WAIT ----- (Excel is 'locked' until SysCAD is finished) -----

  On the **Status Bar**, you will be shown the progress of report generation. When finished, the active application will again be SysCAD.

- Close the dialog box;
- Switch to MS Excel and confirm that the report has been processed correctly.

Any errors encountered will be listed on the **Tag Errs** worksheet.

If you find messages such as "tagname" not found, this indicates incorrectly labelled tag names have been used. The error messages will display the location of the problem tags.

If there are errors, correct them and regenerate the report.

Remember to save the Excel spreadsheet BEFORE you try and generate a report from SysCAD.

11.3. Reporting SysCAD Values to Excel as a Table

11.3.1. Using Quick View to Setup a Report in Excel

The report type we will look at here is the common table format, where the stream name forms column headings and variable names form the row headings. This report type is especially useful for generating stream properties reports.

We would like to create the report shown below: We will define Columns A, B, C AND Row 8, SysCAD fill in data in cells D9 – F16.

	A	B	C	D	E	F
8			SysCAD_TagTable(Report2, H, 3, 8)	P_001	P_002	P_003
9	Description		GenDesc			
10	Mass Flow	t/h	Qm (t/h)			
11	Volume Flow	m^3/h	Qv (m^3/h)			
12	Temperature	C	T (C)			
13	Pressure	kPa	Po (kPa)			
14	Vapour Fraction	%	Qo.Vf (%)			
15	Liquid Fraction	%	Qo.Lf (%)			
16	Solid Fraction	%	Qo.Sf (%)			

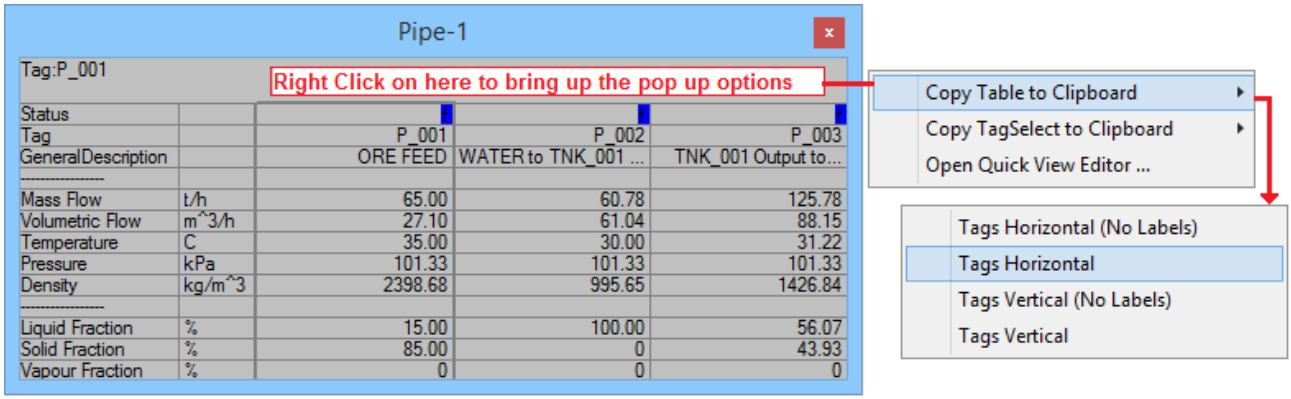
To make things easier, we will use the **Quick View List** that was introduced in Section 4.5 to construct our report.

Revision Task:

- If you have not already done so, customise the Quick View List for the pipe model so that it contains a list of tags that you would like to report, including appropriate labels.

By Example

- Build a **Quick View Table** containing P_001, P_002 and P_003 (Hint: Shift+Ctrl+Left Click).
- Right click on quick view table;
- Choose "Copy Table to Clipboard" – "Tags Horizontal".



- Go to the worksheet we have used previously;
- Paste the contents of the clipboard into cell A8.

A pre-defined SysCAD Report Table format will be pasted (as shown above).

Column A will be the labels, Column B will be the engineering units, and Column C will be the SysCAD variable Tags. The pipe names will be in row 8 (D8 – F8).

The SysCAD report keyword is in cell C8: **SysCAD_TagTable("", H, 3, 8)**

- The first part of this string **SysCAD_TagTable** is a report keyword, which SysCAD will search for during a report generation.

➢ Change the "" to **Report2.** This is the name of the SysCAD report.

- The **H** part of the string denotes the stream name is in the **Horizontal** plane (thus column headings). Another valid option is **V** for **Vertical**, where the stream names will be row headings.
- The next two numbers are the search length or maximum table size of the Get Tag reports in the form of number of columns and number of rows. In the example given, the table is of size **3** columns x **8** rows.

To manually add an additional tag to report use ***Copy Tag*** (right click on the variable name in SysCAD *Access Window*) instead of *Copy Full Tag* to copy just the variable part of the tag.

For example, when copying the mass flow of P_001, using

- *Copy Full Tag ----> P_001.Qm (t/h)* and
- *Copy Tag ----> Qm (t/h)* only.

➢ **Save** the file.
➢ Return to SysCAD;
➢ *Tools - Reports…* (OR OR <CTRL+R>);
➢ Add the report you have just created and **Generate** the report.

Hint:

Instead of adding each new report to SysCAD, once the file is selected, use "*" for the report name, then SysCAD will generate all reports in that file.

11.4. Reporting SysCAD Values to Excel Using Filters

When creating a SysCAD report, we can add in some filters to selectively choose tags that meet some pre-defined criteria. This is done using the Tag Select Report.

SysCAD Tag Select report syntax is:

SysCAD_TagSelect(Name, V/H, MaxColCount, MaxRowCount, Option1, {Option2,...}).

The first four parameters are the same as the SysCAD_TagTable(…) report we have used in the last example. The {} denotes optional selection parameters. The Options may be provided in any order and are not case sensitive.

There are many Example Tag-Select Expressions in our online help documentation, along with full explanation of each expression used. Please see the following link for more information.

http://help.syscad.net/index.php/Excel_Tag_Select_Reports_9.3

In this section, we will complete a couple of simple examples to introduce the Tag Select Report.

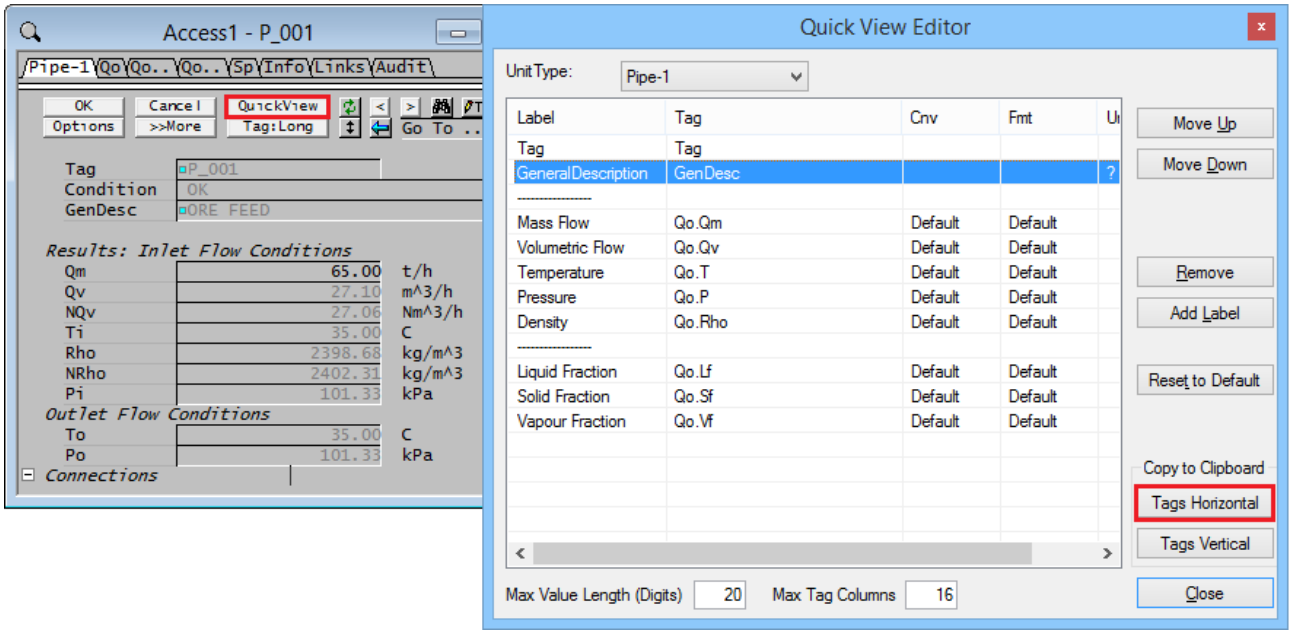
1. We want to extend the TagTable report we have completed before to include ALL the streams in the model automatically.
2. We want to apply a filter to only report streams that contain solids.

Again, we will use the **Quick View List** to help set up our report.

First we will use the Tag Select command to extract all the stream names from SysCAD. This is useful for generating a full stream report.

By Example

- Right click on any pipe;
- Press the QuickView button.
  This will open the **Quick View Tag List** dialog box;



- Press the Tags Horizontal button;
- Switch to the Excel workbook we have been using;
- Open a new worksheet;
- Paste the contents of the clipboard into cell A1.

As per the previous example, a pre-defined table format will be pasted into the worksheet:

	A	B	C
1			**SysCAD_TagSelect("Pipe-1", H, 250, 12, Select [UnitTpye] == "Pipe-1", Orderby [Graphic] [Tag], ClearTags: On)**
2	Tag		Tag()
3	GeneralDescription		GenDesc()
4	----------		
5	Mass Flow	t/h	Qo.Qm (t/h)
6	Volumetric Flow	m^3/h	Qo.Qv (m^3/h)
7	Temperature	C	Qo.T (C)
8	Pressure	kPa	Qo.P (kPa)
9	Density	kg/m^3	Qo.Rho (kg/m^3)
10	----------		
11	Liquid Fraction	%	Qo.Lf (%)
12	Solid Fraction	%	Qo.Sf (%)
13	Vapour Fraction	%	Qo.Vf (%)

This table is similar to the last example, with the following differences:

- The keyword used is different, it now contains a number of new expressions;
- The Pipe tag names (Table Column Headings) are no longer defined by the user. SysCAD will automatically generate all of the stream tags during the report generation step.

As we can see in the table, the SysCAD keyword is:

SysCAD_TagSelect("Pipe-1", H, 250, 12, Select [UnitType] == "Pipe-1", Orderby [Graphic] [Tag], ClearTags: On)

- The first part of this string SysCAD_TagSelect is a report keyword, which SysCAD will search for during a report generation.
- "Pipe-1" is the name of the SysCAD report.
- The H part of the string denotes the stream name is in the Horizontal plane (thus column headings). Another valid option is V for Vertical, where the stream names will be row headings.
- The next two numbers are the search length or maximum table size of the Get Tag reports in the form of number of columns and number of rows. In the example given, the table is of size 250columns x 12rows.
- The Select statement used here will include all Pipes and Direct Links as these all belong to the Stream Unit Group.
- The stream names will be Orderby Graphic (flowsheet) and then by Tag.
- The ClearTags option is on. This means SysCAD will clear the report contents and headings before a new report is generated.

➢ **Save** the file.
➢ Return to SysCAD;

➢ <**Menu Command**> **Tools | Reports**… (OR  OR <CTRL+R>);
➢ Add the report you have just created and **Generate** the report. This will produce a stream report for all the streams in the project.

Exercise

For Example 2, we will look at how to limit the data extracted from SysCAD. To demonstrate this we will extract only the streams which contain solids.

- Access the Pipe Quick View Editor as before and select 'Copy to Clipboard';
- Go to the same worksheet used in the previous example for Tag Select;
- Paste to the worksheet under the existing Tag Select report;
- Before generating the report, modify the Tag Select statement as shown below:

  SysCAD_TagSelect("Solid Streams", H, 1000, 20, Select [UnitGroup] == "Stream" **and [Qo.Sf (%)]>0**, Orderby [Graphic] [Tag], ClearTags: On)

- **Save** the file.
- Return to SysCAD;
- Run the report, as previously.

11.4.1. Some Example Tag Select Expressions for Report Generation

To extract only the streams from a specific flowsheet:

*SysCAD_TagSelect(Pipes, H, 100, 10, Select **[Graphic]=="Page1"** and [UnitGroup]=="Stream", OrderBy [Tag] Asc)*

Please see *View – PlantModel – Flowsheets* for list of flowsheets.
In this example, Page1 = 01.Autoclave.

To extract all the feeders (inlet and outlet) in a project, ordered by flowsheet number:

*SysCAD_TagSelect(Feeders, V, 1, 100, Select **[UnitType]==" FeederSink",** OrderBy [Graphic] Asc)*

To extract all the units which contain reactions, ordered by flowsheet number:

*SysCAD_TagSelect(Reactions, H, 80, 1, **Select [EB.Reactions]<>0 or [Reactions]<>0**, OrderBy [Graphic])*

To extract all pipes or direct links those have a tag starting with "P_":

*SysCAD_TagSelect(Streams, H, 80, 1, Select [UnitGroup] == "Stream" and **[Tag] like "P_.*"**)*

For more examples, please visit the online help file:

http://help.syscad.net/index.php/Excel_Tag_Select_Reports_9.3#Stream_Reports_Examples

11.4.2. Useful features of SysCAD Tag Report

- When a formula is present within the report search area. SysCAD reports will register the formula and skip over the cell leaving it untouched.
- Empty columns or rows are allowed within the search area. SysCAD will simply register them as incomplete tags and will leave the cells blank.

11.5. Setting a List of Values into SysCAD from Excel

11.5.1. Setting up the Set Tag List Report in Excel

We can set up a list of values in Excel and send them into SysCAD as project input data.

In this example, we will use a Set Tag List Report to set a handful of values in the model.

Notes:

Only configurable variables can be set (white cells).

Some example variables we can set into the model are: required flowrates, ratios, controller set points and so on.

By Example

Example data we want to send into Excel are:

	A	B
1	**SysCAD_SetTagList(Report3, V, 5)**	
2	STEAM.T_Reqd (C)	280
3	Autoclave_Control.Cfg.[1].Spt	140
5	Water_Control.TC[1].Ratio	1.2
4	Autoclave_Control.Cfg.[2].Spt	5
6	WashSolution_Control.TC[1].Ratio	3

We need to set up the Report Format as well as the required values in Excel.

- Switch to MS Excel and go to a new blank worksheet;
- In cell A1, type the text string: **SysCAD_SetTagList(Report3, V, 5)**

  The variables in the brackets have the same meanings as the TagList report we have looked at earlier. We need to copy the SysCAD tags to be set in the five cells immediately under cell A1.

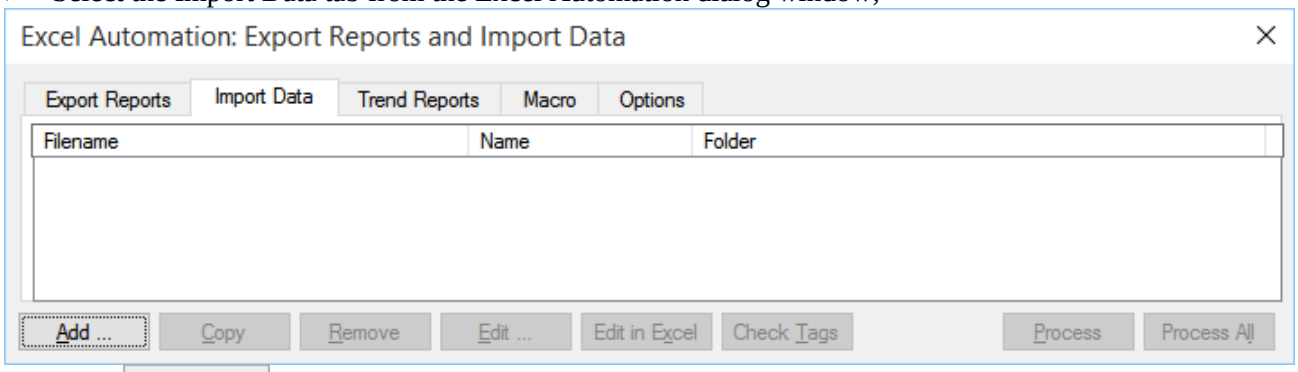
- Return to SysCAD;
- Right click on the Steam feeder to open its *Access Window*;
- Select the tag "T_Reqd" and press <CTRL+T> or right mouse click, Copy Full Tag;
- Return to Excel and paste the tag into cell A2;
- Repeat for "Autoclave_Control.Cfg.[1].Spt", the steam controller setpoint by opening the *Access Window* for Autoclave_Control, copying the setpoint tag and pasting it into cell A3;
- Repeat for "Water_Control.TC[1].Ratio", the ratio of water to ore feed set by the set tag controller by opening the *Access Window* for Water_Control, copying the **Ratio** tag and pasting it into cell A4;
- Repeat for two other tags of interest that you would like to set and paste the tags into cells A5 and A6.
    - **Note**: All tags in this list **MUST** be tags that can be set (i.e. in white boxes).
- Enter reasonable values for the five variables in the column **directly** adjacent to the SysCAD tags.
- **Save** the file.

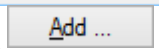
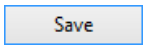
11.5.2. Importing Data into SysCAD from Excel

Once a SysCAD Set Tag Report is created and saved, we can import the values into SysCAD via the Excel Automation: Export Reports and Import Data Dialog box.

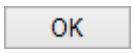
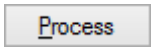
By Example

- Switch to SysCAD;
- *Tools - Reports…* (OR  OR <CTRL+R>);
- Select the Import Data tab from the Excel Automation dialog window;



- Click  to open the **Import Data (SetTags)** dialog;
- Click .
- Select the Excel file that you just created and saved and click the  button;

  You will be returned to the Import Data (SetTags) dialog box with the full filename entered into the Excel Filename text box.

- Click  to return to the Excel Automation dialog box. We will see that an entry has been made in the list box;
- Select this entry and press the  button to import the data.

  You will see Microsoft Excel open the report and display the message:
  ----- Please WAIT ----- (Excel is 'locked' until SysCAD is finished) -----

  On the Status Bar, you will be shown the progress of report processing.

  When finished, the active application will again be SysCAD.

- Close the dialog box;
- Switch to MS Excel and confirm that the report has been processed correctly. Any errors encountered will be listed in the Set Tag Errs worksheet. If you find messages such as “tagname” not found, there must have been incorrectly labelled tag names; the error messages will let you know the location of the problem tags. If this is the case, correct the error and re-process the report. Remember to save the Excel spreadsheet first though.
- Return to SysCAD;
- Check the data by right clicking on relevant Access Windows and check that the relevant variables have been changed as specified in the Set Tag List Report.

11.6. Setting a Table of Values into SysCAD from Excel

11.6.1. Setting up the Set Tag Table Report in Excel

Another type of set tag report is the SetTagTable report. The format of this report is the same as the TagTable report.

Exercise

➢ Create a report to enter the Feed Composition for the project.

Hint:

- Use the Report Keyword: **SysCAD_SetTagTable(Report, H, 20, 100)**
- Set the column headings as the names of the feeders
- Set the row headings as the fraction of each species in the project.
- The values can be imported into SysCAD the same way as the SetTagList we did earlier.

11.7. Other Useful Features and Examples

- Useful example Excel reports can be found in ..\SysCAD93\Examples\01 Example Reports. The most useful is Project Report.xlsx.
- Species Information Report – press 

button on Export Reports tab page.
- Starting SysCAD from Excel Macro. ..\SysCAD93\Examples\25 Nickel\Demo Nickel Copper Project.spf\Reports\ Project Report.xlsm

11.8. Review

In this module, you have learned how to:

- Export Data from SysCAD to MS Excel;
- Import Data into SysCAD from MS Excel.

Where to find more Tutorial Topics..

This is the last topic covered in this basic tutorial documentation. More Tutorial topics are available for Intermediate and Advanced SysCAD users. Please contact KWA Kenwalt for more information.

SECTION 12

12. PROJECT WORKFLOW SUMMARY

12.1. Module overview

This module summarises the steps needed to produce a SysCAD model.

The example projects we have done so far in the previous sections demonstrated the process of developing a SysCAD model. We have now summarised these in a step-by-step guide. When applicable, please refer to the completed tutorial projects and tutorial documentations to refresh your memory.

12.2. Before you start:

Define the ground rules – for all modellers working on the same project:

Naming and layout of the Graphics Pages:

1. Save the Graphics pages with appropriate names. Adding a PREFIX with an area number will help with the sorting of Graphics pages. For example, 01 Ore Handling; 02 Leaching; 03 Neutralisation, etc.
2. Agree on a standard graphics border and insert this on each new flowsheet page.
3. If the project is to be built by a number of people, then it is recommended that all users agree upon drawings and naming standards so the general look and feel is similar. For example, all the inputs (feeders) come from the left of the page, and all the outputs go to the right of the page.

Naming of unit operations including Pipes:

1. It is always good practice to use the correct names for pipes and unit operations when the project is created. This is especially important when more than a single modeller is working on the same project, but on different sections. If the projects are to be merged at a later stage, naming the unit operations correctly to start with will avoid any duplicate tag problems.
2. Naming the unit operations logically will make generating reports straightforward and manageable.

Maintaining the data files and project structure:

1. If more than one person is working on the same project, users should agree upon who is the master of the SysCAD.93.db3 and cfg files. This is very important, as you need to keep all the projects using the same set of species and using the same configuration file.
2. Users should also decide on where to keep all the project files.

12.3. Creating a SysCAD Project

Define the problem.

Clearly define the requirements or deliverables of the SysCAD modelling exercise.

Draw a sketch.

Sketch a Block Flow Diagram on paper, as this will assist with defining the model. Depending on the aim of this project (step 1), this Block Flow Diagram can be modified/simplified from the existing Process Flow Diagrams.

Creating a New Project Group.

Create a New Project group to store the project as well as the project configuration file and Species database.

Define the Chemical compounds to be used in the project.

Create/Edit the project Species Database and project Configuration File to include all required compounds.

Draw the Flowsheet(s) in SysCAD.

Transform the Sketch into a SysCAD flowsheet.

It is recommended to keep the flowsheets relatively simple and uncluttered, as this makes it simpler for users to understand the flowsheets.

Configure the unit operations

The first step is to set up the Feed Stream information, including the feed composition, temperature, pressure and flowrate.

Then configure all unit operations.

Add Chemical Reactions

Set up the necessary reaction files and load into the appropriate reaction blocks.

Add Control Strategy

A good SysCAD project model will have a control strategy to produce reliable results.

Users can use a combination of PIDs, Set Tag Controllers, Makeup Blocks and General Controllers to superimpose the control strategy.

Setup Trend Windows

In a Steady State project, the *Trend Window* can be set up to monitor the convergence of the solution and Key Performance Indicators (KPIs) for the model.

Key parameters can be trended to check the controllers' action or logic.

Setting up Excel Report(s)

MS Excel Reports can be set up to enter data into a SysCAD project as well as to report data.

This includes stream data, mass balances, water balance, etc.

The user may customise the report format to suit individual preference.

Save the Project

It is recommended to save the SysCAD project often to avoid loss of work.

12.4. Solving the SysCAD Project

Solve the Project

When the configuration of SysCAD unit operations is complete, reaction files and controllers are in place, the user can solve the project.

To check if the project has produced acceptable data, the *Trend Window* and SysCAD Reports can be used.

Debugging the SysCAD Project

SysCAD tries to provide as many error-messages as possible to help the user debug the project. If a project does not converge, the user should look at the following:

- Check that the data in the Species Database is correct.

- Check the process flowsheet - is a solution feasible? Have the flowsheets been correctly drawn, i.e., are connections correct? Are all cross page connectors connected properly?
- Feeder information - has the correct feed data been entered?
- The configuration of any SplitFlow sub-models – have these been correctly configured?
- The reaction files - are these correct reactions? Have the reaction extents been achieved? For example, has a reaction been starved of reagent?
- The control strategy - is this the correct way to control the process? What if the control was done in a different way?
- Are controllers at a limit or changing too fast to obtain a solution? Use the trend window to observe the behaviour of the controllers. If the controllers are too sensitive, slow them down.
- The report - are you reporting the correct streams? Looking at the latest reports?
- Create Overall mass balance report to see if material is going to the right places. Other reports such as Reaction report and PID reports can also be useful to check if the project is behaving as expected.

Saving the Base Case.

Once the project has been solved, it can be used as a base case for further work. That is, it can be used to check alternate configuration of the flowsheet or run models for different feed compositions and so on.

Hint:

Make sure back-ups are made for this base case project before making any significant changes to the flowsheet. Use **Save Project As** or **Save Project Version** to create projects for further work.

Making Changes to the Project

Changes made to the base case can be used to complete Sensitivity and Feasibility studies.

13. PULL-OUT SECTION

Tutorial Exercise Project – Leach and CCD Simulation

Aim

The aim of this tutorial exercise is to simulate a simplified leach process to dissolve metal, Nickel, Magnesium and Cobalt into solution for further downstream process. The unit operations used include: ore preparation, high pressure leaching, Counter Current Decantation (CCD) circuit and tailings neutralisation.

Process Description

Ore Preparation:

The ore feed will be diluted with water at a given ratio to ensure the leach feed slurry will be pumpable.

High Pressure Leaching

The valuable metals (Ni, Mg, Co) will be leached using concentrated H2SO4 to form soluble sulphates. Acid addition will be in excess to keep the leached solution acidic. Steam is added to maintain reactor temperature.

CCD Circuit:

The leached slurry will first be cooled then washed and decanted in 3 stages. The amount of wash added to the CCD circuit is based on the solids feed to washer 1. Washer 1 overflow will report to downstream processing and the Washer underflow will be sent to tailings neutralisation.

Tailings Neutralisation:

The tailings will be neutralised with NaOH and sent to Tailings storage.

Process Criteria

Ore Feed

Ore Feed		Units
Mass Flow	65.0	t/h
Temperature	35.0	°C
Moisture	15.0	wt%
Solids (dry wt%)		
CoO(s)	0.5	wt%Sol
Fe2O3(s)	30.0	wt%Sol
MgO(s)	8.0	wt%Sol
Na2CO3(s)	2.0	wt%Sol
NiO(s)	1.8	wt%Sol
SiO2(s)	57.7	wt%Sol

Water Addition to Ore Prep Tank

1.1 tonne of water added per tonne of dry ore feed.

Autoclave:

Steam Feed		Units
Mass Flow	Calculated	t/h
Temperature	275	°C
Pressure	At Saturation	kPa abs

Concentrated Acid		Units
Mass Flow	Calculated	t/h
Temperature	30	°C
H2SO4(l)	98.3	wt%

- *Pressure*: 15 bar,
- *Temperature* Target 150 C
- Excess Acid**:** 2 g/L H2SO4(aq) (autoclave outlet)
- Nickel and Cobalt: 95% dissolution
- Magnesium: 100 % dissolution
- Sodium sulphate concentration in leached solution: 2.75 g/L

Reactions:

1 NiO(s) + 1 H2SO4(aq) = 1 NiSO4(aq) + 1 H2O(l)
Extent : Fraction NiO(s) = 0.95

1 CoO(s) + 1 H2SO4(aq) = 1 CoSO4(aq) + 1 H2O(l)
Extent : Fraction CoO(s) = 0.95

1 MgO(s) + 1 H2SO4(aq) = 1 MgSO4(aq) + 1 H2O(l)
Extent : Fraction MgO(s) = 1

1 Na2CO3(s) + 1 H2SO4(aq) = 1 Na2SO4(aq) + 1 CO2(g) + 1 H2O(l)
Extent : FinalConc Na2SO4(aq) = 2.75

CCD Circuit:

Cooled Leach Solution Feed to CCD: 50 ºC

Heat Loss in Washer 1 – Temperature drop of 1 ºC

Wash water to Last washer: 2 tonnes water per tonne of solids in CCD feed

Tailing Neutralisation:

Fully neutralise the acid using NaOH.

Sodium Hydroxide		Units
Mass Flow	Calculated	t/h
Temperature	30	°C
NaOH(aq)	50	wt%

Reactions:

1 H2SO4(aq) + 2 NaOH(aq) = 1 Na2SO4(aq) + 2 H2O(l)
Extent : Fraction H2SO4(aq) = 1

Figure 1. 05_Flowsheet (Autoclave).scg

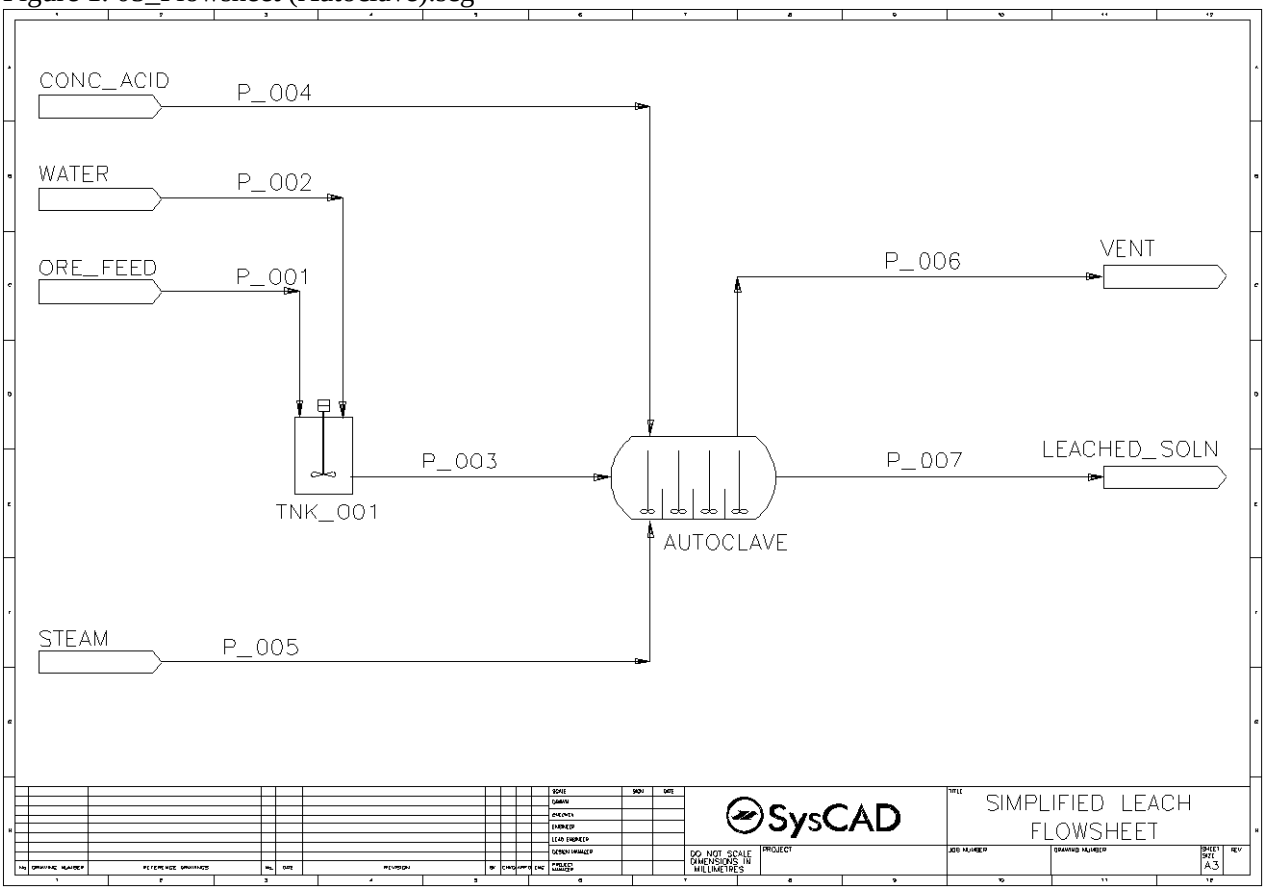


Figure 2 10_Flowsheet (Before copy & Paste in Section 7)

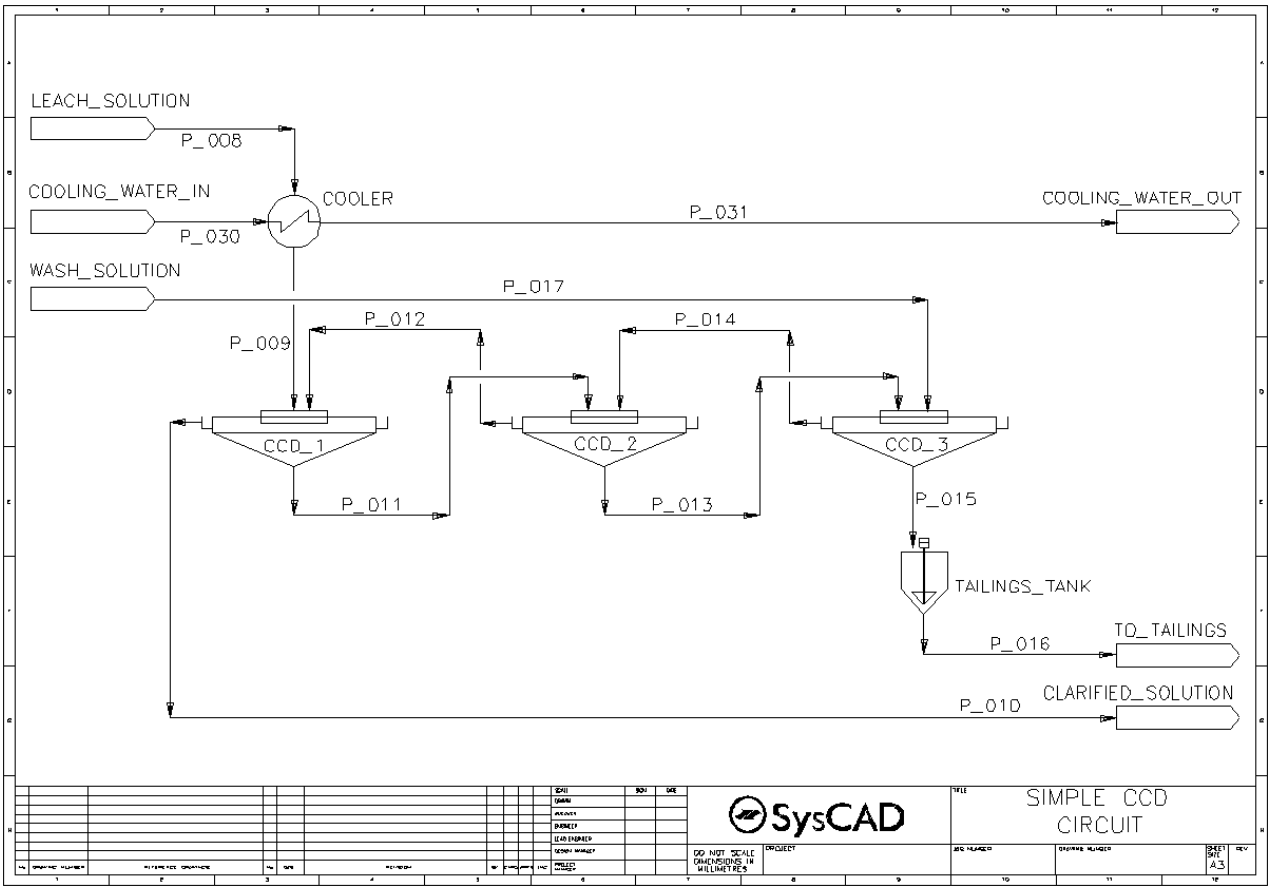


Figure 3 10_Flowsheet (After copy & Paste in Section 7) CCD Stage 1-3

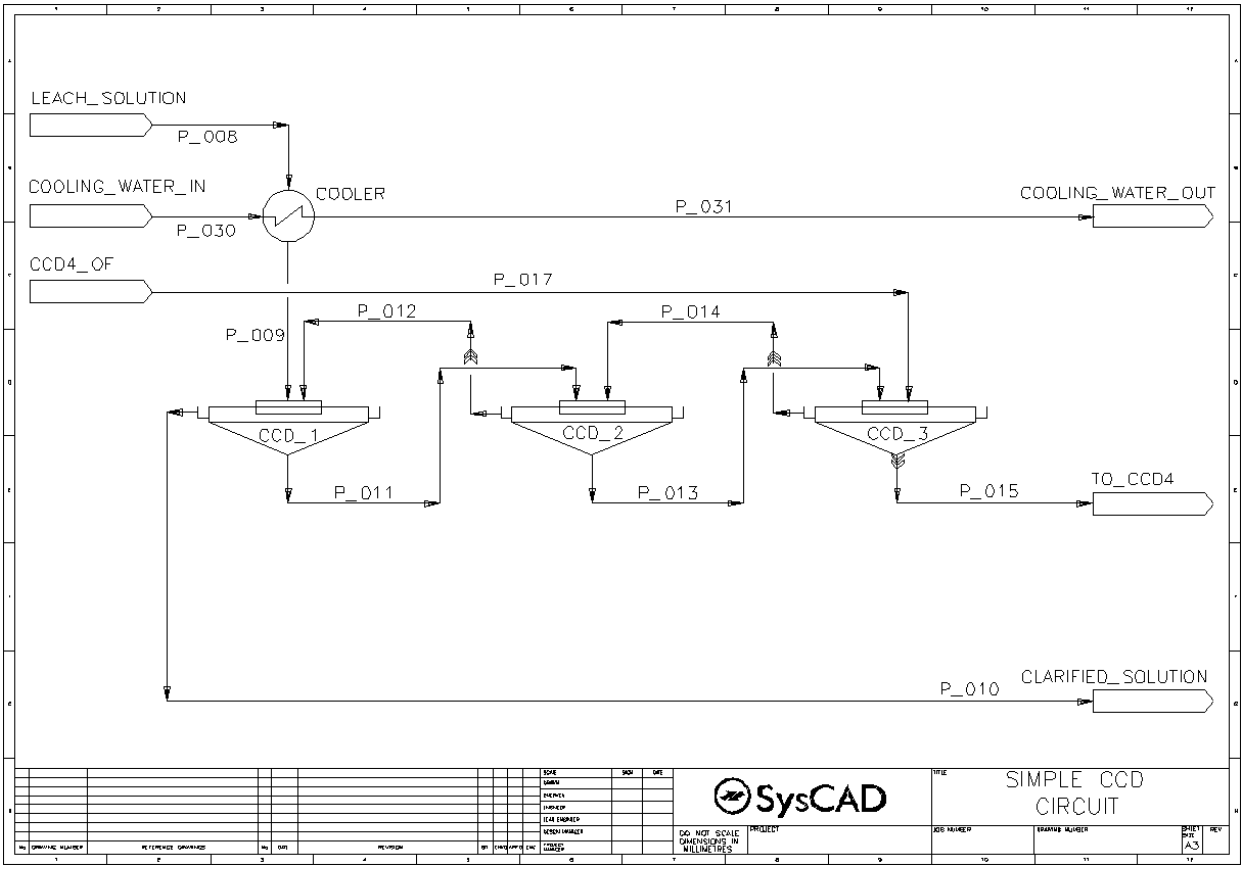
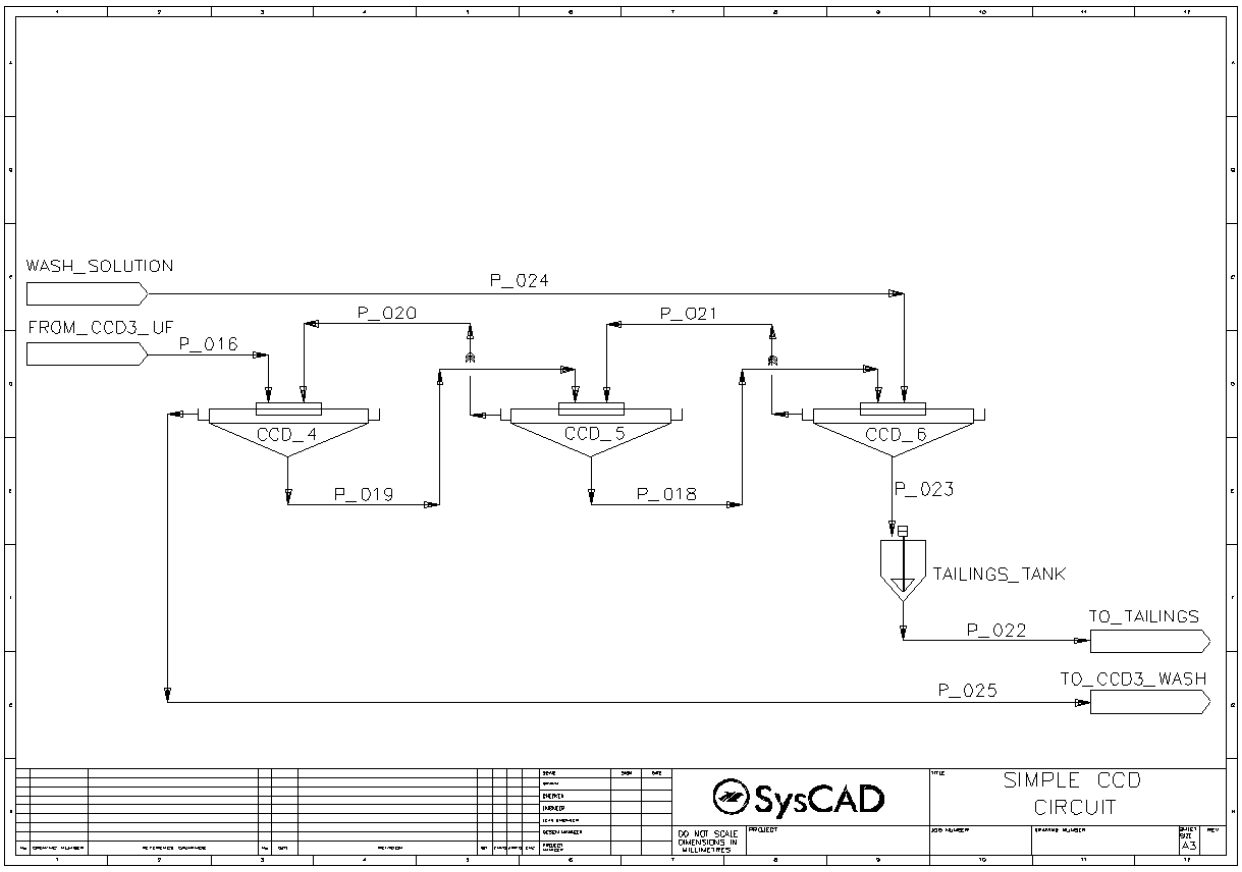


Figure 4 15_Flowsheet (After copy & Paste in Section 7) CCD Stage 4-6



Summary Table for all Unit Operation used in the Project (Before Copy & Paste in Section 7):

Operation Type	Graphics Symbol used	Tag	Scale (%)		Rotation
			X	Y	
Flowsheet Autoclave Leach					
Process – Feeder/Sink/CrossPage	Feed | Feeder04_TagTopLeft	Ore_feed	100	100	0
	Feed | Feeder04_TagTopLeft	Water	100	100	0
	Feed | Feeder04_TagTopLeft	Conc_acid	100	100	0
	Feed | Feeder04_TagTopLeft	Steam	100	100	0
	Feed | Feeder04_TagTopLeft	Leached_soln	100	100	0
	Feed | Feeder04_TagTopLeft	Vent	100	100	0
Process – Tank(1)	Tank | Agitated	Tnk_001	100	100	0
	Tank | LeachTank_4C	Autoclave	125	125	0
Flowsheet CCD Circuit					
Process – Feeder/Sink/CrossPage	Feed | Feeder04_TagTopLeft	Leach_Solution	100	100	0
	Feed | Feeder04_TagTopLeft	Cooling_Water_In	100	100	0
	Feed | Feeder04_TagTopLeft	Cooling_Water_Out	100	100	0
	Feed | Feeder04_TagTopLeft	Wash_Solution	100	100	0
	Feed | Feeder04_TagTopLeft	Clarified_Solution	100	100	0
	Feed | Feeder04_TagTopLeft	To_Tailings	100	100	0
Separation - Thickener - Washer	WasherDecanter | Default	CCD_1	120	120	0
	WasherDecanter | Default	CCD_2	120	120	0
	WasherDecanter | Default	CCD_3	120	120	0
Process – Tank(1)	Tank | Agitated2	Tailings_Tank	100	100	0
Heat Transfer – Simple Heat Exchanger	HeatExchange | HX	Cooler	100	100	0

Summary Table for all Links used in the Project (Before Copy & Paste in Section 7):

Tag	Source unit	Source IOTag	Destination unit	Destination IOTag
Flowsheet Autoclave Leach				
P_001	Ore_feed		TNK_001	Input
P_002	Water	-	TNK_001	Input
P_003	Tnk_001	Output	Autoclave	Input
P_004	Conc_acid	-	Autoclave	Input
P_005	Steam	-	Autoclave	Input
P_006	Autoclave	Output	Vent	-
P_007	Autoclave	Output	Leached_soln	-
Flowsheet CCD Circuit				
P_008	Leach_Solution	-	Cooler	PriIn
P_009	Cooler	PriOut	CCD_1	Washer_Feed
P_010	CCD_1	Washer Overflow	Clarified_Solution	-
P_011	CCD_1	Washer_Underflow	CCD_2	Washer_Feed
P_012	CCD_2	Washer Overflow	CCD_1	Washer Input
P_013	CCD_2	Washer_Underflow	CCD_3	Washer_Feed
P_014	CCD_3	Washer Overflow	CCD_2	Washer Input
P_015	CCD_3	Washer_Underflow	Tailings_Tank	Input
P_016	Tailings_Tank	Output	To_Tailings	-
P_017	Wash_Solution	-	CCD_3	Washer Input
P_030	Cooling_Water_In	-	Cooler	SecIn
P_031	Cooler	SecOut	Cooling_Water_Out	-

Summary Table for all Unit Operation used in the Project (After Copy & Paste in Section 7):

Operation Type	Graphics Symbol used	Tag	Scale (%)		Rotation
			X	Y	
Flowsheet Autoclave Leach (Unchanged)					
Flowsheet CCD 1-3 Circuit					
Process – Feeder/Sink/CrossPage	Feed | Feeder04_TagTopLeft	Leach_Solution	100	100	0
	Feed | Feeder04_TagTopLeft	Cooling_Water_In	100	100	0
	Feed | Feeder04_TagTopLeft	Cooling_Water_Out	100	100	0
	Feed | Feeder04_TagTopLeft	CCD4_OF	100	100	0
	Feed | Feeder04_TagTopLeft	Clarified_Solution	100	100	0
	Feed | Feeder04_TagTopLeft	To_CCD4	100	100	0
Separation - Thickener - Washer	WasherDecanter | Default	CCD_1	120	120	0
	WasherDecanter | Default	CCD_2	120	120	0
	WasherDecanter | Default	CCD_3	120	120	0
Heat Transfer – Simple Heat Exchanger	HeatExchange | HX	Cooler	100	100	0
Flowsheet CCD 4-6 Circuit					
Process – Feeder/Sink/CrossPage	Feed | Feeder04_TagTopLeft	From_CCD3_UF	100	100	0
	Feed | Feeder04_TagTopLeft	CCD4_OF	100	100	0
	Feed | Feeder04_TagTopLeft	To_Tailings	100	100	0
	Feed | Feeder04_TagTopLeft	To_CCD3_Wash	100	100	0
Separation - Thickener - Washer	WasherDecanter | Default	CCD_4	120	120	0
	WasherDecanter | Default	CCD_5	120	120	0
	WasherDecanter | Default	CCD_6	120	120	0
Process – Tank(1)	Tank | Agitated2	Tailings_Tank	100	100	0

Summary Table for all Links used in the Project (After Copy&Paste in Section 7):

Tag	Source unit	Source IOTag	Destination unit	Destination IOTag
Flowsheet Autoclave Leach (Unchanged)				
Flowsheet CCD 1-3 Circuit				
P_008	Leach_Solution	-	Cooler	PriIn
P_009	Cooler	PriOut	CCD_1	Washer_Feed
P_010	CCD_1	Washer Overflow	Clarified_Solution	-
P_011	CCD_1	Washer_Underflow	CCD_2	Washer_Feed
P_012	CCD_2	Washer Overflow	CCD_1	Washer Input
P_013	CCD_2	Washer_Underflow	CCD_3	Washer_Feed
P_014	CCD_3	Washer Overflow	CCD_2	Washer Input
P_015	CCD_3	Washer_Underflow	TO_CCD4	-
P_017	Wash_Solution	-	CCD_3	Washer Input
P_030	Cooling_Water_In	-	Cooler	SecIn
P_031	Cooler	SecOut	Cooling_Water_Out	-
Flowsheet CCD 4-6 Circuit				
P_016	From_CCD3_UF	-	CCD_4	Washer_Feed
P_018	CCD_5	Washer_Underflow	CCD_6	Washer_Feed
P_019	CCD_4	Washer_Underflow	CCD_5	Washer_Feed
P_020	CCD_5	Washer Overflow	CCD_4	Washer Input
P_021	CCD_6	Washer Overflow	CCD_5	Washer Input
P_022	Tailings_Tank	Output	To_Tailings	-
P_023	CCD_6	Washer_Underflow	Tailings_Tank	Input
P_024	Wash_Solution	-	CCD_6	Washer Input
P_025	CCD_4	Washer Overflow	To_CCD3_Wash	-