Step-by-Step Guide to Nelprof® 6 Control Valve Selection Software

Jon Monsen, PhD, PE

http://www.control-valve-application-tools.com

This guide is applicable to Nelprof Version 6.0.3 through 6.2.5. Depending on the version of Nelprof you are using you may see minor differences from the screen shots herein. Future versions may function differently or have different features. From time-to-time Metso adds new products to the list of valves for which sizing coefficients are included and fixes bugs. If you make serious use of Nelprof to select Metso valves you should make sure you are using the most up-to-date version.

Disclaimer

This guide was prepared by an experienced user of Nelprof. He has no affiliation with Metso and no endorsement of this guide by Metso is implied.

This guide is furnished at no cost on an as-is basis. The author has made a reasonable effort to ensure the accuracy and completeness of the information herein. However, the information contained in this guide is provided without any representation or warranty as to accuracy or completeness or otherwise and should be used only as a general guideline and not as an authoritative source of technical information. The author will not be held liable for any injury, loss, damage or disruption caused, or alleged to be caused, either directly or indirectly, by the information contained in this guide.

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Nelprof features

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- Any combination of units
- Graphical representation of application
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Unlike many valve manufacturer supplied valve sizing programs that only support valves of that manufacturer, Nelprof also includes generic data files for most of the common control valve styles.

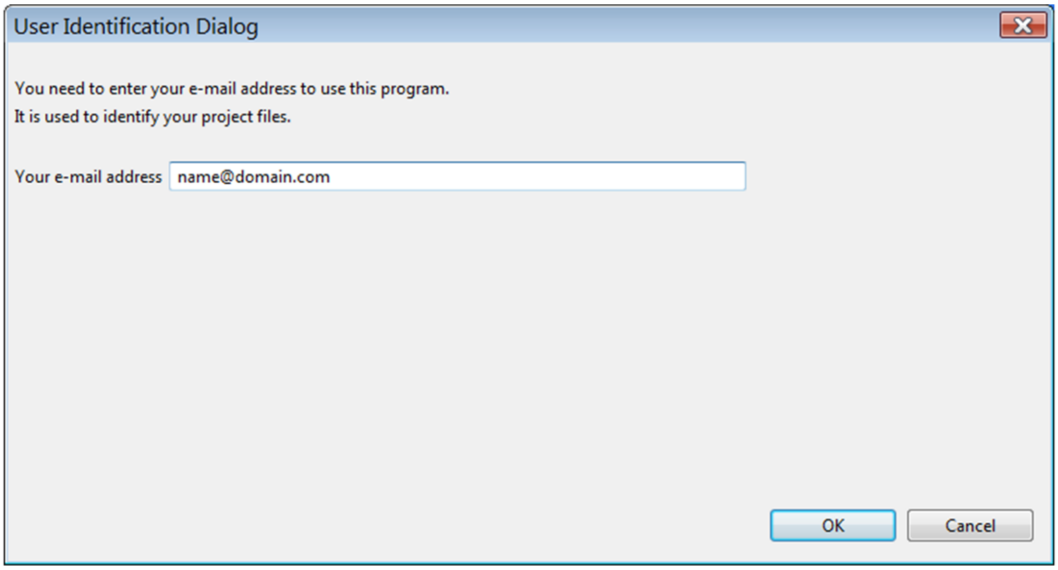
The “Graphical representation of application” point refers the Nelprof’s ability to graph the installed characteristic and installed gain of a control valve. These graphs give a great deal of insight as to how well a particular valve will be able to control a particular process.

The subjects of installed flow and installed gain are discussed in articles that can be found on he “LINKS” tab at:

www.control-valve-application-tools.com

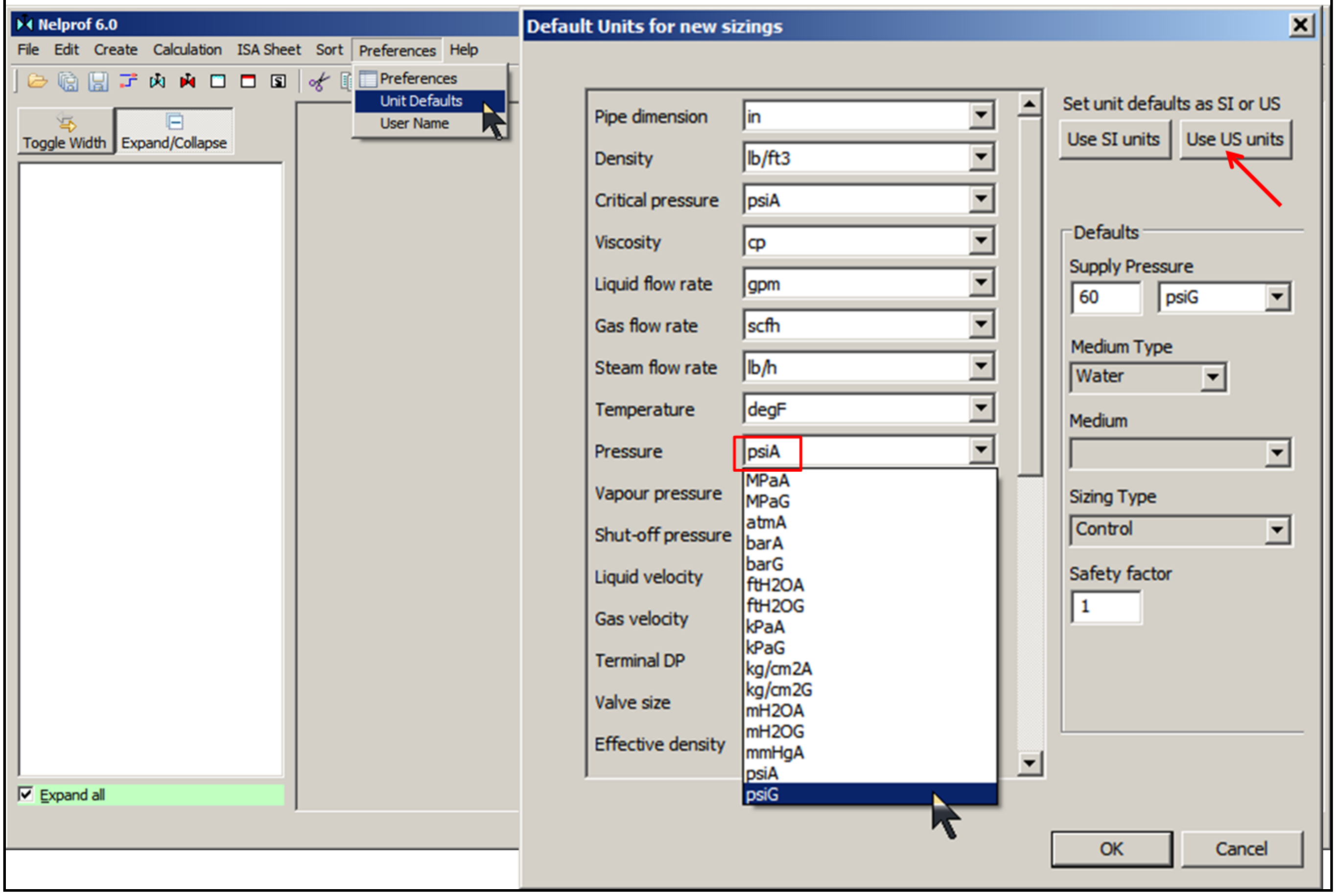
The subject is also covered in Valin Corporation’s book *Control Valve Application Technology.* Details about this book can be found on the “BOOKS” tab on the above web site.

User identification



The first time you start Nelprof, it will ask you to enter your e-mail address. Don’t worry, the program won’t send you any e-mails. When you print out any valve sizing calculations, there is a place at the top of the sizing sheet that says “Created by” followed by whatever appears before the “@” symbol. The printout will show any uppercase letters you type as lower case. Click OK when you are finished.

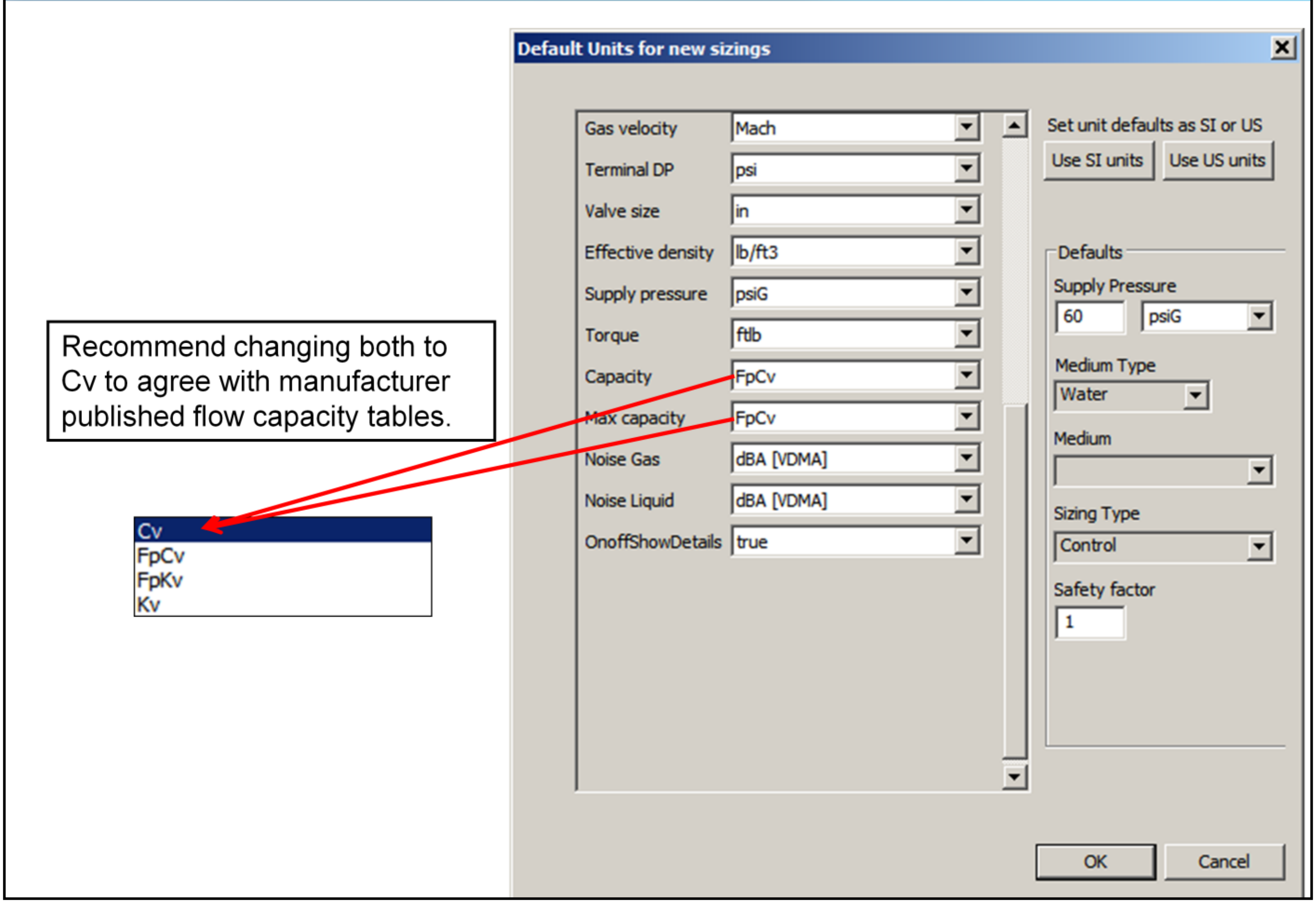
Set default engineering units



By default, Nelprof uses the SI system of engineering units. If you want to use US units, you can change the default units to US. From the menu select Preferences > Unit defaults. The “Default Units for new sizings” dialog appears. Click the “Use US units” button and all the units will change to US units. In general you will probably be satisfied with the units the program has selected for each parameter. One possible exception is that the program sets up “psiA” for pressure units. If you normally like to use psiG, change it now. Open the drop down list for Pressure and select psiG.

The list of units is longer than will fit on one screen. On the next slide is the units scrolled down so you can see the rest of it.

Set default engineering units (continued)



The valve’s “Max capacity” (that is the manufacturer’s rated fully open capacity) and “Req capacity” (the valve capacity calculated by the program for each column of process data) can be chosen to be either Cv or Kv, or FpCv or FpKv. Cv or Kv are the capacity values published by the valve manufacture in their capacity tables. FpCv or FpKv are defined in the ISA/IEC valve sizing equation standards as the effective flow capacity of the combination of valve with attached pipe reducers. Most people would prefer the units to be Cv rather than FpCv since Cv is what is published by the valve manufacturers.

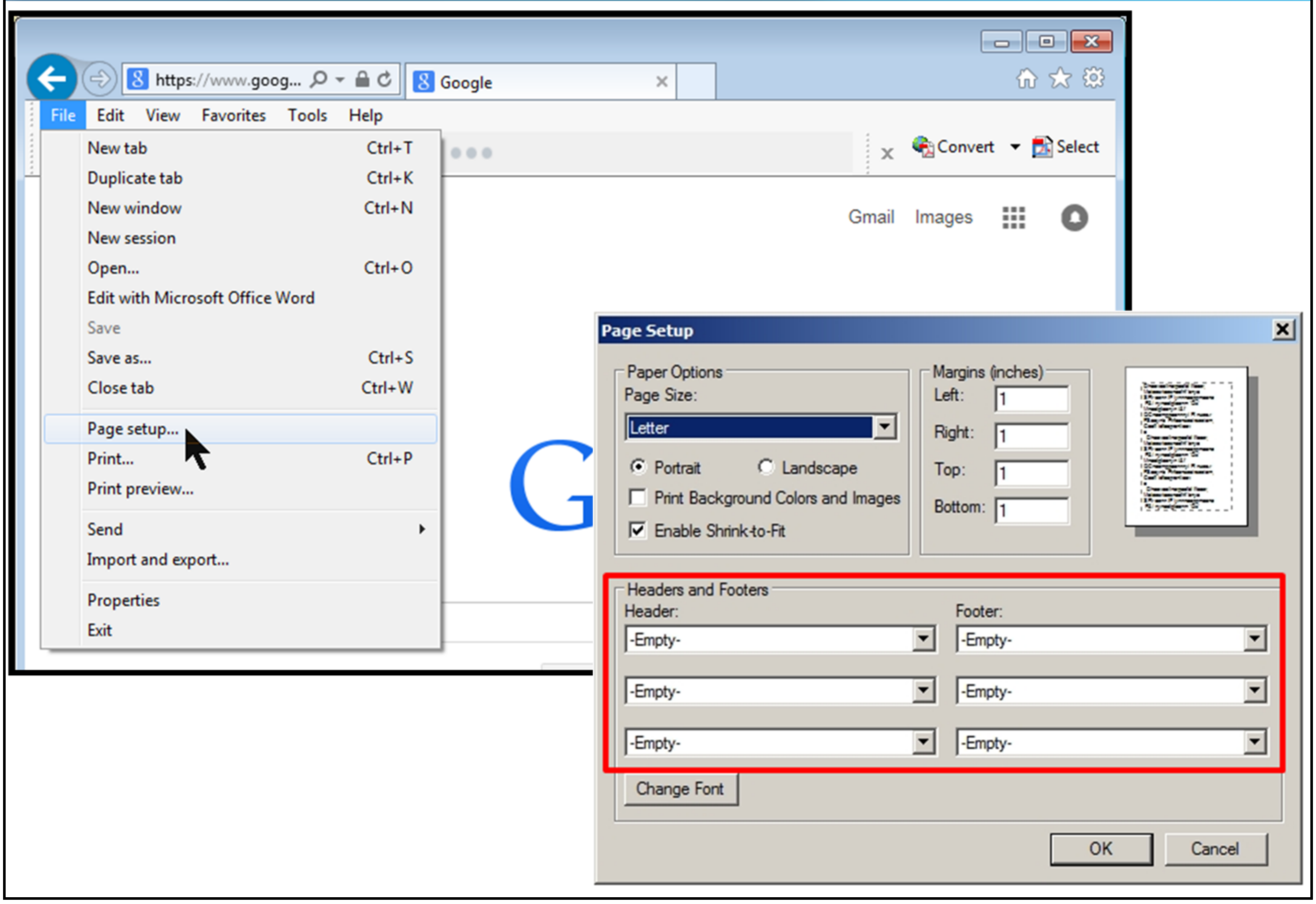
You can also have the default noise calculations be by the German VDMA method or by the IEC method. Neles’ noise recommendations for avoiding cavitation damage are based on the VDMA method. If you plan to use the generic valve files, only the VDMA method works tor them.

You have the option to select the air supply pressure you are most likely to use for actuator sizing. You also need to choose which medium type you expect to do valve sizing for most frequently. The choices are: Liquid, Water, Pulp, Gas, Steam and 2-Phase. If you select either Liquid or Gas, then you can choose the particular liquid or gas that you will do sizing for most frequently from the “Medium” drop down list (providing that your medium is in the list).

At a later date, you can come back to this screen and change your global default units. The changes will only apply to new sizings, not to ones you have already done.

You will see later how you can also assign different sets of default units that will apply to only one project.

Printing setup



Header and footer fields should be cleared in your Windows internet browser page setup.

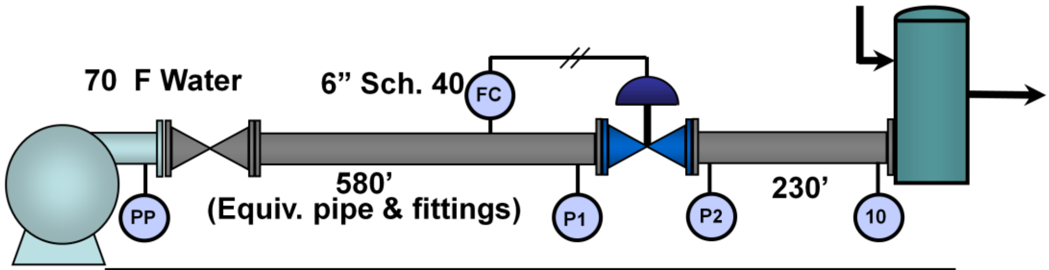
With any web page displayed in Internet Explorer, from the File menu, select “Page setup” and make sure all Header and Footer entries are set to “Empty.”

Possible help file problem

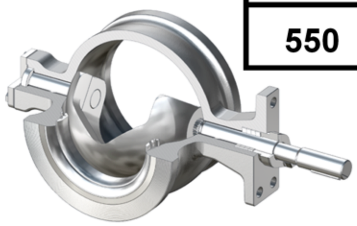
If the screen shots are missing when you open the *Nelprof 6 User's Manual* from the help menu, do the following:

Go to "C:\Program Files\Metso\Nelprof6\help" in Windows Explorer and rename the folder "Nelprof6_files" to read "Nelprof5_files."
This was a problem in some earlier versions of Nelprof 6, but it is not a problem in Nelprof 6.0.6

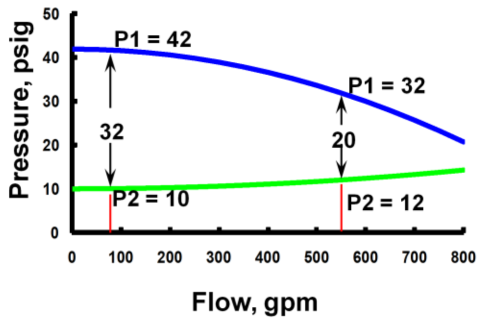
Nelprof sizing example



Flow gpm	P_P psig	Pipe Loss (up)	P_1 psig	Pipe Loss (down)	P_2 psig	ΔP
80	42	0.1	42	0.05	10	32
550	37	5	32	2	12	20



=% Inherent characteristic



To demonstrate how to use Nelprof, we will start out with a sample valve sizing and selection exercise that will show how to select the best valve for an application by considering the installed characteristic and installed gain.

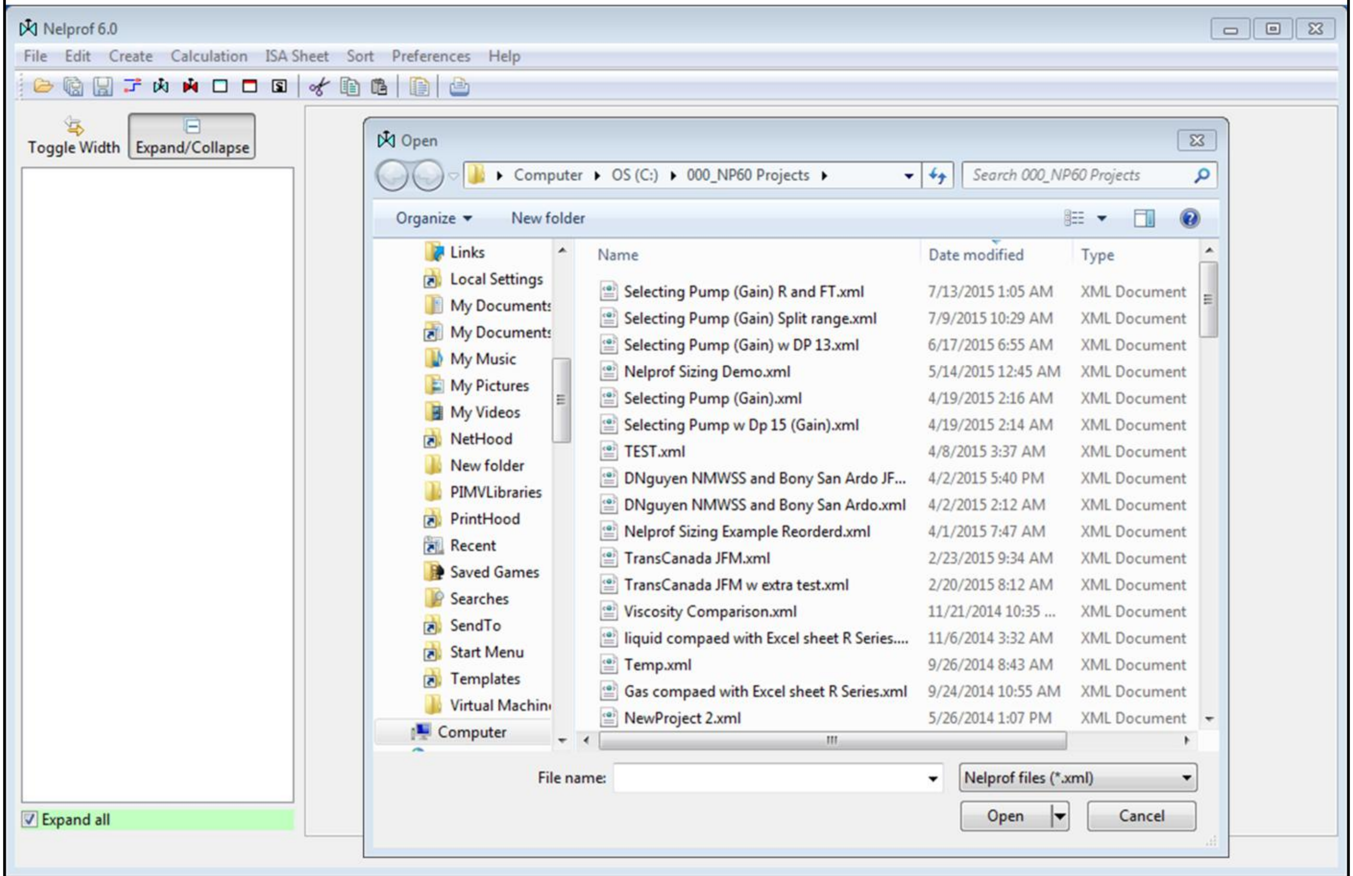
Our task is to select a properly sized Neles R SERIES SEGMENT BALL control valve. The process data is given in the table. By entering at least the maximum and minimum flows, along with the upstream pressure, P1, and either the differential pressure or P2 at those flow rates, the program can calculate how P1 and P2 will behave at all flow rates by fitting parabolic curves to the data, using a least squares curve fit. The graph shows how P1, P2 and ΔP vary with flow.

The program has the inherent flow characteristics of all Neles and Jamesbury valves, plus generic inherent flow characteristics for the most popular valve types.

Knowing both how the system behaves and what the valve's inherent flow characteristic is, Nelprof can calculate the valve's installed characteristic and installed gain.

For this example things like choked flow, noise, and velocity do not affect the selection, allowing us to concentrate on installed characteristics and gain.

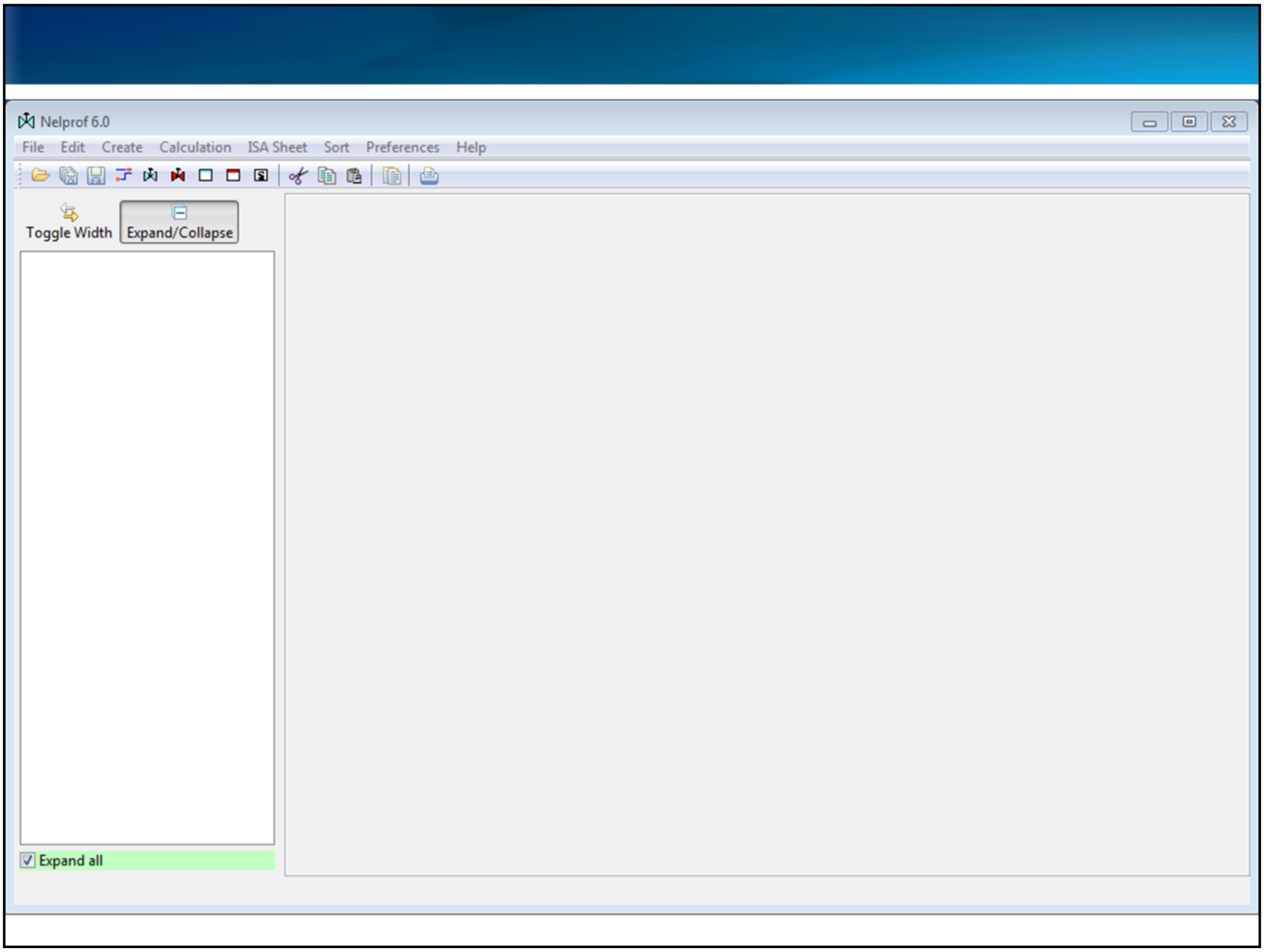
Open a previously saved project



Once Nelprof has been configured with your name,(e-mail address), the set of engineering units you want to use and your web browser configured for printing Nelprof results, when you start Nelprof, this is what you will see.

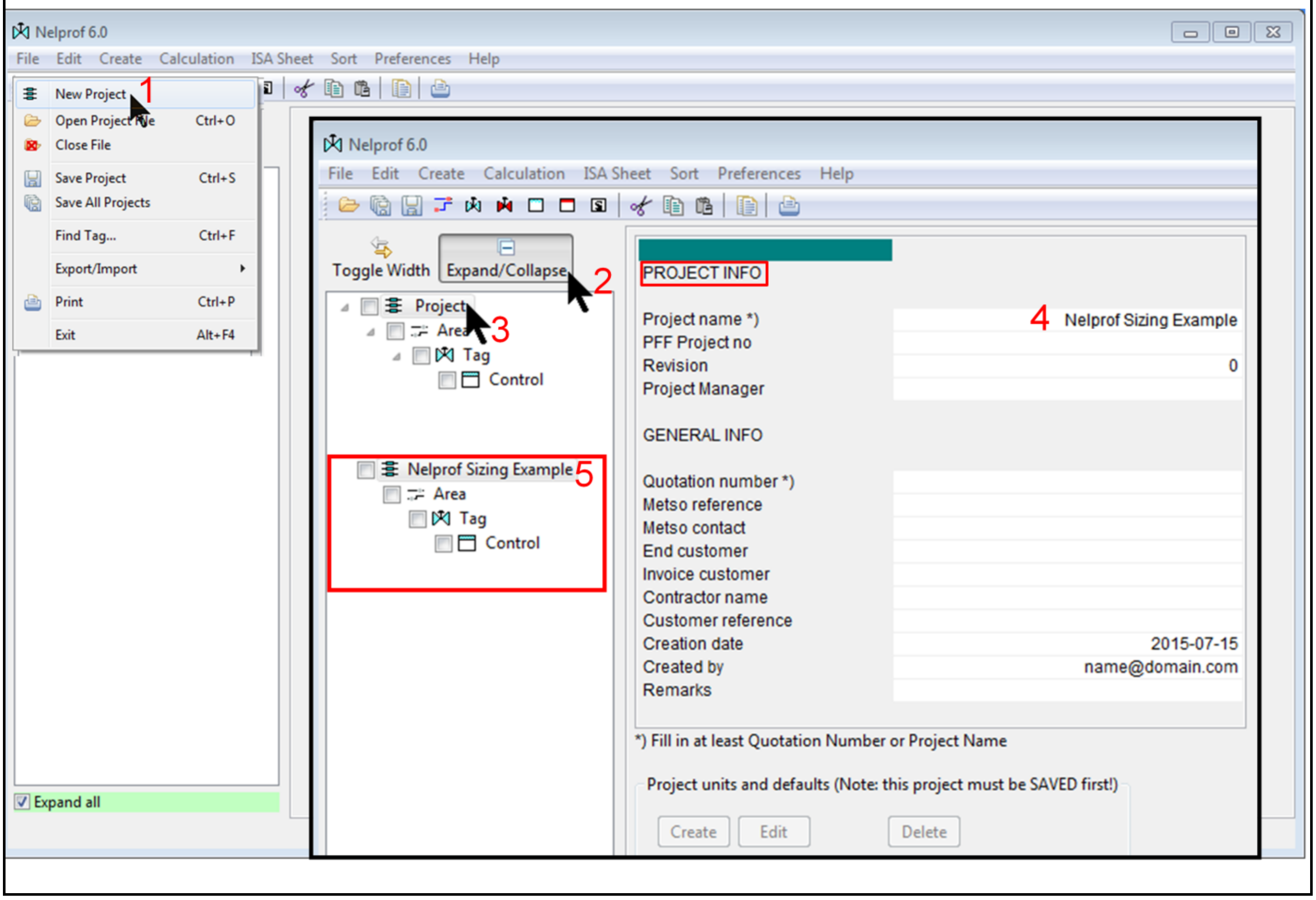
If you want to work on an existing project, select it from this screen.

If you want to start a new project, as we will be doing for this demonstration, close this “Open” dialog by clicking the Cancel button.



After closing the “Open” dialog this is what you will see

Start a new project



1. From the menu, select File > New Project. An item appears in the Project Tree window with the default project name of “Project” (where arrow 3 is pointing)

2. Click twice on the “Expand/Collapse” button. The project tree expands to show three items below “Project.” An “Area,” under the Area a “Tag” and under the Tag a sizing calculation, with the default name of “Control.”

3. Click on “Project.” The PROJECT INFO dialog window appears.

4. Type in the name of the project.(In this example it is “Nelprof Sizing Example.” The program has entered “0” in the “Revision” field, the current date in the “Creation date” field and your e-mail address in the “Created by” field.

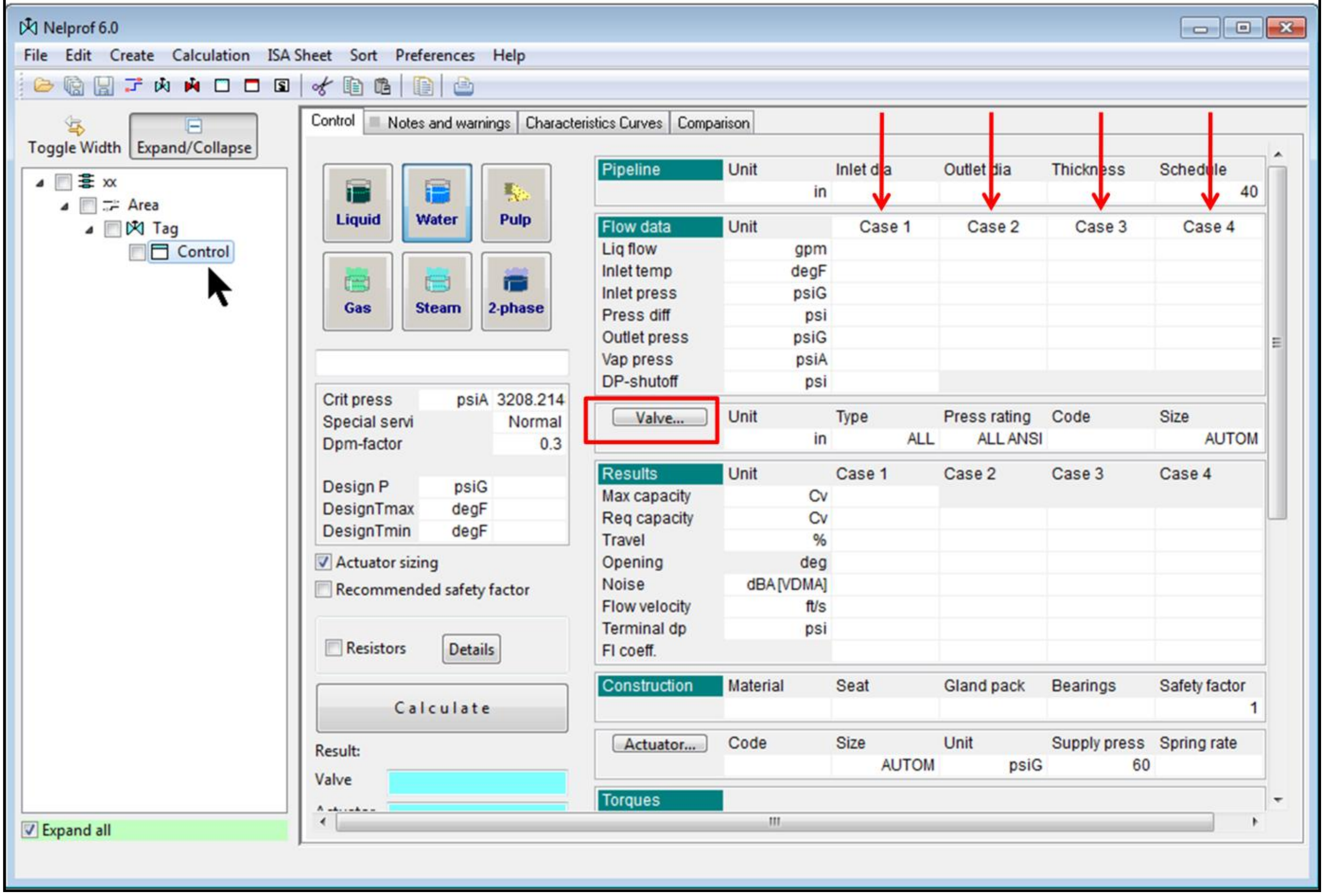
5. As soon as you save the project the project's default name of “Project” changes to the name you typed into the “Project name” field.

This is a good time to save the project. When you select “Save Project” from the File menu, Nelprof will prompt you for a file name. A good choice for the file name would be the same thing you have entered in the “Project name” field.

Each project is saved as an individual file, making it easy to work on the project on a different computer, or share it with another person who has a copy of Nelprof.

When creating a new project, you can choose default units for that project that differ from the set of units that you have selected as your global default units. To do this, you must have first saved the project, then you must click to open another item in the tree (for example the “Area” item) and then click back on the “Project” item on the tree to reopen this PROJECT INFO screen. You can then, in the Project units and defaults dialog near the bottom of the screen, click on “Create” and then select the set of units that will be the defaults for that project only. If, after you have done some calculations for this project, come back here and create or edit the units for the project, the changes will only apply to new sizings, not to ones you have already done.

Start a new sizing calculation

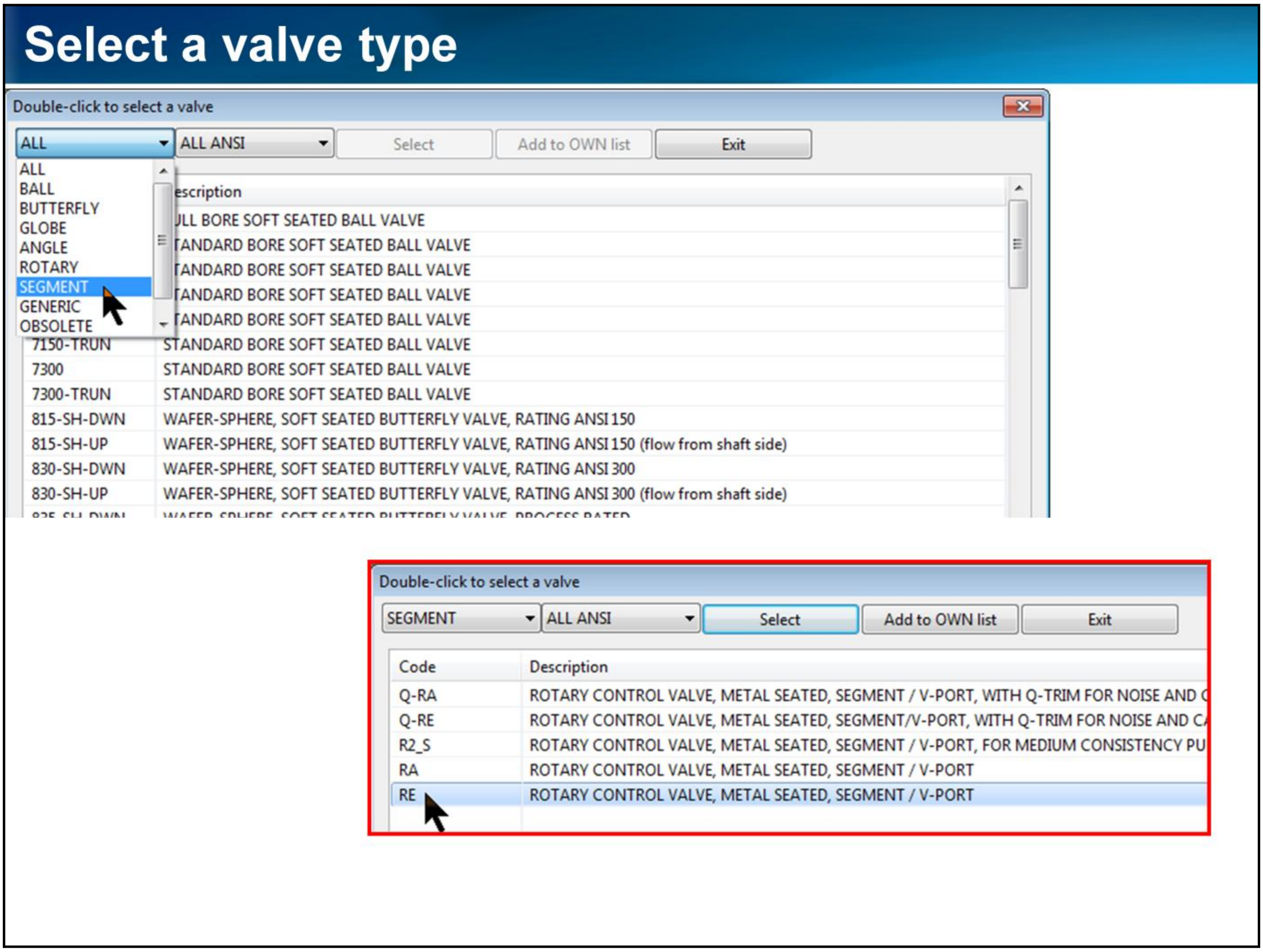


To begin a sizing calculation, click on the item in the project tree named “Control.” (Control is the default name for a sizing calculation, which you can change later to help keep track of several trial calculations for the same valve.)

When this particular copy of Nelprof was configured for the default set of engineering units, Water was selected as the default media type, so when the “Control” was clicked, the Water calculation screen came up. Since our sample exercise is for water, this is the sizing screen we want. There are buttons for the other possible media.

Nelprof can do sizing calculations for up to four sets of process conditions.

Start the calculation process by selecting the valve type you want to do a calculation for. Click the “Valve…” button.



A list of valve types appears.

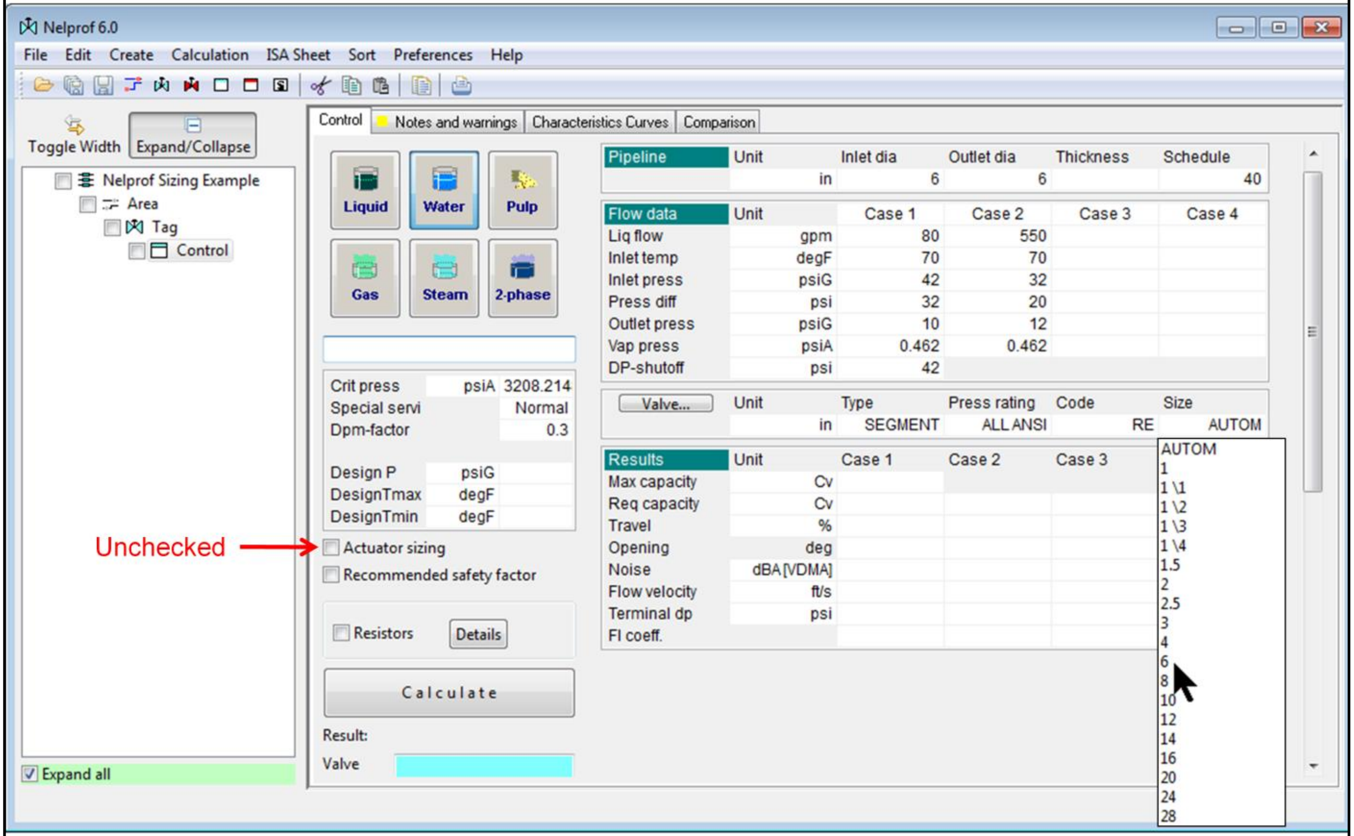
From the drop down list at the upper left of the valve selection window, select “SEGMENT.” A list of all the Neles segment ball valves appears.

Double click on “RE   ROTARY CONTROL VALVE, METAL SEATED, SEGMENT / V-PORT” (The model “RE” is the standard construction Neles segment ball valve that is marketed in North America.

You will be returned to the main water sizing screen

Note that there is a “GENERIC” category. In the generic category are valve characteristic tables, without being identified with a Neles or Jamesbury name or model, of several common control valve types.

Enter process data



In the line where valve information goes, the Type is SEGMENT, the Pressure rating has remained “All ANSI” (which is the default) and the Code is “RE” which is the model number we selected on the previous page, and the size is the default “AUTOM” for automatic.” If the Size field is left at “AUTOM” the program will select the size of RE segment ball valve that it thinks is the best choice. AUTOM is actually a pretty good choice for general sizing. For this example the program would choose a 3 inch valve, which we will see is the best choice. Sometimes you might end up choosing a size other than Nelprof’s recommendation. One example of this is that if a particular valve would be 80.5% open at maximum flow, it would select one size larger valve because it prefers valves that are not over 80% open.

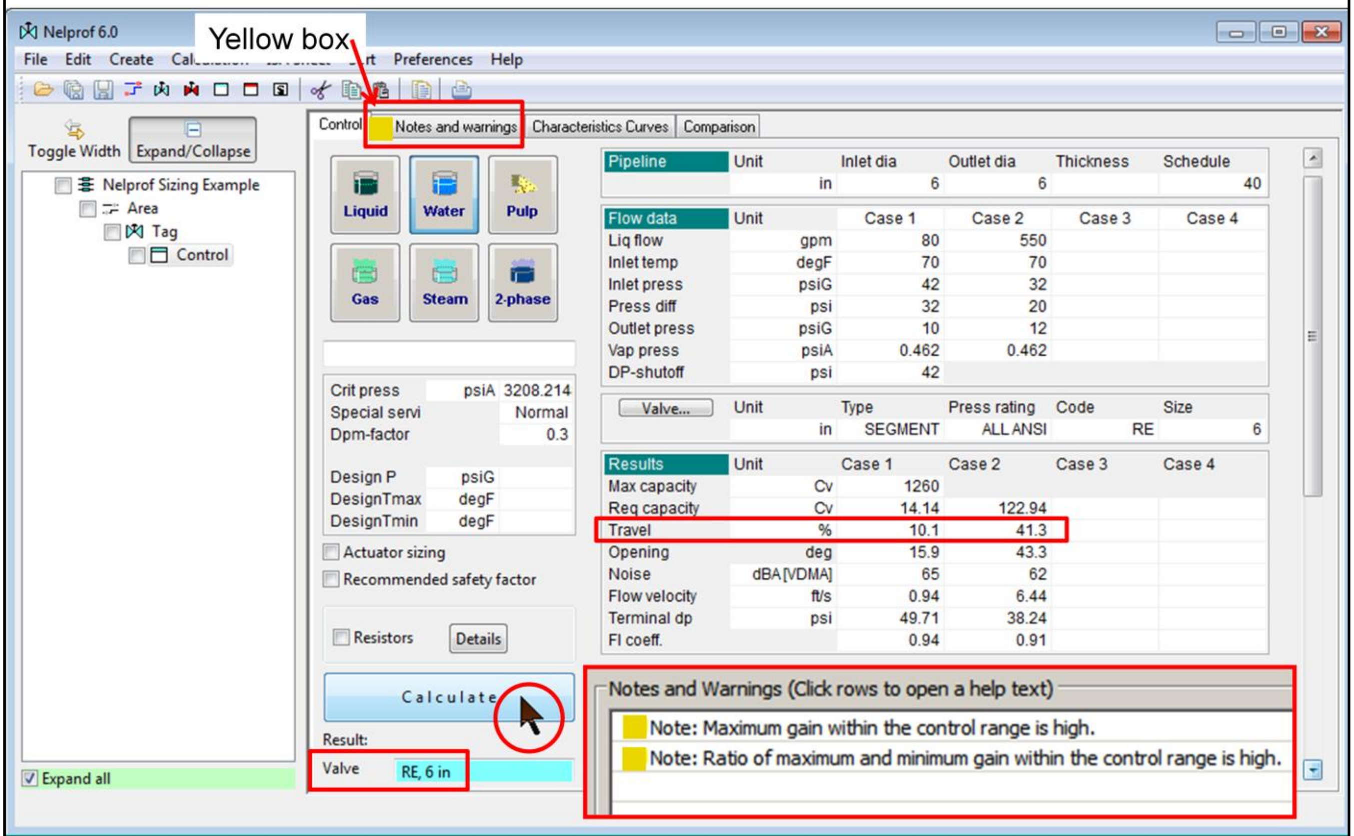
All of the given process data has been entered into the top portion of the screen. There are fields for both Pressure difference and Outlet pressure. You can enter either one of these, and the program fills in the other. The program also fills in the vapor pressure of water at the given Inlet temperature, and fills in the Critical pressure of water on the left side of the screen. The program uses the density of water at the given Inlet temperature in the calculation, but does not show it on the screen. The program also enters shutoff pressure “DP-Shutoff” at the bottom of Case 1. The value that the program enters will be the greatest of the Inlet pressures that have been entered in the four cases. The user can manually override this value if necessary. The shutoff pressure is used in the actuator sizing calculation.

There are other fields at the left side of the screen which we can ignore. “Special service” will suggest actuator safety factors for difficult media which can increase valve torque. “Dpm-factor” is used when installed curves are desired when only one set of process data is entered and is an approximation at best. See Section 2.4.4 of the Metso *Flow Control Manual.* Design pressure and temperature fields are for documentation only and have no effect on the calculation.

In this demonstration, we want to show how an installed gain analysis can guide you in selecting the valve that will give the best control, so we will do calculations for a 6 inch, a 4 inch and a 3 inch valve and look at the installed characteristic and installed gain of each. We will start by forcing the program to do a calculation for a 6 inch valve. To do this, we left click inside the Size field, then select “6” from the list of all the sizes that the Series RE valve is available in.

The “Actuator sizing” check box has been unchecked. It saves time to postpone selecting an actuator until you have selected the exact valve you intend to use. Or you may prefer to leave the actuator sizing to your sales rep.

Calculate results



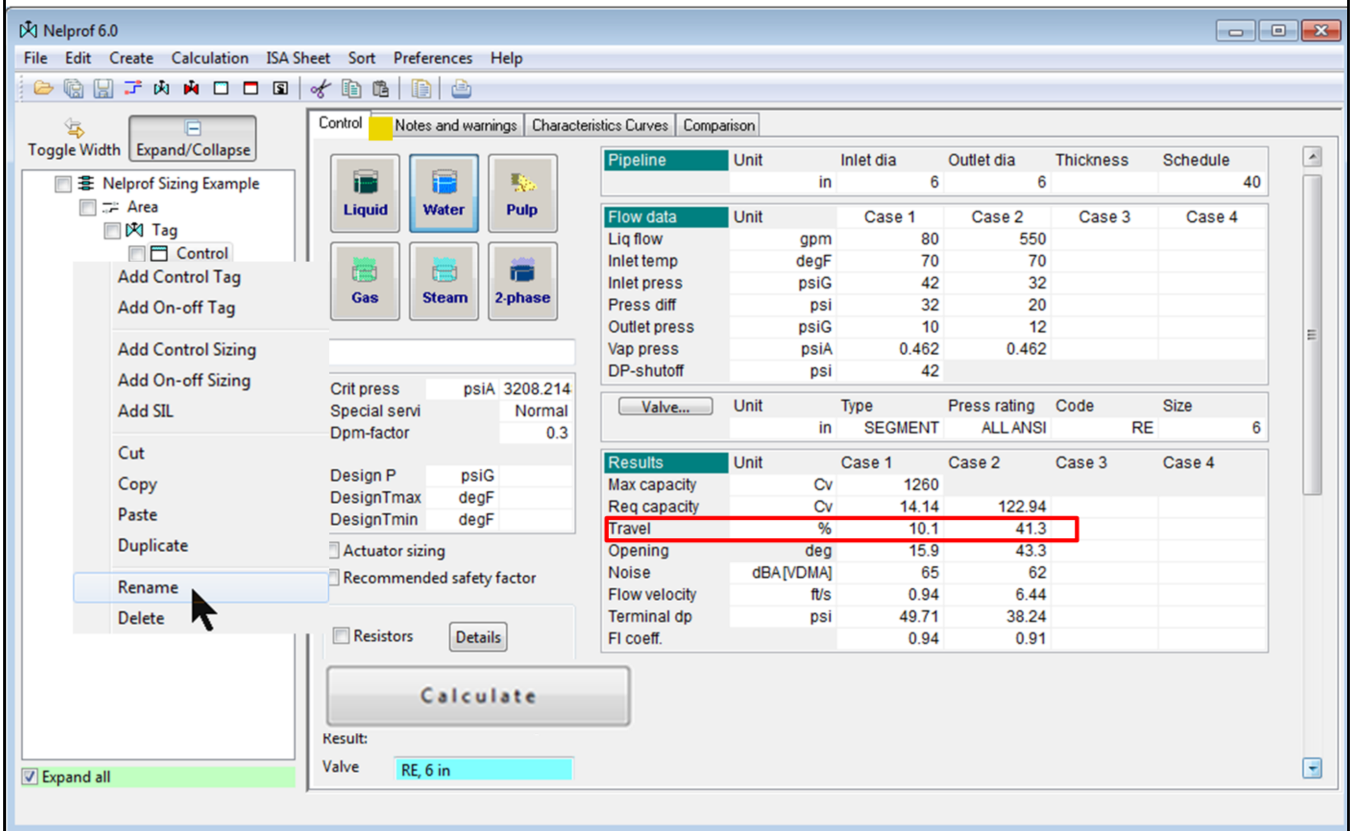
Click the large “Calculate” button and the calculated results appear. In the lower left corner of the sizing screen the “Results” field tells us that a 6 inch RE valve has been selected. If we had asked the program to select an actuator, the selected actuator would also be listed in the Results area below the valve.

This example was selected so that installed gain would be the only thing that would determine the best valve for the application. The other calculated results will be within acceptable limits for each of the three valve sizes we will examine. One thing of note in the calculated results is that the six inch valve will be operating between about 10% open and 41% open. Most people who subscribe to the rule of thumb that a control valve should operate between not much less than 20% open at the minimum flow whenever possible and somewhere between 60% and 80% open at the maximum flow would say that the six inch valve is oversized for this application. We will look at the installed characteristic and installed gain of all three valves after we have done the sizing calculation for all three sizes.

Notice that a small yellow box has appeared on the “Notes and warnings tab. The yellow box means that there is something Nelprof doesn’t like about the selected valve and has created a note that explains what the program doesn’t like. If there is something Nelprof thinks is really serious, it generates a Warning and the box on the Notes and warnings tab will be red.

You will see what the entire Notes and warnings page looks like later. For now, just the part of the Notes and warnings page that has the notes for this calculation has been superimposed on top of the valve sizing calculation page (the page that belongs to the “Control” tab). Shortly we will see why Nelprof has generated these notes for the 6 inch valve.

Rename the sizing calculation

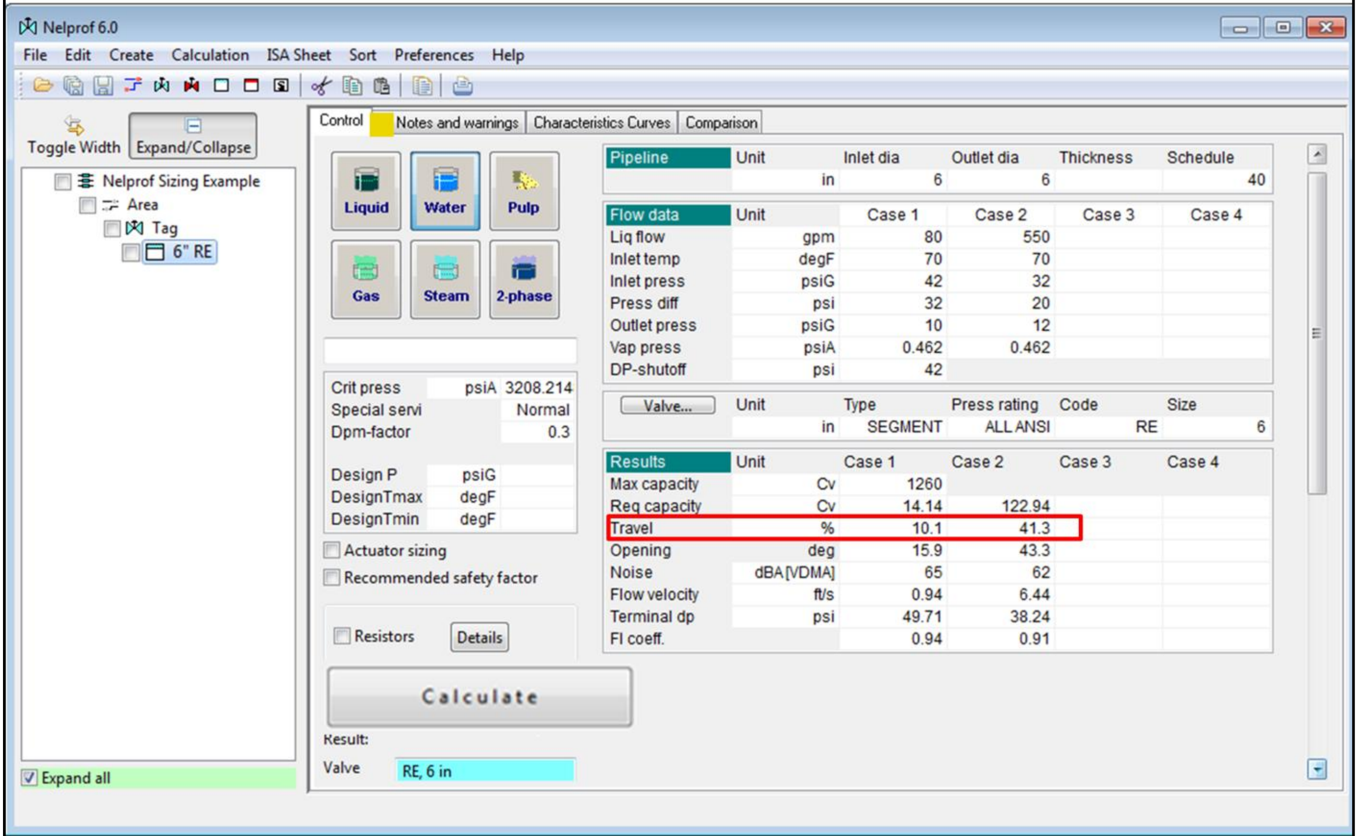


For convenience we will rename this calculation from its default name of “Control” to “6” RE”

Right click on “Control” then select “Rename” In the same manner that Windows Explorer lets us rename files, we will be able to change “Control’s” name to “6” RE”

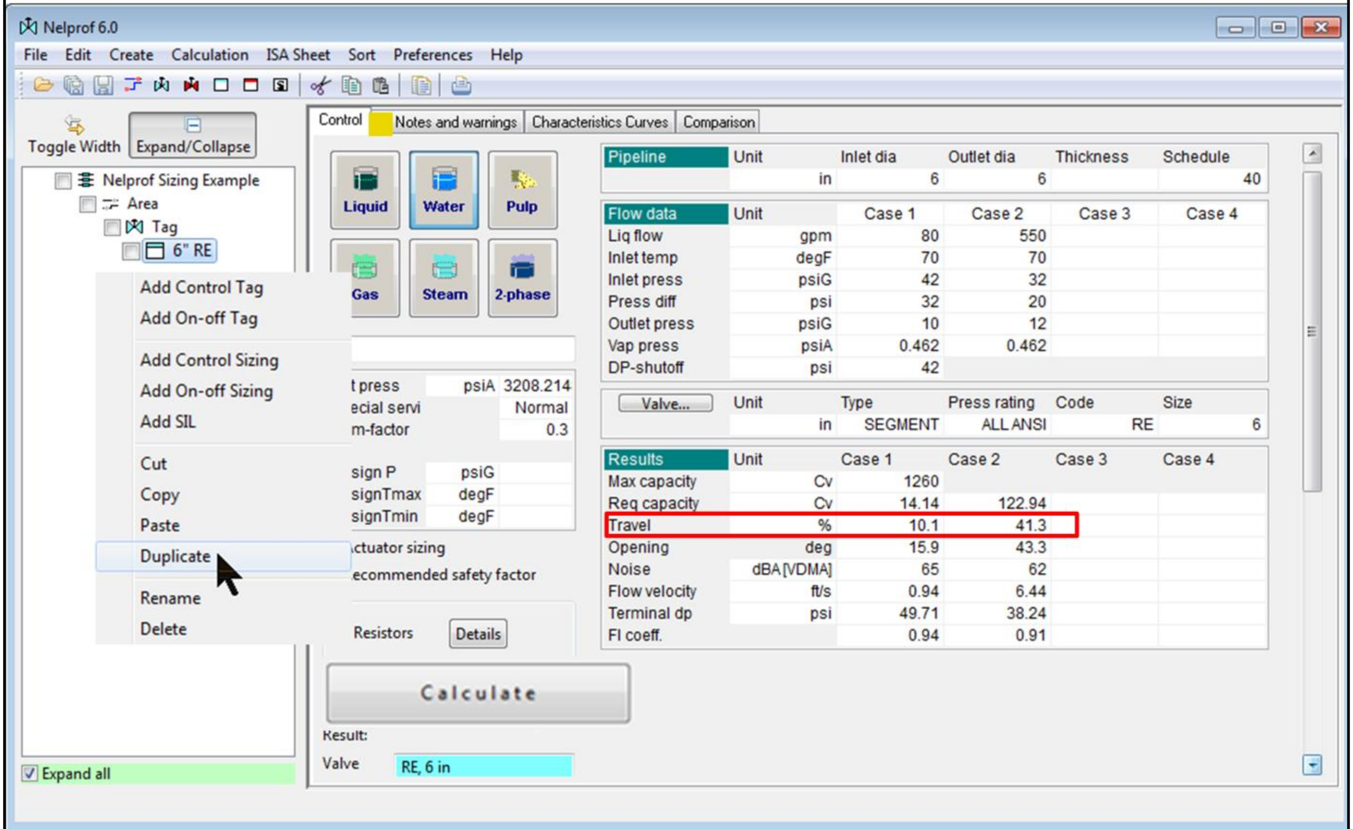
Press the Enter key to accept the new name.

Rename the sizing calculation



The calculation for the 6 inch RE segment ball valve has been renamed 6” RE

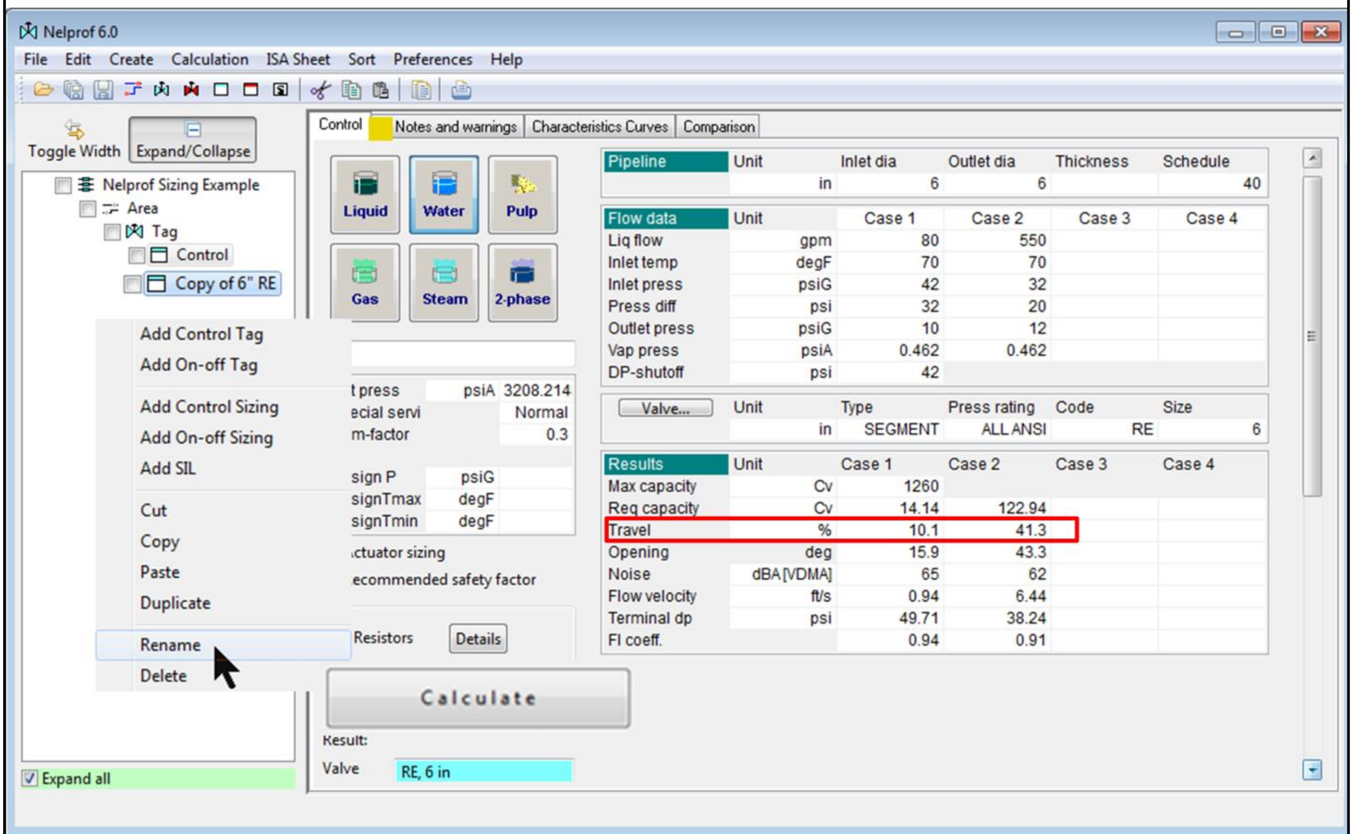
Create a new similar calculation



It is very easy to create a new calculation for a 4 inch RE segment ball valve.

Right click on “6”RE” and select “Duplicate”

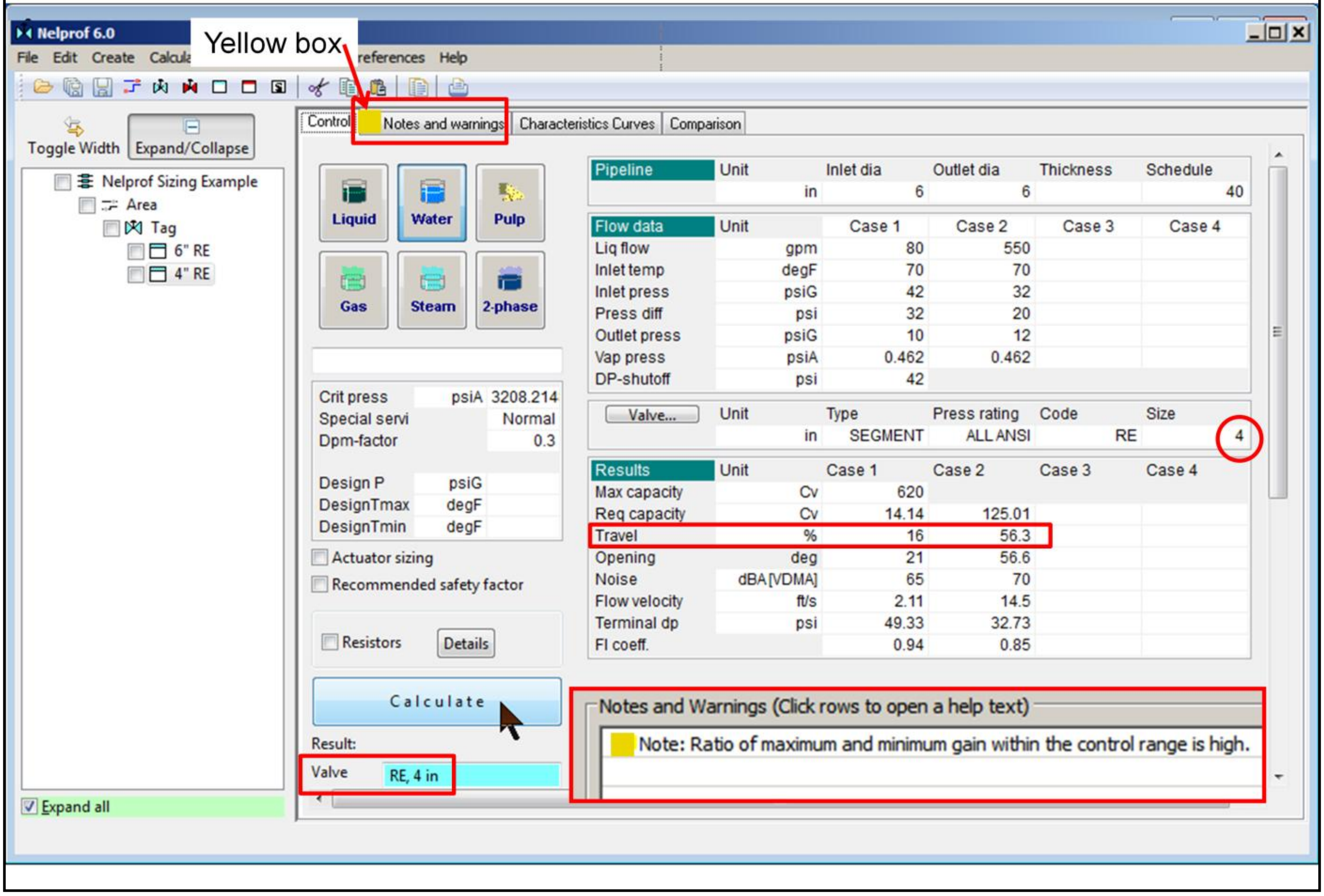
Rename the new calculation



A new sizing calculation appears below “6”RE” named “Copy of 6” RE”

Right click on this copy and select “Rename” and rename it “4”RE.”

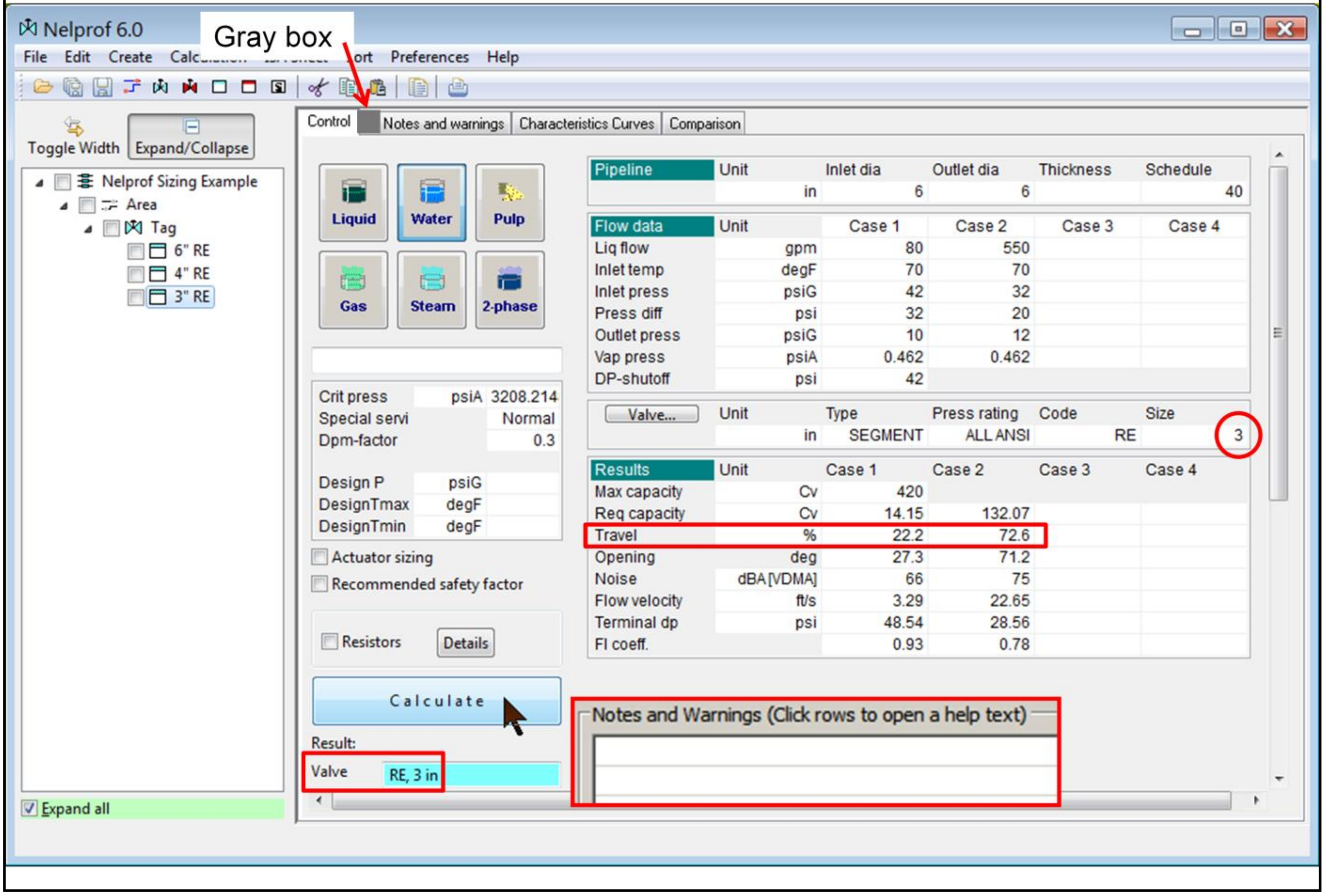
Change valve size and recalculate



Go the “Size” field and select “4” and click the large “Calculate” button.

The valve travel for a 4 inch valve is between 16% and 56.3%, much closer to the rule of thumb of not being much less that 20% open at minimum flow and between 60 and 80% open an maximum flow. The notes and warnings tab still has the yellow box, and we have superimposed the notes portion of the Notes and Warnings page at the bottom of the sizing screen. There is only one note this time, compared to two notes for the 6 inch valve.

Make another duplicate, change size & calc.



We have done the same thing to the 4 inch valve as we did to the 6 inch valve to quickly create a calculation for a 3 inch valve.

The travel range for this valve is between about 22% and 73%. And there are no notes or warnings, meaning there is nothing Nelprof does not like about this valve.

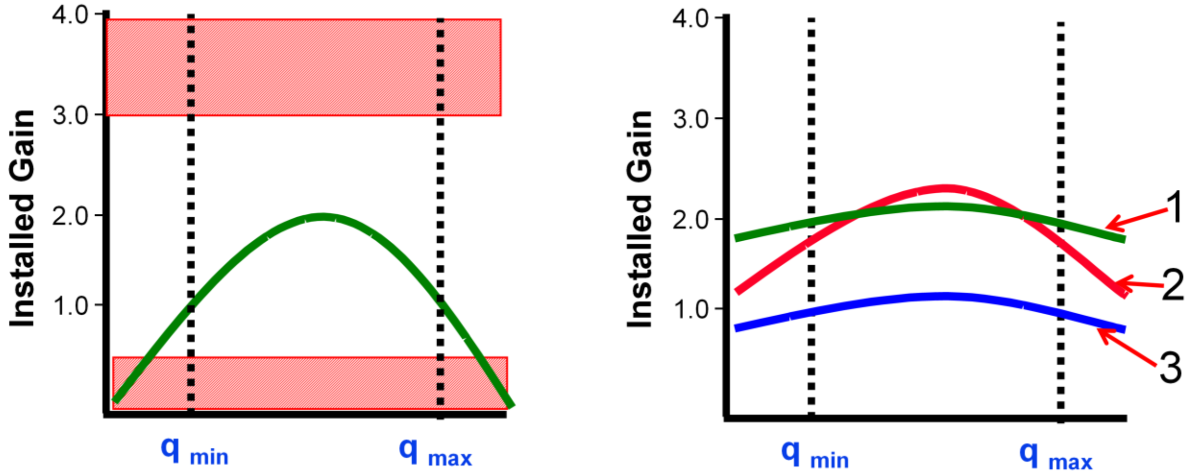
Installed gain recommendations

Gain $= \Delta q / \Delta h$

$\Delta q = \Delta h * \text{Gain}$

Within the specified control range:

1. **Gain ≥ 0.5**
2. **Gain ≤ 3.0**
3. **Gain (max) / Gain (min) ≤ 2.0**
4. **As constant as possible**
5. **As close to 1.0 as possible**



Points 1, 2 and 3 are Neles' recommendations (and the rules that Nelprof uses when selecting the best valve size for an application) for gain magnitude and variation.

Within the specified control range (by definition we will not be controlling outside this range so we are not concerned with what happens there) that is between q min and q max, the gain should not be less than 0.5, or greater than 3.0.

The definition of control valve gain (upper left equation) says that the installed gain of a control valve equals a change in flow (Δ**q**) divided by the corresponding change in valve position (Δ**h**). By rearranging the upper equation, we can see that a change in valve position (Δ**h**) multiplied by the gain tells us how much the flow will change. If the gain is too low, when the valve moves the flow hardly changes, which means the valve will not be effective in controlling flow. If the gain is too high, small errors in valve position (such as might be caused by a sticky valve) will result in large errors in flow, making it difficult to control accurately.

Typically, if the gain changes by not much more than a 2 to 1 ratio, it will be possible to come up with one set of PID tuning parameters that will result in good control and stability throughout the required flow range.

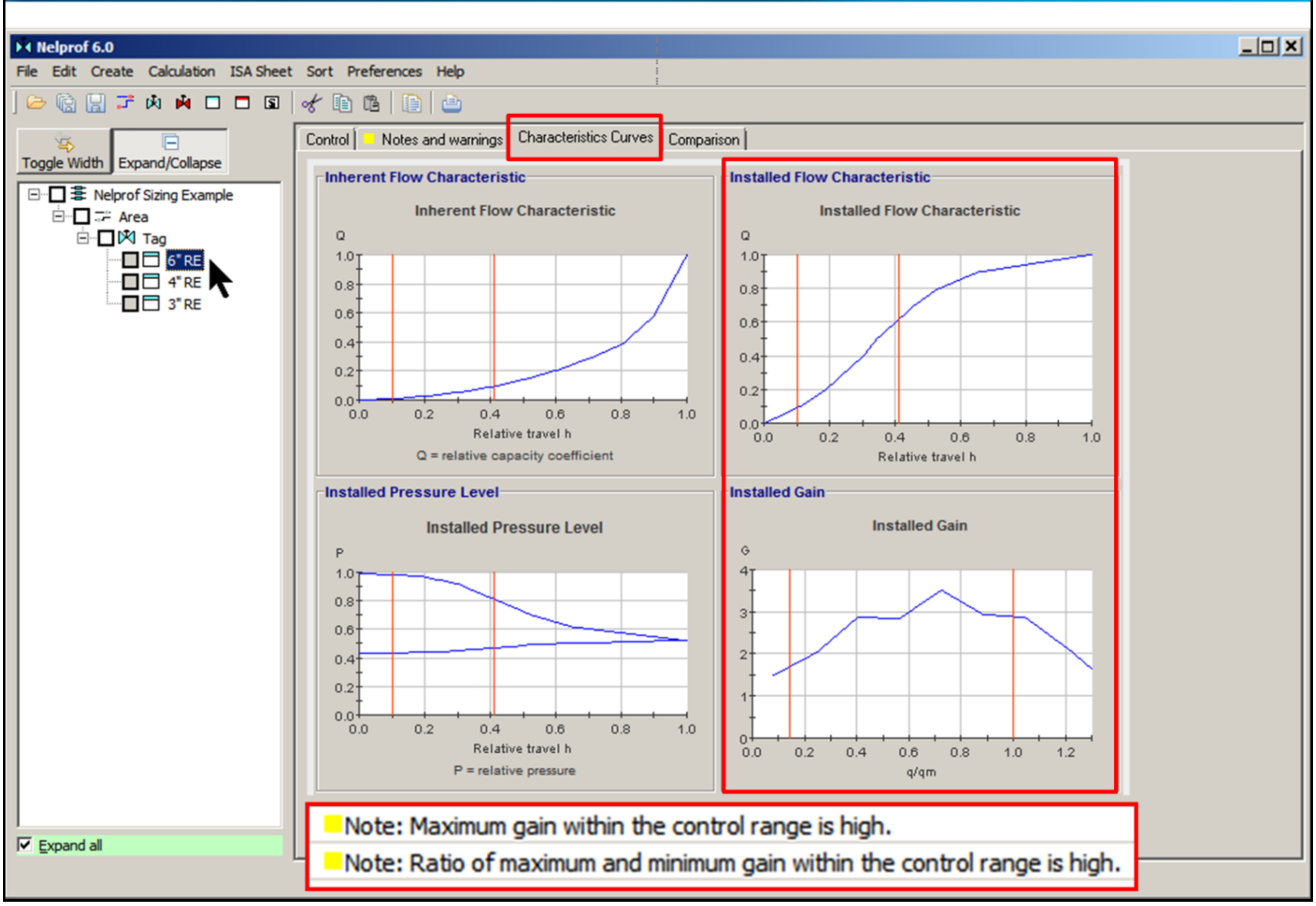
If you can't find any valve that meets the first three criteria, or if you want to select the best valve of several that all meet the first three, then use criteria 4 and 5.

The gain should be as constant as possible. The more constant the gain, the more aggressive can be the PID tuning without the danger of instability. If you had the choice between Valve 1 and Valve 2, Valve 1 would be the best choice because the PID tuning could be more aggressive.

The gain should also be as close to 1 as possible. Valve 1 and Valve 3 both allow equally aggressive tuning, but Valve 3 is a better choice.

For a valve position error of 1%, Valve 1 would give a flow error of about 2% and Valve 3 would give a flow error of about 1%.

Compare installed flow and gain



Now that we have calculations for all three sizes of valves we can select the “Characteristics Curves” tab and compare the Installed Flow Characteristic and Installed Gain graphs. The program also generates graphs for the valve’s Inherent Flow Characteristic and the Installed Pressure Level (that is, what P_1 and P_2 are doing as valve travel changes). The Inherent Flow Characteristic is interesting because it allows us to see the extent to which the inherent characteristic is modified by the system characteristic to produce the installed characteristic. The Installed Pressure Level can help us identify a situation where excessive piping pressure losses or an undersized pump make it impossible to get a linear flow characteristic regardless of the valve selection. However, it is the Installed Flow Characteristic, and even more so, the Installed Gain that give us a good look at how well the valve will be able to control the process.

For the Inherent Flow Characteristic graph, the Installed Flow Characteristic graph and the Installed Pressure Level graph, the graphed parameter is graphed as a function of valve Relative travel, h. Each of these three graphs has two vertical lines, one placed at the valve Relative travel at the specified minimum flow (in our example 80 gpm), and one placed at the valve Relative travel at the specified maximum flow (550 gpm). On the Installed Gain graph, gain is plotted as a function of q/qm (actual flow divided by the maximum specified flow) where 1.0 in our example is 550 gpm. So the vertical line at the left represents 80 gpm and the line at the right represents 550 gpm.

Looking at the Installed Flow Characteristic of the 6 inch valve we see that on the low end, there is not a lot of safety factor. We can also see that we are only using about 42% of the valve's capacity. The rest of the valve's capacity is not being used, meaning that a 6 inch valve is larger than required for the application. The effect of decreasing pressure drop across the control valve with increasing flow has resulted in this equal percentage valve having a fairly linear installed characteristic, especially within the specified flow range of 80 to 550 gpm.

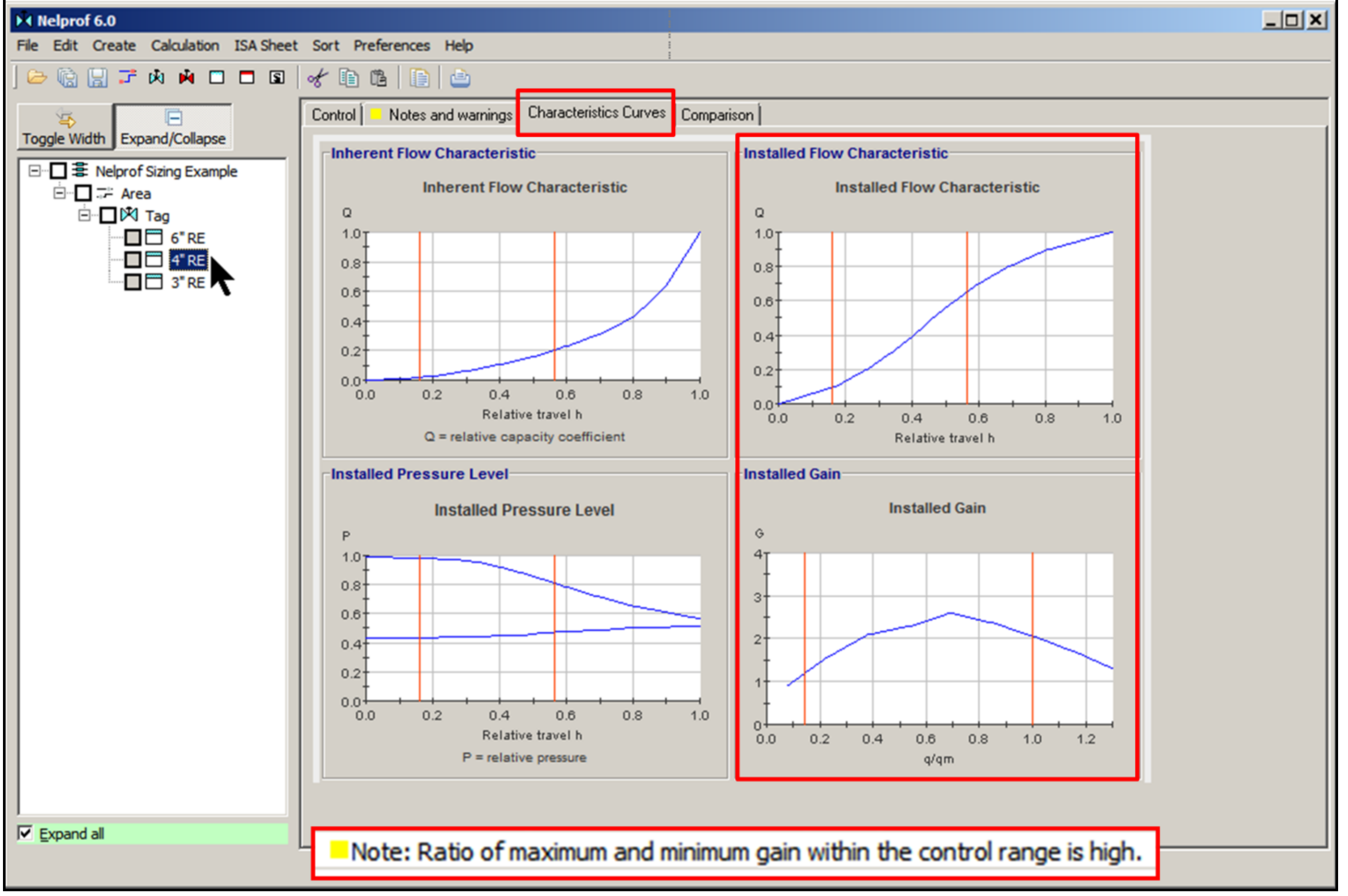
Looking at the Installed Gain graph for the 6 inch valve, we see that the gain varies by slightly more than Neles’ recommended maximum of 2:1 within the specified control range, thus the Note about the ratio of maximum and minimum gain. The more the gain changes within the control range, the more difficult it is to tune the control loop for both quick response and stable operation. Also, the gain has a maximum value of 3.5, higher than Neles’ maximum recommendation of 3.0, thus the note about the maximum gain being high.

The maximum gain of 3.5 occurs at q/qm of 0.7 or 70% of 550 gpm. At this point, a position error of 1% would cause a flow error of 3.5%. This would make it difficult for the system to control accurately.

The conclusion from examining the installed characteristic and gain graphs is that the 6 inch segment ball valve is not an ideal choice for this system.

Here and on the next page, we have superimposed the notes that are actually shown on the “Notes and warnings” tab.

Compare installed flow and gain



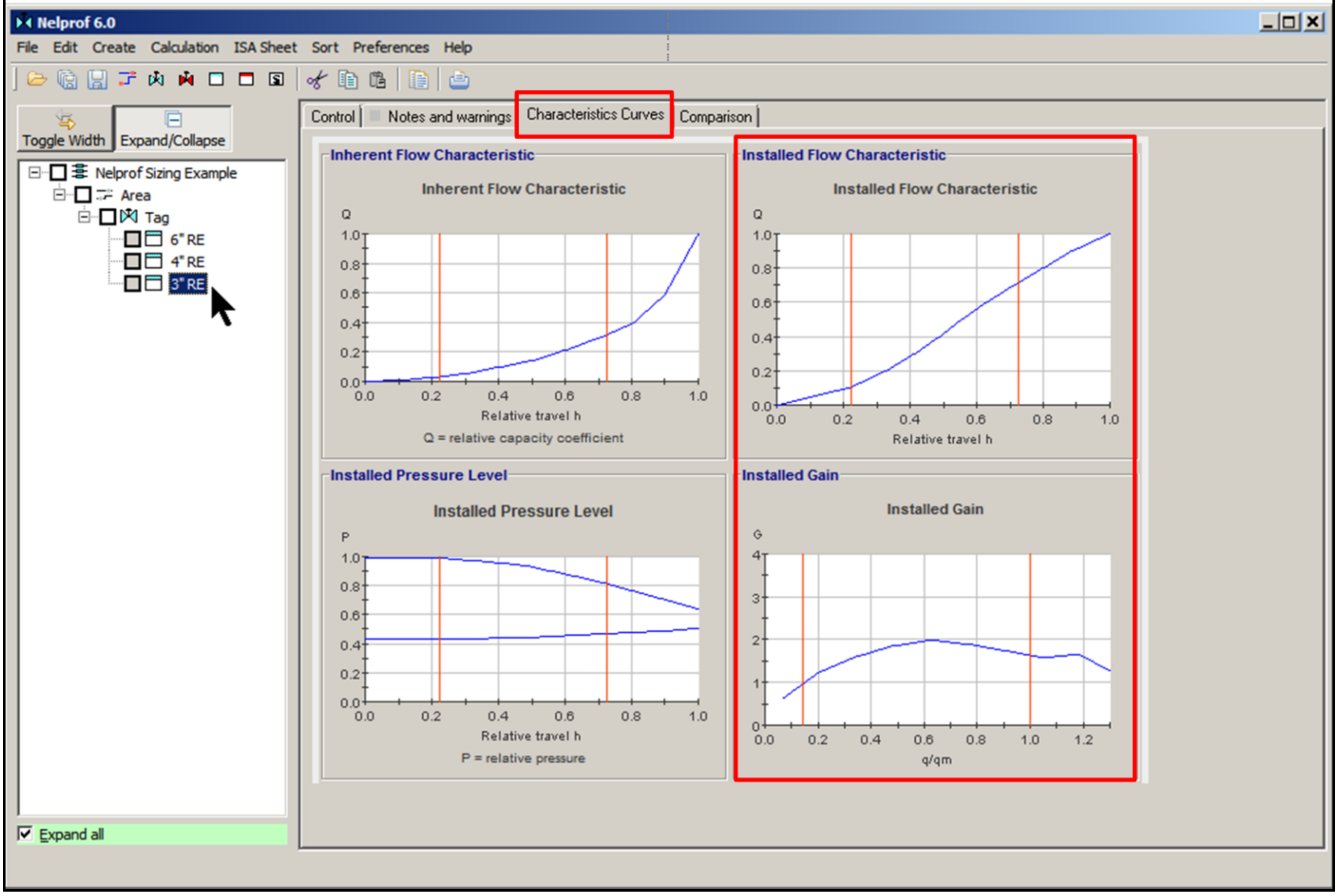
Clicking on the 4 inch valve in the Project tree switches the view to the graphs of the 4 inch valve. Because the horizontal axis for the installed characteristic graph is valve travel, the vertical lines representing 80 and 550 gpm for the 4 inch valve are both at larger openings for the smaller valve.

The installed characteristic is quite linear within the specified flow range, which is good. The 4 inch valve has more safety factor on the low end, and less wasted capacity on the high end.

Looking at the Installed Gain graph, we see that the maximum gain of the 4 inch valve is lower, meaning for the same position error, the flow error will be less. Since the maximum gain is less than 3.0, there is no Note about the maximum gain being high. The gain still varies by slightly more than Neles' recommended maximum of 2:1 within the specified control range, thus the Note about the ratio of maximum and minimum gain.

The conclusion is that the 4 inch valve is a better choice than the 6 inch valve.

Compare installed flow and gain



Clicking on the 3 inch valve in the Project tree switches the view to the graphs of the 3 inch valve. Because the horizontal axis for the installed characteristic graph is valve travel, the vertical lines representing 80 and 550 gpm for the 3 inch valve are both at larger openings than they were for the 4 inch valve.

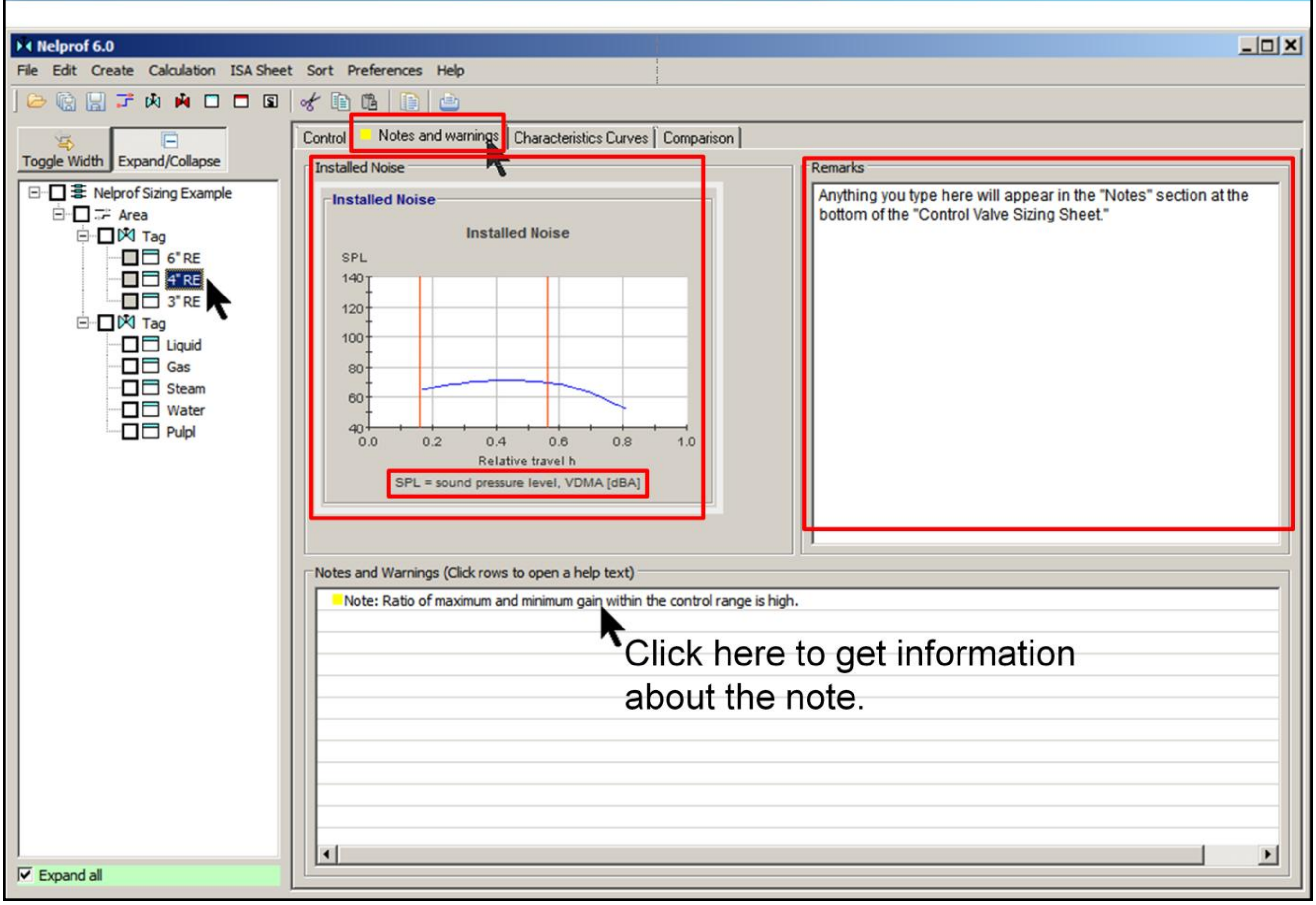
The minimum and maximum specified flows of 80 and 550 gpm, represented by the vertical lines on the installed characteristic graph, are more symmetrically located on the installed characteristic, resulting in nearly equal safety factors on both the low end and the high end. The installed characteristic is also quite linear within the specified flow range.

The installed gain graph has the lowest maximum value of all three valves, which will result in the lowest flow error for the same position error. The variation in gain within the specified flow range is the least of all three valves, making possible the most aggressive PID tuning. There were no notes, meaning there is nothing that Nelprof doesn’t like about the 3 inch valve.

The conclusion is that of the three valves analyzed, the 3 inch valve will provide the best control.

The three pages of graphs can be compared as quickly as you can click between the three valves in the Project tree.

Noise and notes tab



The Notes and warnings tab shows three things:

1. A graph of the valve noise throughout the flow range. It is not unusual for the noise to peak in the center. If you have done sizing at the minimum and maximum flows, it is possible that it may be higher somewhere between the minimum and maximum points than at the two points you have calculated results for.

   This graph always displays noise by the VDMA method.
2. Any remarks you want to make about the calculation. Anything you type in this field will appear in the Notes field at the bottom of the printed “Control Valve Sizing sheet.”
3. Notes and warnings about your calculation that the program has generated.
4. If you click on one of the Notes or Warnings, the Nelprof User’s Guide will open to the section that explains the note you have clicked on.

   (Some earlier versions of Nelprof will simply open the Nelprof users guide to the beginning and you will have to scroll down to the place where the note is explained.)

Information about the note

29 Ratio of maximum and minimum gain within the control range is high.

THEORY

The quality of the valve installed flow characteristic curve with respect to valve controllability and accuracy can be measured by means of a valve installed gain curve. The gain of an installed valve is the change in relative flow rate divided by the change in relative travel. In other words the change in relative flow rate is the gain multiplied by the change in the valve relative travel.

PROBLEM

If the gain value is too low or too high, or if it changes considerably in the process operating range, process control will generally become very difficult.

High change of the gain within control range means in practice that the stability and accuracy of the control valve will change as the installed gain changes throughout the control range. This may cause some problems when tuning the controller.

SOLUTION

Large changes in gain value are usually a result of over sizing of the valve in which case selecting a smaller size valve will improve the situation.

If gain is high with low openings and low with high openings then the situation may be improved by using a valve with more equal percentage flow characteristic or in most cases selecting a smaller size valve will help.

If gain is high with high openings and low with low openings then the situation may be improved by using a valve with more linear inherent flow characteristic or by using a fixed resistor downstream or upstream of the valve.

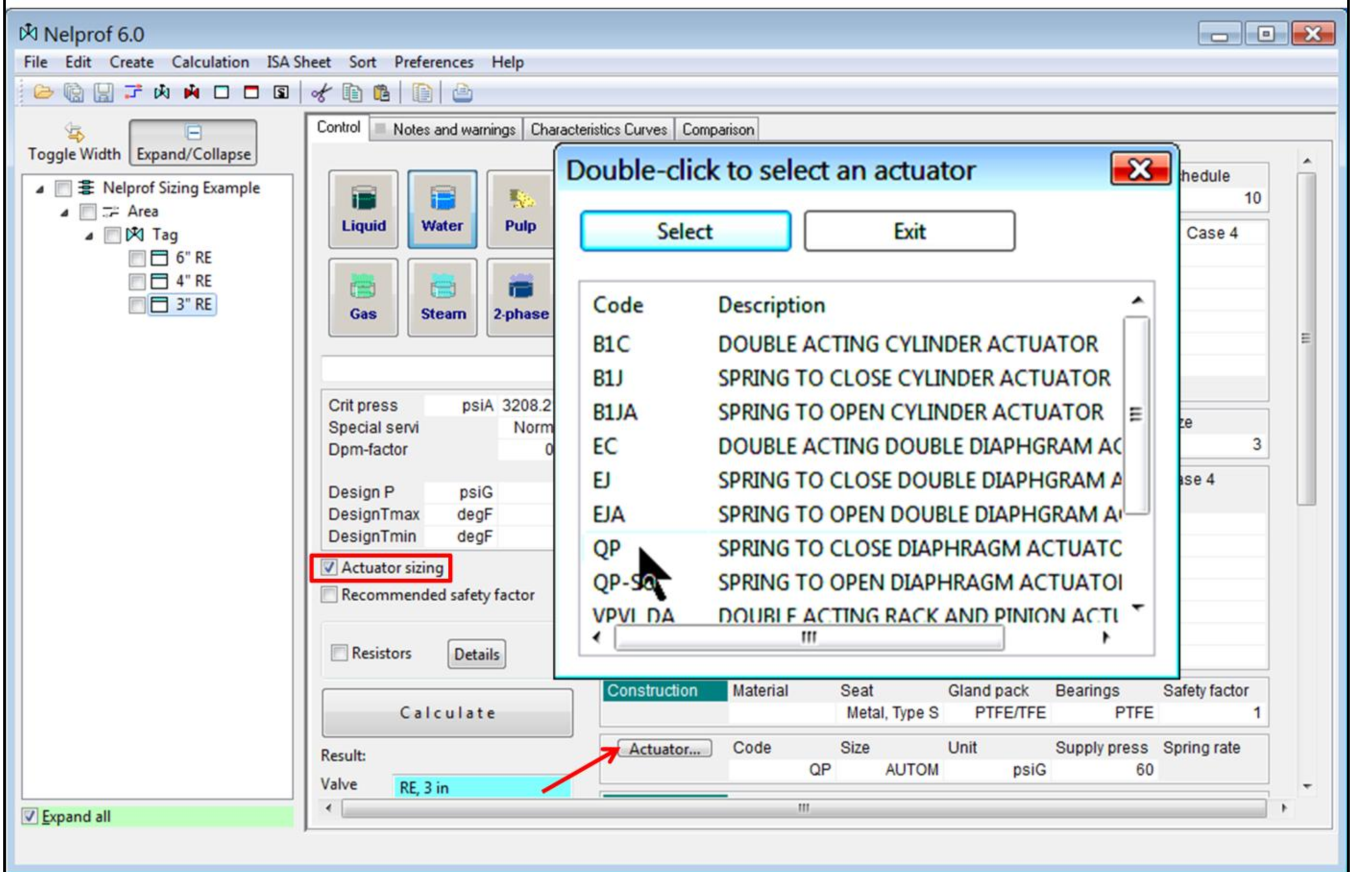
It is also possible that the system pressure losses compared to valve pressure drop with maximum required flow rate are very high. In that case the solution may be split range or signal modification.

REFER TO FLOW CONTROL MANUAL:

2. Control valve installed performance - 2.1 General
2.4 Control valve flow characteristics
2.4.3 Installed gain
2.4.6 Control valve characterization

The User's Guide has a short discussion of the Theory, the Problem, the Solution, and references to where the subject is discussed in the Metso *Flow Control Manual* which can be accessed from the Nelprof Help menu.

Actuator sizing

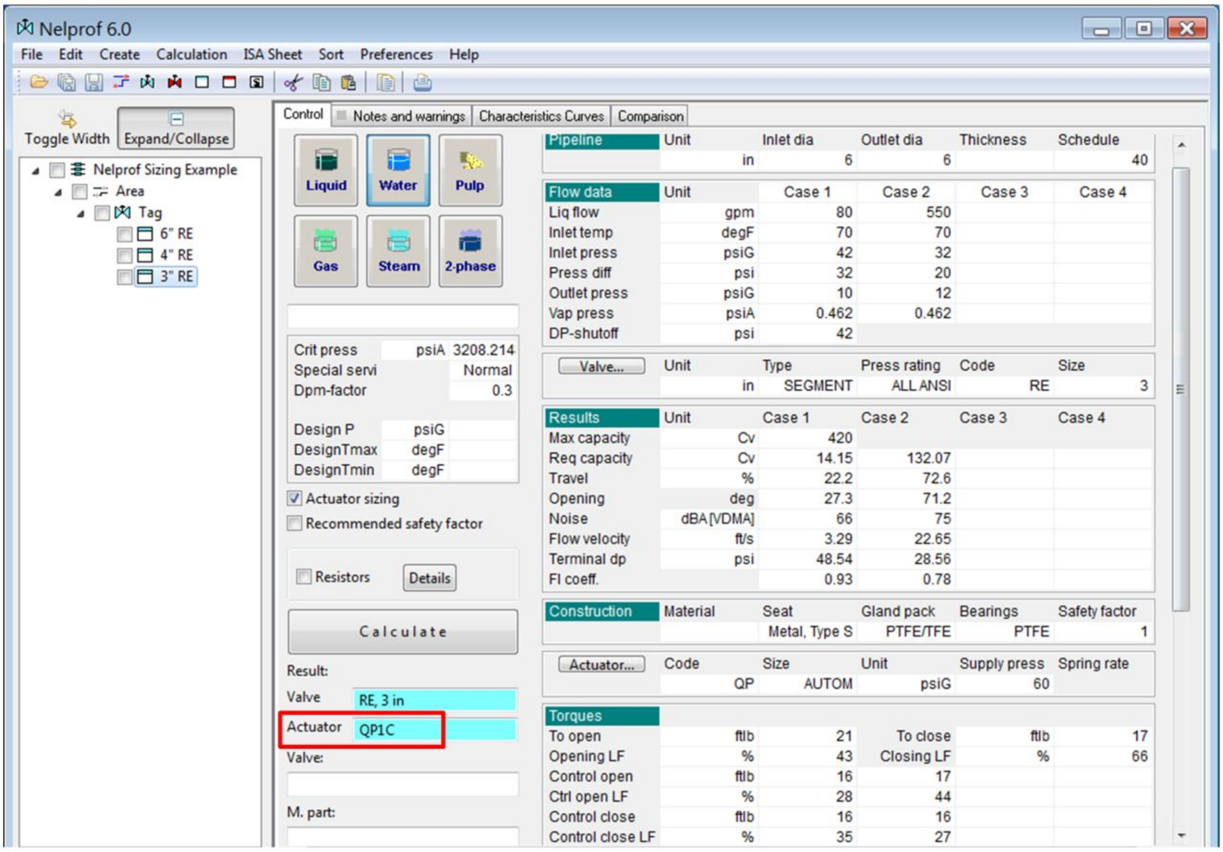


As mentioned earlier, it will save time if you leave sizing the actuator until you have zeroed in on the right valve. Or if you will be purchasing the valve from someone else, you may want to let them do the actuator sizing. If you are using the generic valve files for doing the sizing calculations, the option of sizing an actuator is not available.

To size an actuator, put a check mark in the “Actuator sizing” check box.

Click on the “Actuator” button and a list of the available actuators appears. You might want to check with your Metso representative to see which model actuator is most likely to meet your needs and would be the most readily available. Double click on the actuator you want to select. In the example, the Jamesbury Quadra-Powr (QP) spring diaphragm actuator has been selected.

Actuator sizing



The selected QP actuator appears on the "Actuator" line. The default size is "AUTOM" for automatic. You can also select a particular size actuator by clicking in the "Size" field and selecting a size from the list that appears. Nelprof has entered 60 psi for the air supply pressure, because that was the value that was put into the default units dialog when this copy of Nelprof was configured. You can type in another value to override the default.

The shutoff pressure "DP-shutoff" automatically entered by Nelprof at the end of the Flow data section. It chose the highest entry on the "Inlet press" line. You can change it to something else if you know the actual shutoff pressure may be higher or lower.

The default value of the safety factor, entered in the "Safety factor" field is 1. See the next page for additional information on actuator Safety factor.

The field "Special service" on the left side of the screen will suggest actuator safety factors from a drop down list. Note, it only makes suggestions, and does not automatically implement them. It is left up to the user to enter any desired safety factor in the Safety factor field.

Click the Calculate button, Nelprof selects a Quadra-Powr spring and diaphragm actuator, size1 with a 60 psi spring and displays an analysis of the torque requirements.

The top row, "To open" and "To Close" gives the torque required by this valve get the ball to move out of the fully closed position and the torque required to get the valve fully seated in the fully closed position. In this case 21 foot-pounds to open the valve and 17 foot-pounds to close the valve. The "Opening LF" (Load Factor) of 43% on the second line means that generating the required 21 ft-lb will take 43% of the torque capability of the actuator when it is starting to open a valve from the closed position. The "Control open" and "Control close" are the torques required to modulate the valve a small amount in the opening or closing direction from the position the valve is shown to be in in its respective column and the "Control open LF" and the "Control close LF" (Load Factor) are the percentage of the actuator's capability at that point that is required to generate that torque. There are columns of Control open and Control close torques and load factors corresponding to each of the four sizing cases.

When the Safety factor is the default 1, Nelprof selects an actuator based in the rules 1) Neither the "Opening Load Factor" or the "Closing Load Factor should be greater than 90% and 2) None of the "Control open" or the "Control close" load factors should be greater than 60%.

Actuator safety factor

Default: 1

Ball valves in dirty, sticky, non-lubricating service: 1.5

Construction	Material	Seat	Gland pack	Bearings	Safety factor
		Metal, Type S	PTFE/TFE	PTFE	1

Actuator...	Code	Size	Unit	Supply press	Spring rate
	QP	AUTOM	psiG	60	

Torques					
To open	ftlb	21	To close	ftlb	17
Opening LF	%	43	Closing LF	%	66
Control open	ftlb	16	17		
Ctrl open LF	%	28	44		
Control close	ftlb	16	16		
Control close LF	%	35	27		

90% max SF = 1
67% max SF = 1.5

60% max SF = 1
40% max SF = 1.5

The default value of the actuator “Safety factor” entered by Nelprof is 1. For ball valves in dirty, sticky and non-lubricating service (applications where the process medium can increase the torque required to operate the valve) Metso recommends using a Safety factor of 1.5. Also, some end users specify that actuators be sized to provide 1.5 times the required operating torque.

If you enter a safety factor of 1.5, Nelprof should select an actuator that has sufficient torque for a 1.5 safety factor, however the program does not change the torque number shown in the actuator results field.

To be on the safe side, you need to check the Load Factor values shown in the torques field to be sure the selected actuator has the required safety factor.

For a safety factor of 1.5, the “Opening Load Factor” and the Closing “Load Factor” must not be any greater than 67%. All of the “Ctrl open Load Factors” and all of the Control close Load Factors” must not be any greater than 40%.

If any of your load factors exceed these criteria, manually select a larger actuator.

For safety factors greater than 1.1, the maximum “Opening LF” is calculated by:

100/Safety Factor

For the “control” load factors, the maximum “control…Load Factor” is calculated by:

60/Safety Factor

Load factors for “Control” have to be lower than those for opening and closing the valve because in control the actuator must be able to make small smooth adjustments in position.

Graphs identify otherwise unseen problems

Customer's question: Does this look like a good application for a 6 inch Neles segment ball valve?

CONTROL VALVE SIZING: LIQUID				
Flow	gpm	Q	200	1000
Inlet pressure	psiA	P_1	90	60
Pressure drop	psi	DELTA_P	35	5
Specific gravity		G	1	1
Vapor pressure	psiA	P_V	0.5	0.5
Critical pressure	psiA	P_C	3208	======>
Recovery factor		F_L	0.94	0.8
Inlet pipe diameter	inch	D_1	8	======>
Outlet pipe diameter	inch	D_2	8	======>
Valve size	inch	d	6	======>
Valve style SPL code		VSC	2	======>
Pipe wall correction	dB(A)	DeltaLp	-2	======>
Required flow coef. (Cv or Kv)		Cv	33.81	458.78

METAL SEATED V-PORT SEGMENT VALVE (Nelprof® code RB, RE)

SIZE		Relative opening h									
DN	INCH	10 %	20 %	30 %	40 %	50 %	60 %	70 %	80 %	90 %	100 %
	6	13.9	34.1	67.2	115	178	258	352	484	719	1260

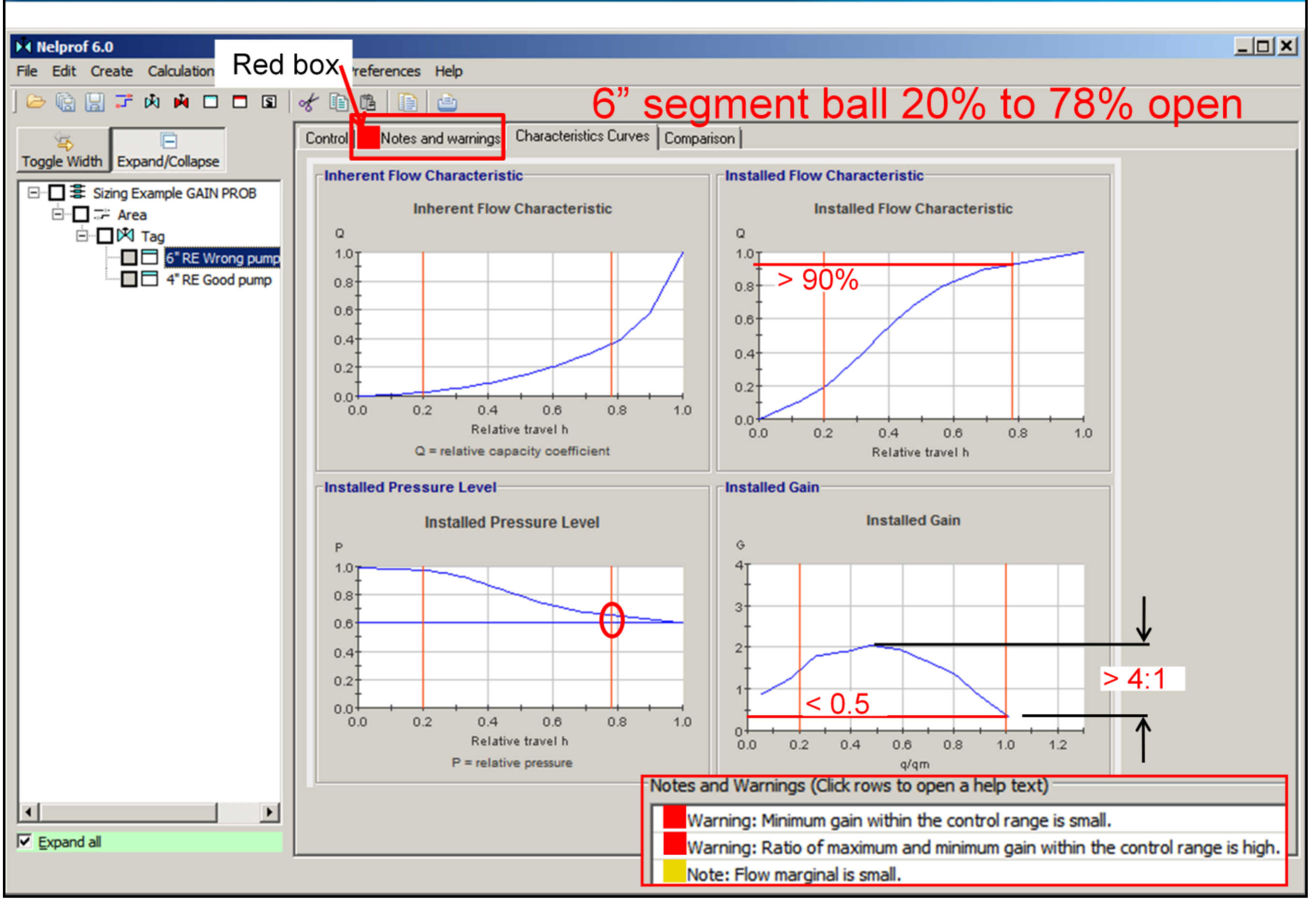
About 20% to 78% open

Since in the sizing example, the valve we selected as the best for the application based on the installed gain analysis also met the popular rule of thumb that a valve should not be much less than 20% open at the minimum flow, and somewhere between about 60% and 80% open at the maximum flow, the question comes up, why the big deal about looking at the installed gain? One answer is that it sounds more professional to choose a valve based on an analysis of how well a valve is going to be able to control rather than based on an old rule of thumb.

The better answer is that the range of opening doesn't always tell the whole story. A few years ago a customer sent us this print out for an Excel valve calculation spreadsheet and asked us if we agreed that a 6 inch segment ball valve was a good choice for the application. It certainly lines up with the rule of thumb.

We entered the process conditions into Nelprof and then took a look at the graphs.

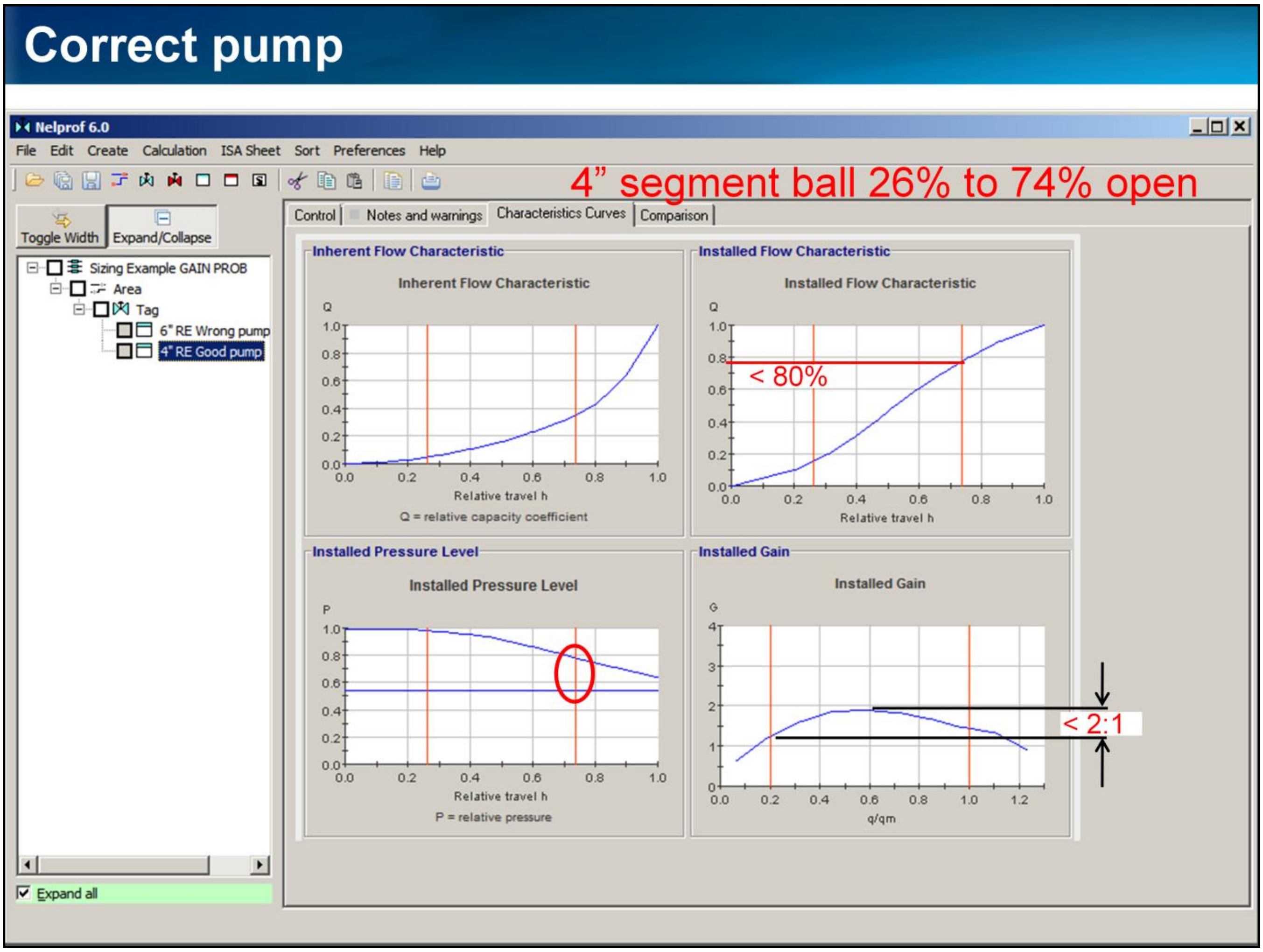
Wrong pump



The installed flow characteristic graph shows that the valve will be operating between 20% and 78% open just like the customer’s sizing calculation said. What would have been difficult to know (without building the system) was that at 78% open the valve would be flowing more than 90% of its fully open capability. There is hardly any safety factor at the high end. Near the 70% open point the installed characteristic has flattened out and correspondingly the gain has taken a real nosedive, dropping to less than 0.5 at the maximum flow. Throughout the flow range, the gain is changing by more than a 4 to 1 ratio, which would make it difficult to tune the PID controller for quick and stable control throughout the flow range.

This wasn’t really a valve problem but a system pressure characteristic problem. Looking at the Installed Pressure Level graph we see that the pressure difference between P1 and P2 is falling off very rapidly as the valve gets close to 78% open. The problem in this case was that the wrong pump had been specified.

The Notes and warnings from the Notes and warnings tab have been superimposed on the screen shot.

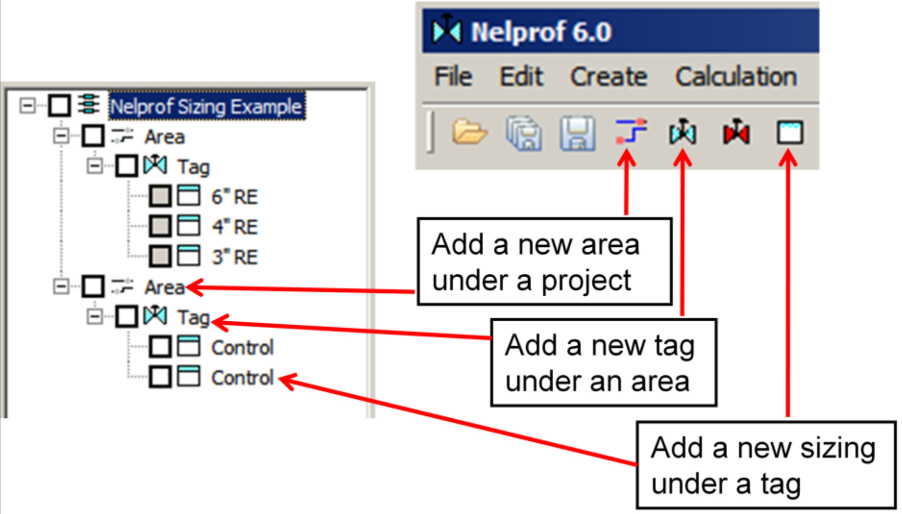


The pump had been specified, but not purchased. The customer found another pump that stared out with a higher head, and a curve that had less droop as the flow ran out to the maximum required.

After analyzing the system for the pressure drop available to the valve at maximum and minimum flow incorporating the new pump’s head curve, it turned out that a 4 inch valve instead of a 6 inch valve was required, there was much more safety factor at the high end (at the maximum specified flow, the flow is less than 80% of the fully open flow) and the installed gain was much more constant throughout the flow range.

Note that there is no red or yellow box on the “Notes and warnings” tab, meaning there is nothing that Nelprof doesn’t like about this application.

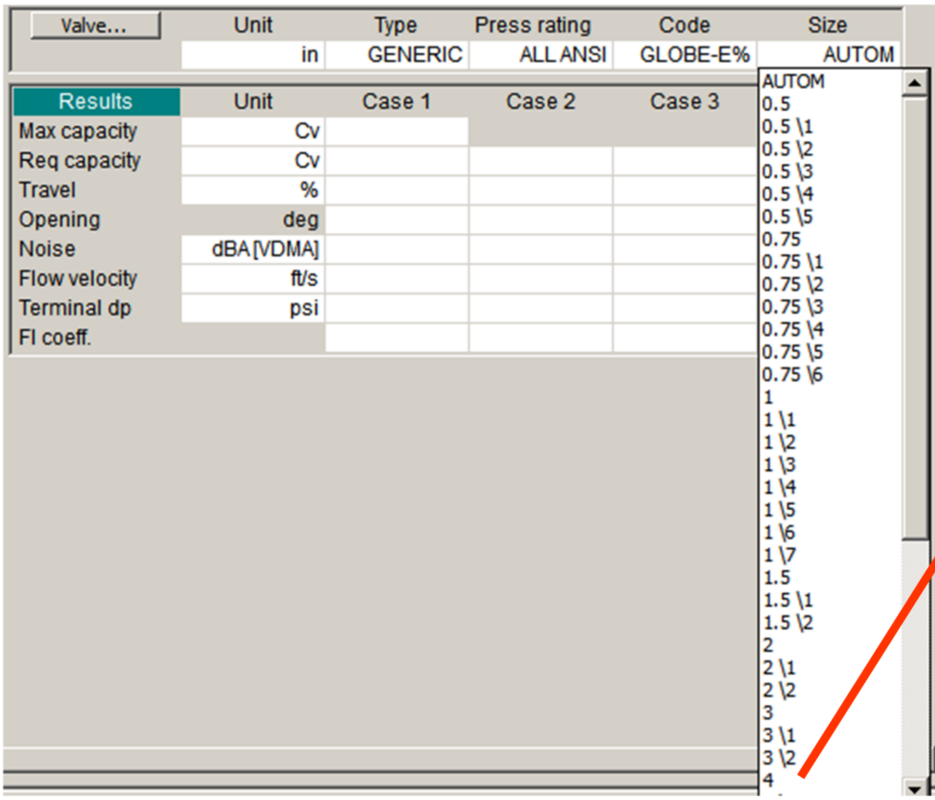
Adding areas, tags and sizing calculations



There are icons on the tool bar at the top of the screen that will add new plant areas under a project, new tags under an area and new sizing calculations under a tag.

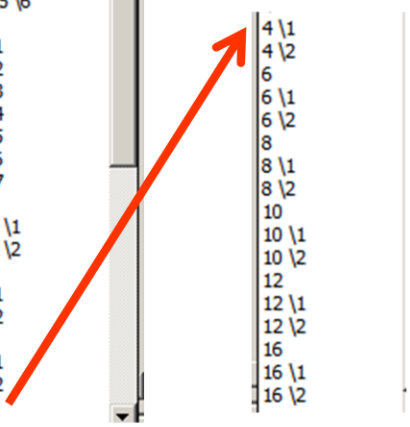
Automatic or manual valve size selection

and reduced trim selection



Default is AUTOM (Automatic)

List shows all available Sizes and reductions
1 = 1 inch full area
1\1 = 1 inch, one size reduced trim



The default entry for the valve “Size” field is “AUTOM” (for automatic). In general this is a good choice. Nelprof will select the valve size it thinks is best by looking at a number of things, such as the valve’s percent of opening at maximum and minimum flow, the amount of flow safety factor at maximum and minimum flow, noise, cavitation potential, installed gain, flow velocity in the valve body, and the size of the selected valve in relation to the size of the pipe it is installed in.

There may be times when you want to compare the automatically selected size to another size. One example is when the program selects a larger valve when you would like to use one size smaller valve. It may turn out that the smaller valve would be only slightly more than 80% open at maximum flow, and your judgment is that 82% or 83% open will be all right for the application. You might also see when you try the smaller valve, there is another reason Nelprof does not like it. Perhaps the smaller valve may have a nose level or flow velocity in the valve body that is too high.

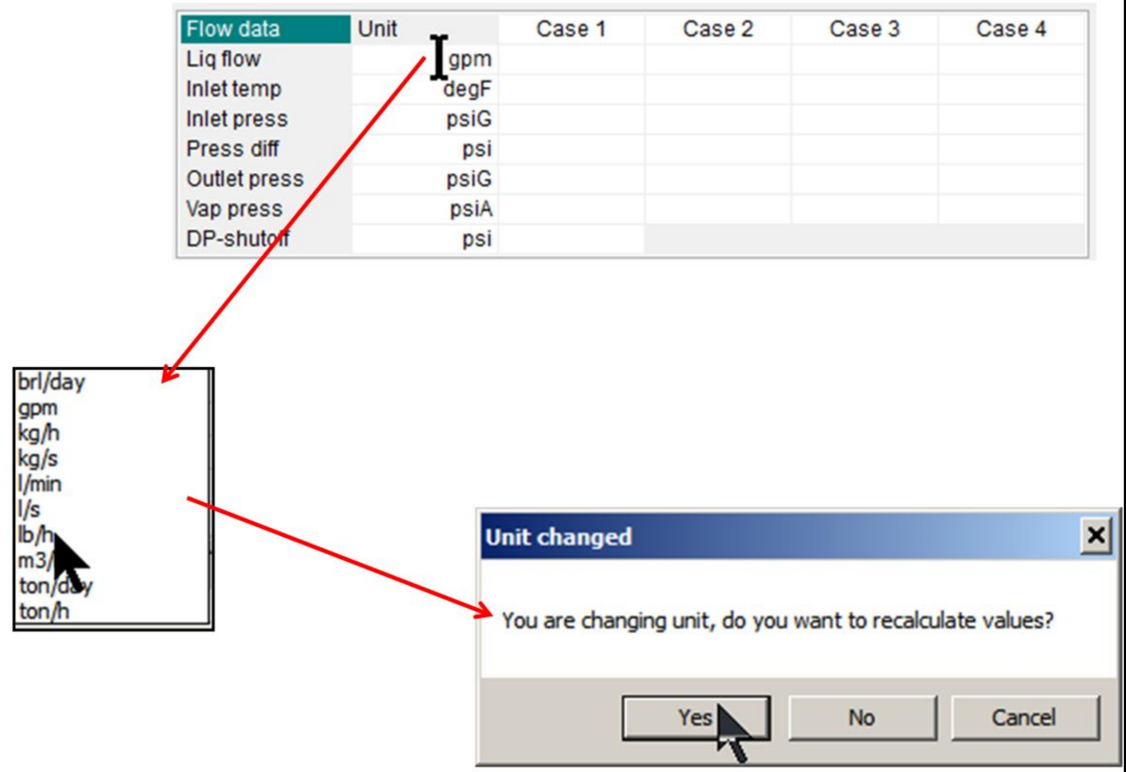
To run a calculation for a valve size other than what Nelprof selects automatically, left click in the valve “Size” field and you will see a list of all the sizes that valve style is available in. Nelprof will not accept a size larger than the pipe size, and will issue a “note” alerting you that the valve size is small compared to the pipeline size if you select a size that is less than one half the pipe size.

In the screen shot shown here, Nelprof has data for generic equal percentage globe valves from ½ inch to 16 inches. (The list is too long for a single screen shot.)

Some valve styles, such as generic globe valve, Neles Finetrol eccentric rotary plug valves, Neles “Rotary Globe” valves and Neles “R” Series segment ball valves (in 1 inch), are available with reduced trim. (Reduced trim means valve internals that give the valve a flow capacity (Cv) that is smaller than the maximum capacity that is possible with that size valve.

In Nelprof, reduced trim is indicted by a “\” mark after the nominal valve size followed by a number that tells how much reduction from maximum that selection represents. For example, 1, means a one inch valve with full area (maximum available Cv) trim. 1\1 means a one inch valve with one size reduced trim, 1\2 means a one inch valve with two sizes reduced trim and so on. The “Max Capacity” field in the “Results” section shows the rated (fully open) Cv of the selected size (and reduction when applicable).

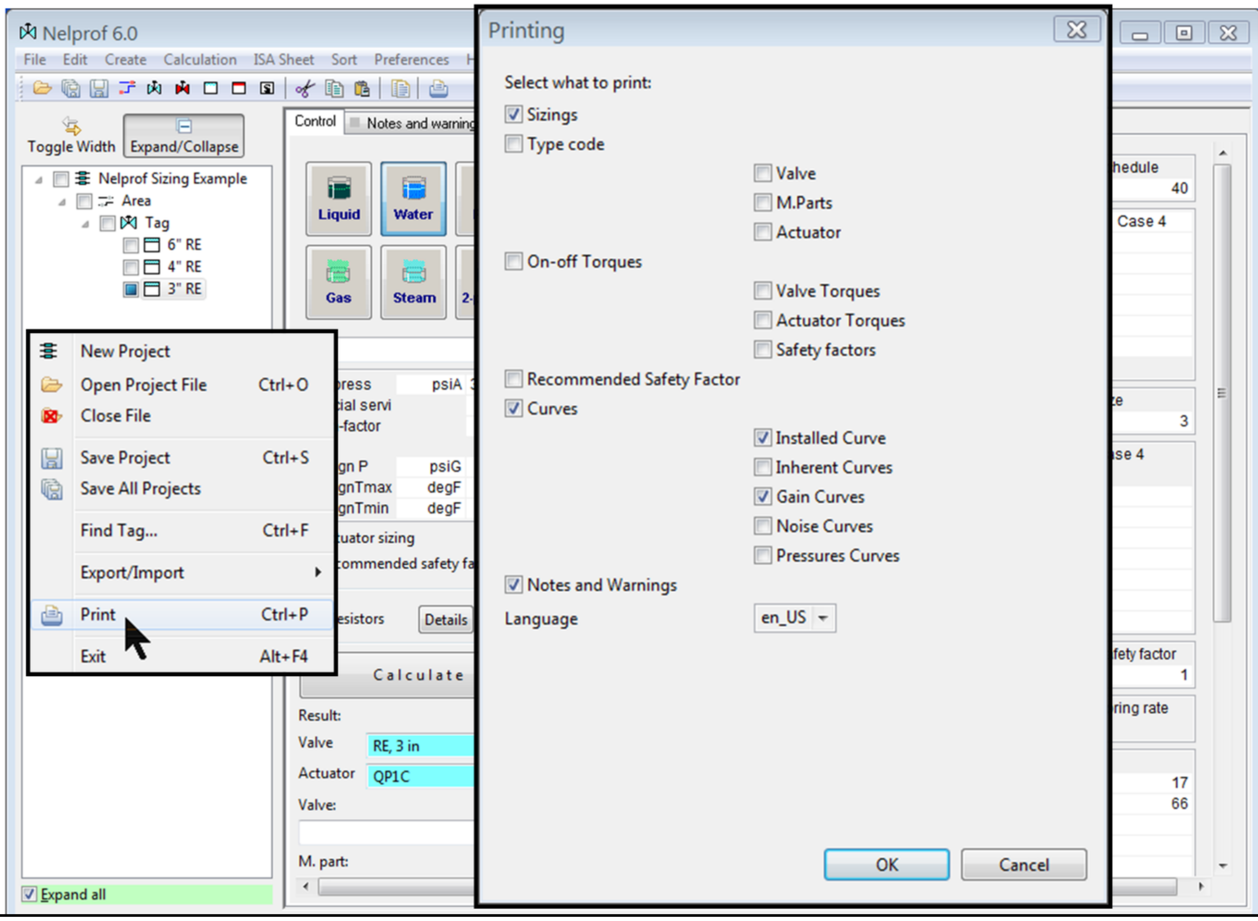
Changing units for an individual calculation



You can change any individual engineering units that will be applicable to only the one calculation you are presently working on (or any new duplicates of that calculation).

With the “Text select” pointer in the “Unit” field that you want to change left click. A list of all the possible units for that unit (in the example the possible units for “Liquid flow”) appears. If we selected “lb/h,” lb/h would replace “gpm.” If a value of flow in gpm had already been entered, the dialog “Unit changed” would appear. If 10 gpm was already in the Case 1 field, clicking the Yes button would change the value to 5002.2 which is the pounds per hour equivalent of 10 gpm of water. Clicking the No button would retain the value of 10 which would then represent a flow of 10 lb/h.

Printing



To print the results of your calculations, click on the check box next to any sizings you want to print. You can select one, several or the whole project. In the example above, only “3” RE” will be printed.

From the File menu select “Print.”

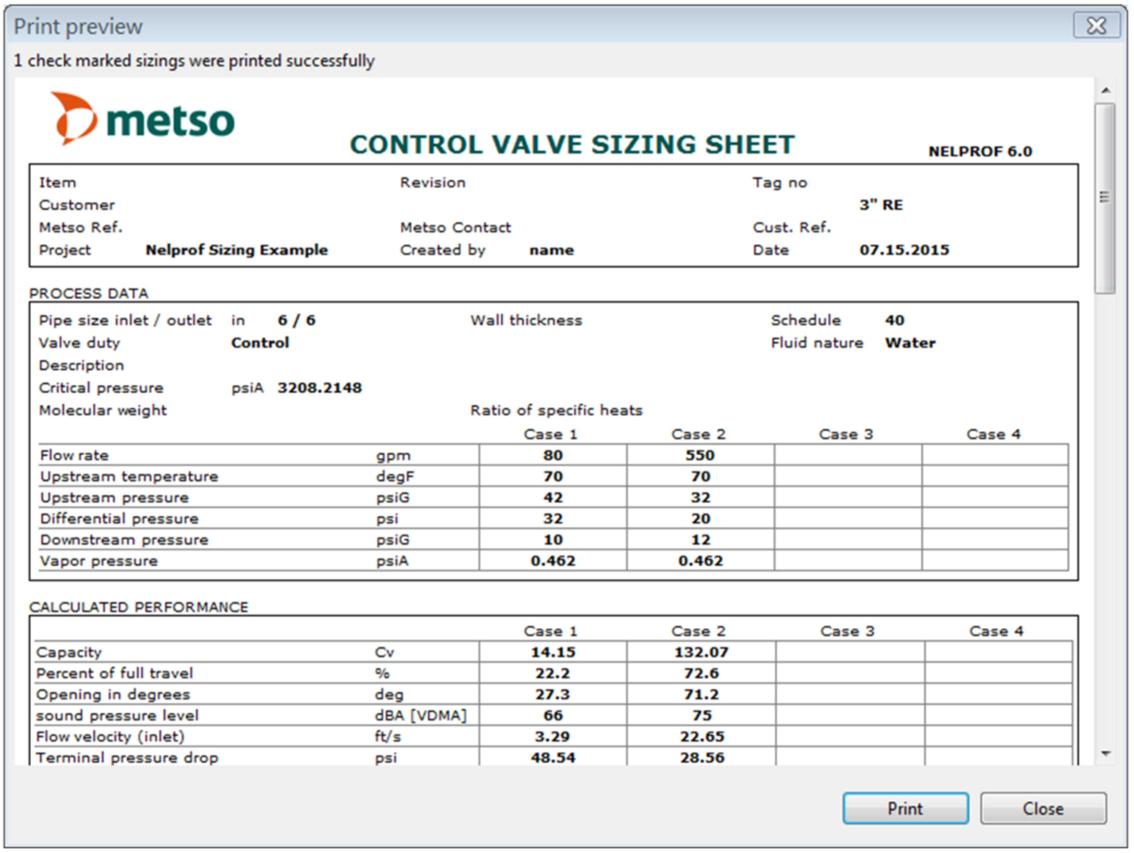
The “Printing” dialog shown above will appear. Under “Select what to print: “Sizings” will be checked as a default. This will print all the process inputs and calculated results including actuator sizing results. The contents of whatever you have typed in the “Remarks” field of the Notes and warnings tab will be printed in the “Notes” field at the bottom of the Sizing print out.

If you want to print any of the graphs, check the “Curves” box, then check the boxes for the graphs you want to print.

To print the notes and warnings that were displayed on the “Notes and warnings tab, check the “Notes and Warnings box.

When you click “OK” you will see a preview of what will be printed.

Print preview



Print preview

1 check marked sizings were printed successfully

metso

CONTROL VALVE SIZING SHEET **NELPROF 6.0**

Item		Revision		Tag no	
Customer					3" RE
Metso Ref.		Metso Contact		Cust. Ref.	
Project	Nelprof Sizing Example	Created by	name	Date	07.15.2015

PROCESS DATA

Pipe size inlet / outlet	in 6 / 6	Wall thickness		Schedule	40
Valve duty	Control			Fluid nature	Water
Description					
Critical pressure	psiA 3208.2148				
Molecular weight		Ratio of specific heats			

		Case 1	Case 2	Case 3	Case 4
Flow rate	gpm	80	550		
Upstream temperature	degF	70	70		
Upstream pressure	psiG	42	32		
Differential pressure	psi	32	20		
Downstream pressure	psiG	10	12		
Vapor pressure	psiA	0.462	0.462		

CALCULATED PERFORMANCE

		Case 1	Case 2	Case 3	Case 4
Capacity	Cv	14.15	132.07		
Percent of full travel	%	22.2	72.6		
Opening in degrees	deg	27.3	71.2		
sound pressure level	dBA [VDMA]	66	75		
Flow velocity (inlet)	ft/s	3.29	22.65		
Terminal pressure drop	psi	48.54	28.56		

Print Close

This is a preview of what will be printed. You can scroll down so that you can review everything that will print to make sure you are satisfied with it.

Print preview

VALUE SELECTION

Nominal size in	3	Maximum capacity	Cv	420	FpCv	263.24
Valve type	SEGMENT					
Valve serie	RE	ROTARY CONTROL VALVE, METAL SEATED, SEGMENT / V-PORT				

ACTUATOR SIZING DATA

Supply pressure	psiG	60	Valve seat	Metal, Type S
Max shut off dp	psi	42	Gland packing	PTFE/TFE
Special service req.			Bearings	PTFE

ACTUATOR SIZING RESULTS

Selected actuator **QP1C** **SPRING TO CLOSE DIAPHRAGM ACTUATOR**

Required open	ftlb	21	Required close	ftlb	17
Opening load factor	%	43	Closing load factor	%	66

		Case 1	Case 2	Case 3	Case 4
Req control to open	ftlb	16	17		
Ctrl open load factor	%	28	44		
Req control to close	ftlb	16	16		
Ctrl close load factor	%	35	27		

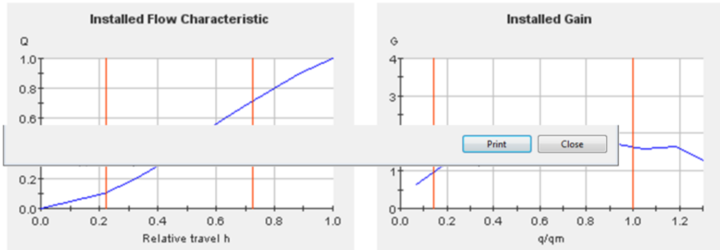
Notes

This is a note in the Remarks fieled.

metso

CHARACTERISTIC CURVES **NELPROF 6.0**

Tag no		
Valve	RE3	ROTARY CONTROL VALVE, METAL SEATED, SEGMENT / V-PORT
3" RE		



Here we have scrolled down to see the rest of the Sizing sheet for “3” RE” along with the curves that we selected.

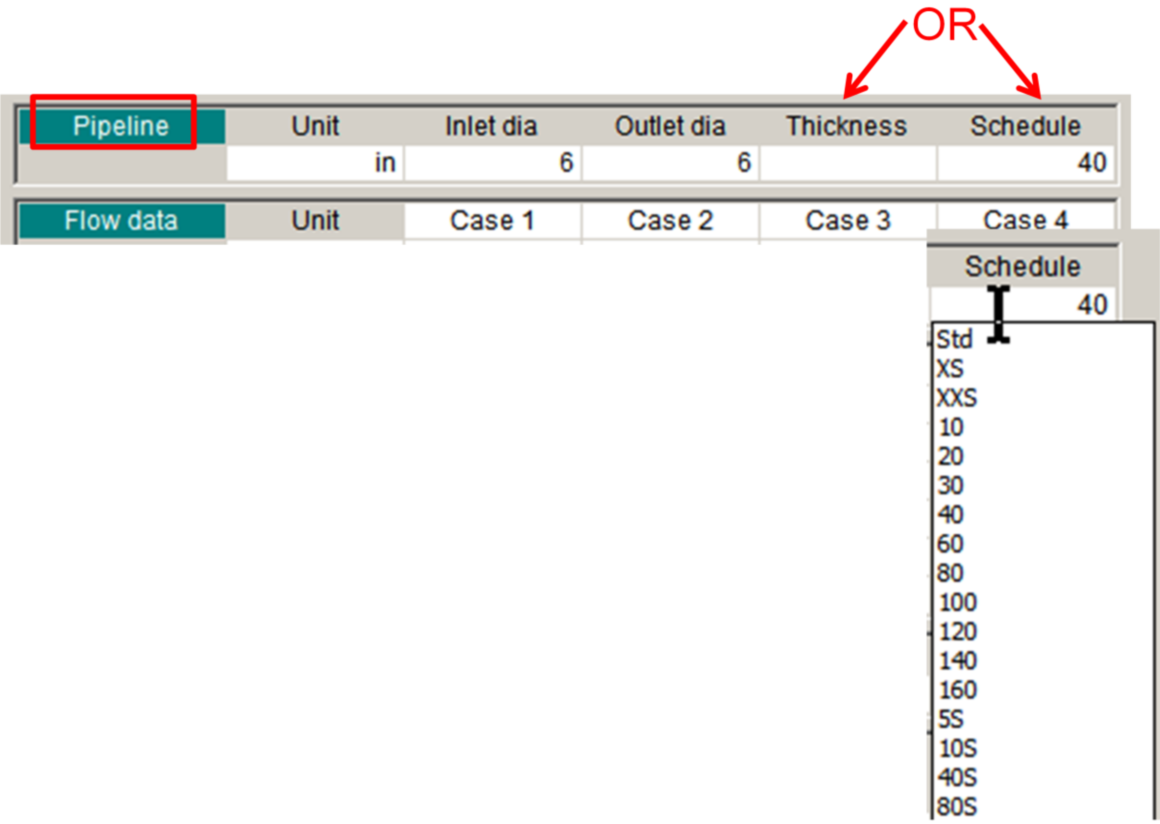
When you click the “Print” button you will see the standard Windows “Print” dialog where you select a printer and set its properties.

If you have a need to edit anything that is in the print-out, left click anywhere in the print preview and then click on “Select all.” Everything in the preview will be highlighted. Copy all of the highlighted content by pressing “Ctrl + C.”

Then open a blank Microsoft Word document and paste the content by pressing “Ctrl + V” and a fully editable copy of the print preview will appear.

Pipeline data entry

Common to all six medium type sizing sheets



The top row of all the sizing sheets is where you enter information about the piping the valve is installed in.

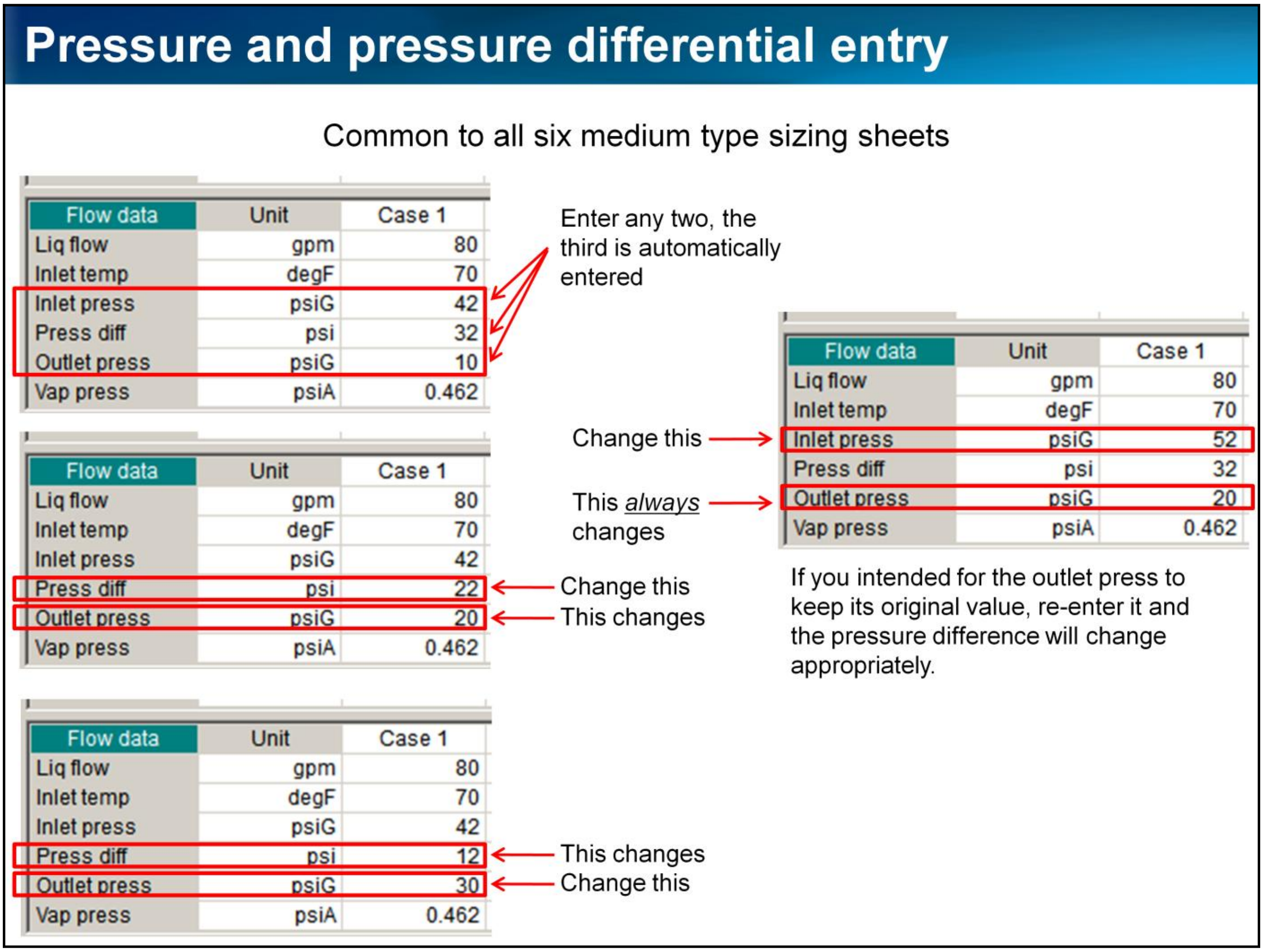
The valve inlet and outlet pipe diameters are used in the calculation that corrects for the effect of pipe reducers. With the exception of the two-phase sizing sheet, for which there is no noise calculation, the outlet pipe diameter and either the outlet pipe wall thickness or the outlet pipe schedule are used in the noise calculation.

When a new sizing sheet is opened, the only default entry in the “Pipeline” row is “40” for the outlet pipe schedule.

You should start with entering the inlet pipe diameter. Then when you either click or tab into the outlet pipe diameter field, the value you have entered for the inlet diameter is automatically copied into the outlet diameter field. Since the vast majority of the time, the upstream and downstream piping will be the same size, this saves typing the downstream pipe size. If the downstream pipe is a different size you can type in its size to overwrite the automatically entered value.

Since pipe wall thickness and pipe schedule convey exactly the same information, only one is needed. Since you are more likely to know the downstream pipe schedule than its wall thickness, and Schedule 40 is the most common schedule, that’s what Nelprof starts with. For any other schedule, left click in the Schedule field and a list will appear for you to choose from.

If you type anything in the “Thickness” field, anything in the “Schedule” field will be deleted. If after entering a Thickness, you select a Schedule from the dropdown list, you Thickness entry will be automatically deleted.



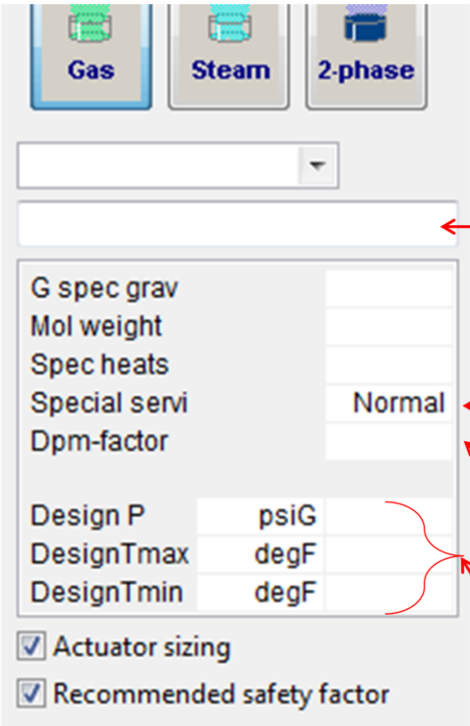
Also common to all of the six of the sizing sheets is the way Inlet pressure, Pressure differential and Outlet pressure are handled by Nelprof.

You can enter any two of the parameters: inlet pressure, outlet pressure and pressure differential in any order you want. Nelprof will fill in the third with the appropriate value as soon as you click on another field, or press the Enter or Tab key. If you change the pressure differential, Nelprof changes the outlet pressure accordingly, and if you change the outlet pressure, Nelprof changes pressure differential accordingly. This is all straight forward. The one thing **you need to be aware of** is that if you change the inlet pressure, Nelprof assumes that you want to keep the pressure differential the same as it is, so it changes the outlet pressure accordingly. This very possibly would be what you intended. On the other hand, if you were to change the inlet pressure you might want to leave the outlet pressure and change the pressure differential accordingly. If that is the case, you will need to manually put the outlet pressure back to what you intended. As soon as you re-enter the correct outlet pressure, Nelprof will put in the appropriate new pressure differential.

This discussion applies to all six medium sizing calculation sheets.

Description, Special service, Dpm, Design P & T

Common to all six medium type sizing sheets*



"Description." Free field. Entry prints in "Description" field near top of sizing print-out. *Not applicable to Two-phase

"Special service" Recommends actuator safety factor for difficult service.

"Dpm-factor." Permits creation of installed graphs with the entry of only one set of process conditions. *Not applicable to Two-Phase.

"Design pressure and temperature." These fields are for documentation purposes only.

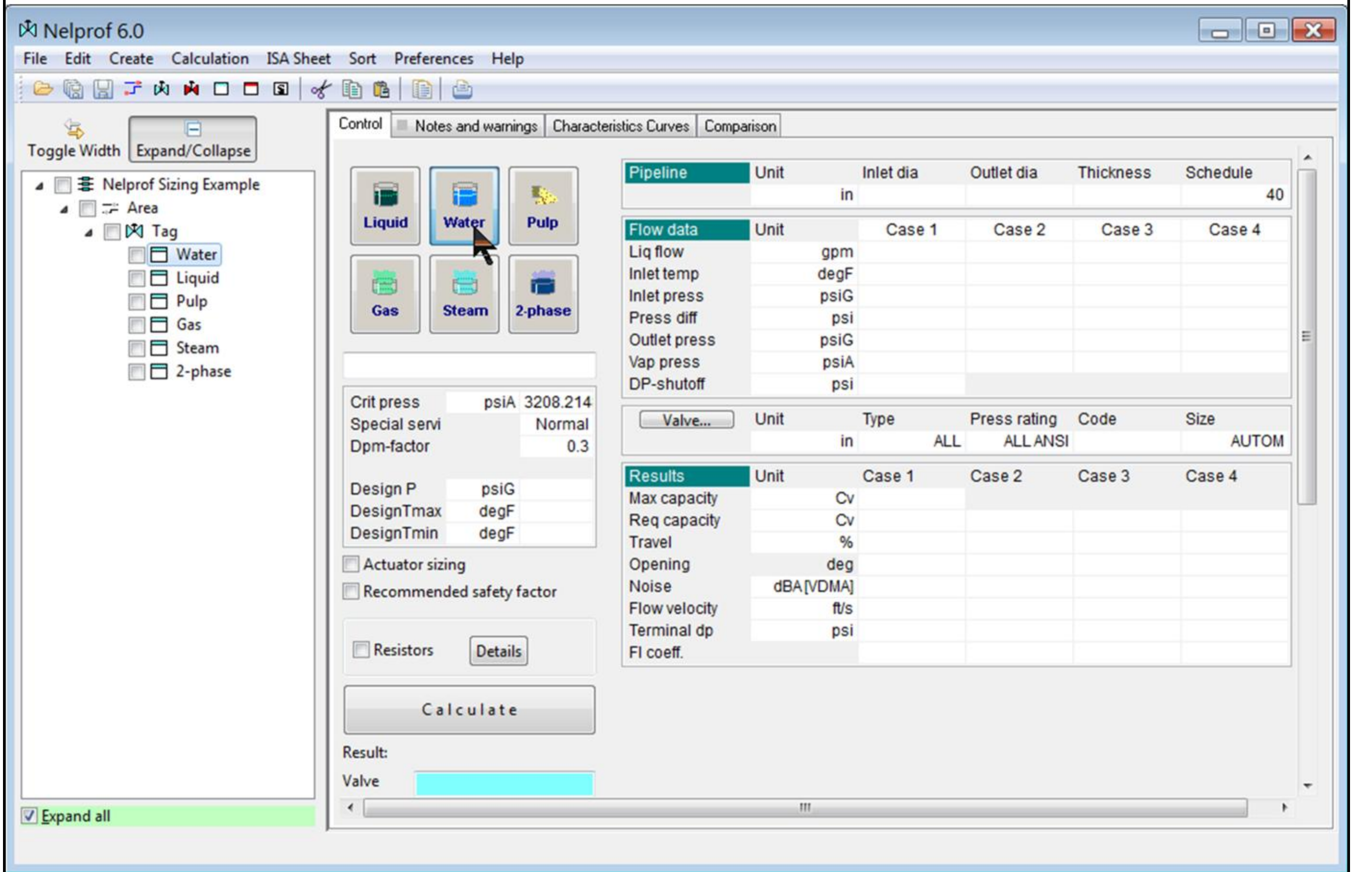
With the exception of the 2-phase sheet, all of the other media sizing sheets have an untitled field where you can put anything you want. It will print out in the "Description" field near the top of the sizing print-out. The designers of Nelprof had in mind for this field to be used to describe the process, something like "Mill water," "Circulating water", "Condensate" or whatever. There is room for 33 characters and spaces on the sizing screen, but you can type in a lot more and it will still print out on the printed sheet.

In the Special service field there is a drop down list where you can select from several types of service that are likely to increase the required operating torque of the valve. If the "Recommended safety factor" box is checked, the program will make a suggestion (just below the actuator results) of how much safety factor to use in selecting an actuator with extra torque. After changing the "Special service" field the recommendation only changes after clicking the "Calculate" button. This will be a suggestion only. The user must decide what safety factor he wishes to add to the required torque.

The Dpm-factor makes it possible to generate installed flow characteristic and installed gain graphs when only one set of process conditions has been entered. Any graphs will be an approximation at best. See Section 2.4.4 Process model and Dpm selection in the *Metso Flow Control Manual.*

The Design Pressure, Design Temperature max and Design Temperature min fields are for documentation purposes only. Entries in these fields have no effect on the calculations or operation of the program.

Water sizing



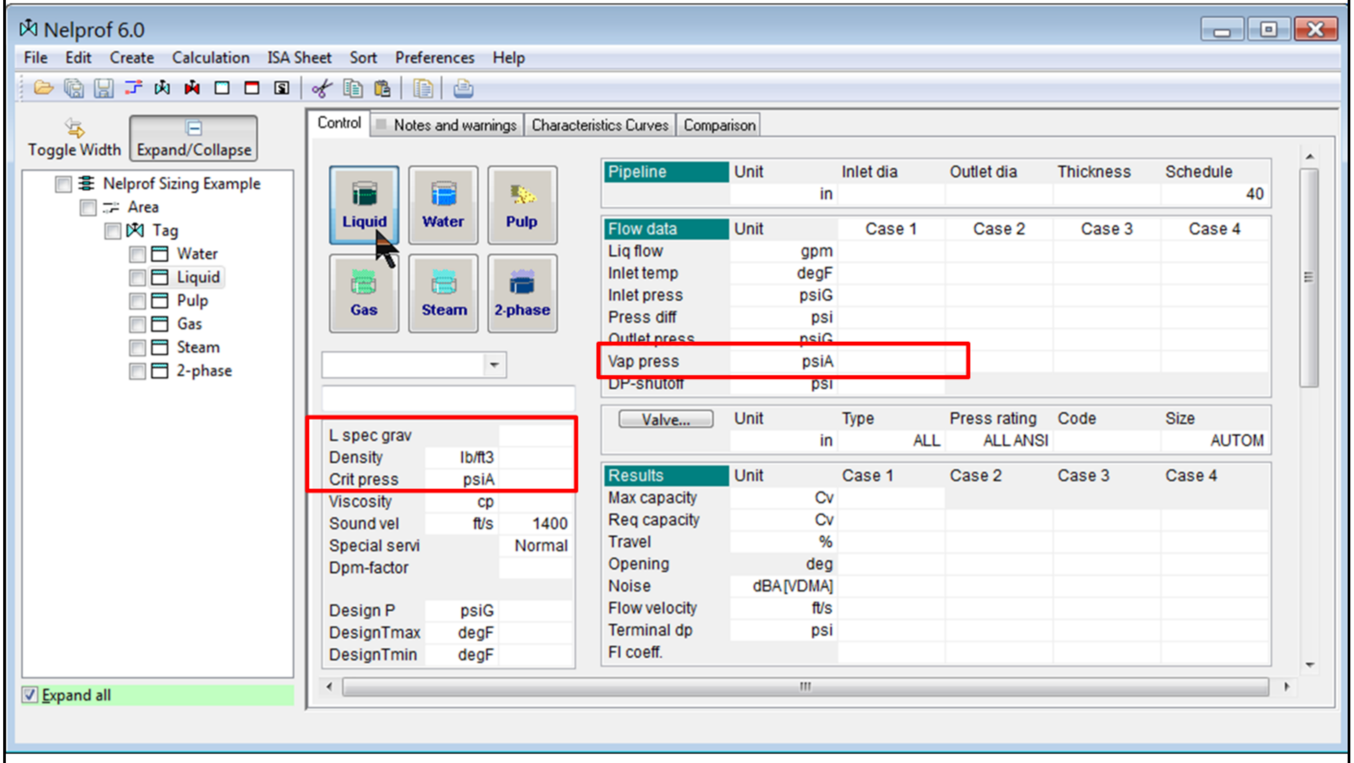
The water sheet is the simplest to use. Things like the specific gravity and vapor pressure depend on the water temperature, and the program figures those out for itself. (The program doesn't show the specific gravity at the operating temperature on the screen, but uses it in the calculation.) The program also enters the critical pressure of water.

All of the inputs are things you will know or easily be able to find out.

Below the six buttons that select the medium type is a field where you can type anything you want to have appear near the top of the printout under "Description."

The "Special service" field on the left side of the screen is discussed on the page "Actuator sizing" and the "Dpm-factor" is used when installed curves are desired when only one set of process data is entered and is an approximation at best.

Liquid sizing



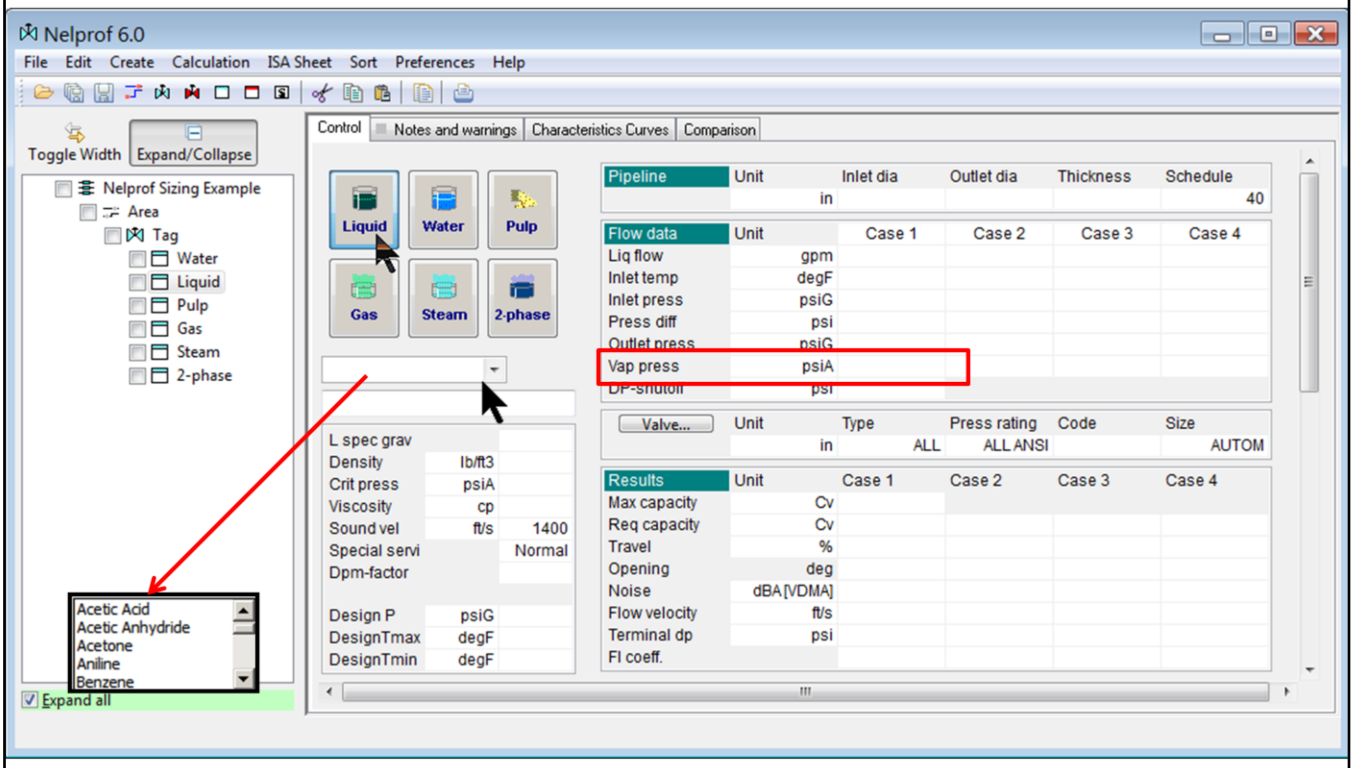
The liquid sizing calculation sheet needs to know either the specific gravity or the density of the liquid and also its vapor pressure.

You do not need to enter a value for viscosity unless you expect it to have an effect on the calculated results. The calculations for the installed flow and gain do not include a correction for viscosity, so the graphs will not reflect the effect of viscosity. There will be a note with a yellow flag stating “Installed flow characteristics have not been analyzed.”

Beginning with Nelprof Rev. 6.2.1 the non-turbulent liquid calculation has been updated to comply with the 2011 version of the IEC control valve sizing equation standard and the 2012 ISA version of that same standard. This should improve the accuracy of non-turbulent flow calculations.

The IEC and ISA Standards state that the effect of pipe reducers attached to a control valve when flow is non-turbulent is unknown. Therefore, the effect of reducers is not included in the IEC/ISA equations of the non-turbulent flow coefficient. The Standards make the following suggestion: “The user of such valves is advised to utilize the appropriate equations for line-sized valves in the calculation of the F_R factor. This should result in conservative flow coefficients, since additional turbulence created by reducers and expanders will further delay the onset of laminar flow.” The author of this “Using Nelprof” document has no argument with the fact that Nelprof includes a reducer calculation and Metso’s inclusion of a reducer correction may be justified, but if you want to follow the suggestion of the Standards, when calculating Cv for non-turbulent flow you will make the pipeline sizes the same as the valve size for which you are doing a calculation. The Standards also state that the methods given for non-turbulent flow are for “non-vaporizing fluids” so any indication of choking or flashing would only be valid if the flow was turbulent. Noise calculations also only apply if the flow is turbulent.

Liquid sizing



There is drop down list of a number of common liquids. If you are lucky, your liquid will be on the list. If it is, select it and the program will insert the density (at 60 degrees F), the critical pressure and the vapor pressure at the inlet temperature for you. If you know the density or specific gravity at your actual operating temperature you can overwrite the automatic value with it.

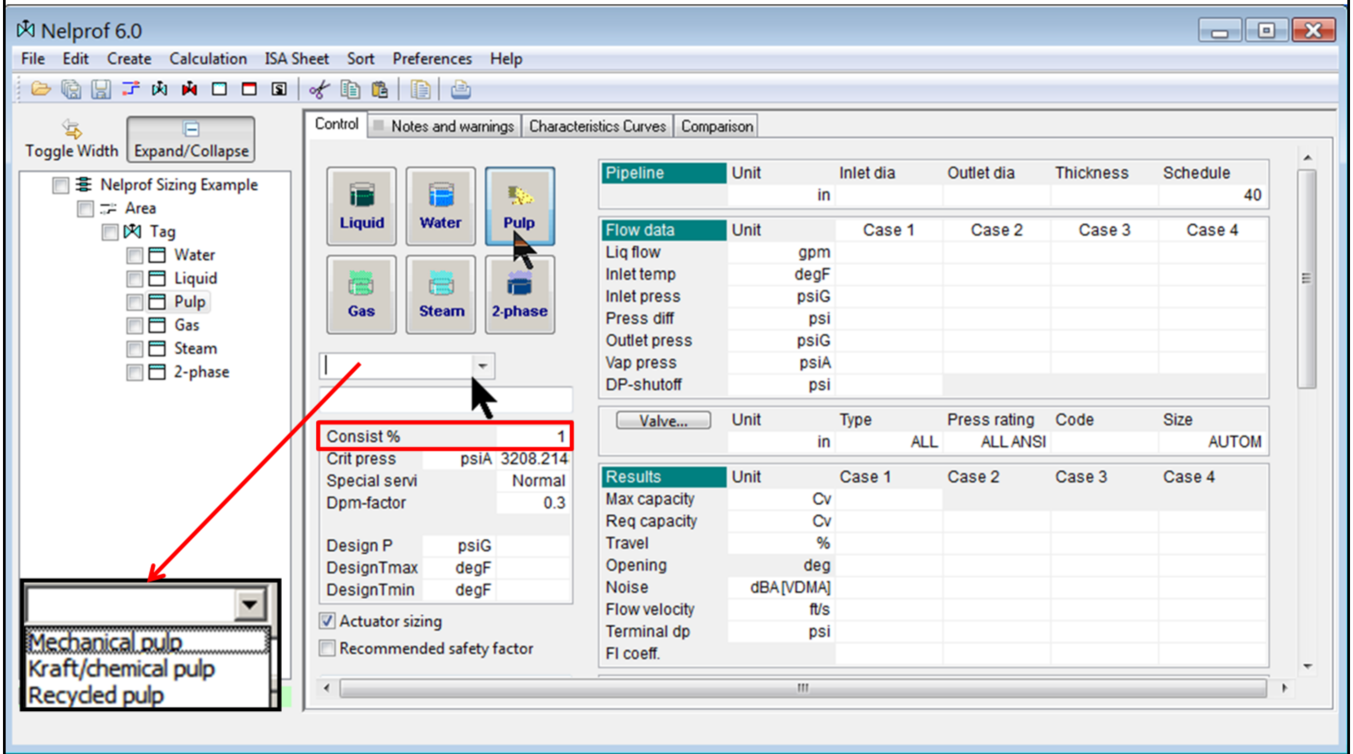
If you do not select one of the liquids from the drop down list, the program will insert the vapor pressure of water without telling you where it got the vapor pressure. The vapor pressure of water is a good guess for water based chemicals but for some liquids it may be a very bad guess. **Something to watch for is, if you manually enter a value for vapor pressure, then later change the inlet temperature, the pressure differential or outlet pressure, the program will overwrite your vapor pressure value with the vapor pressure of water**.

If you click the “Calculate” button without entering the liquid’s Critical Pressure or Sonic Velocity It will insert the critical pressure of water and a typical sonic velocity. The critical pressure of water is a very good guess for water based chemicals and not a bad guess if you can't find the actual critical pressure of other liquids. The critical pressure of water is greater than for most other liquids, and using a critical pressure in the calculations that is higher than the actual critical pressure simply makes the calculation of the terminal pressure drop be on the conservative side. The sonic velocity in liquids is not easy to find and the value the program uses will be satisfactory.

Below the drop down list is a field where you can type anything you want to have appear near the top of the printout under “Description.”

The “Special service” field on the left side of the screen is discussed on the page “Actuator sizing” and the “Dpm-factor” is used when installed curves are desired when only one set of process data is entered and is an approximation at best.

Pulp sizing



Things like the specific gravity and vapor pressure depend on the temperature, and the program figures those out for itself. (The program doesn’t show the specific gravity at the operating temperature on the screen, but uses it in the calculation.) The program also enters the critical pressure of water

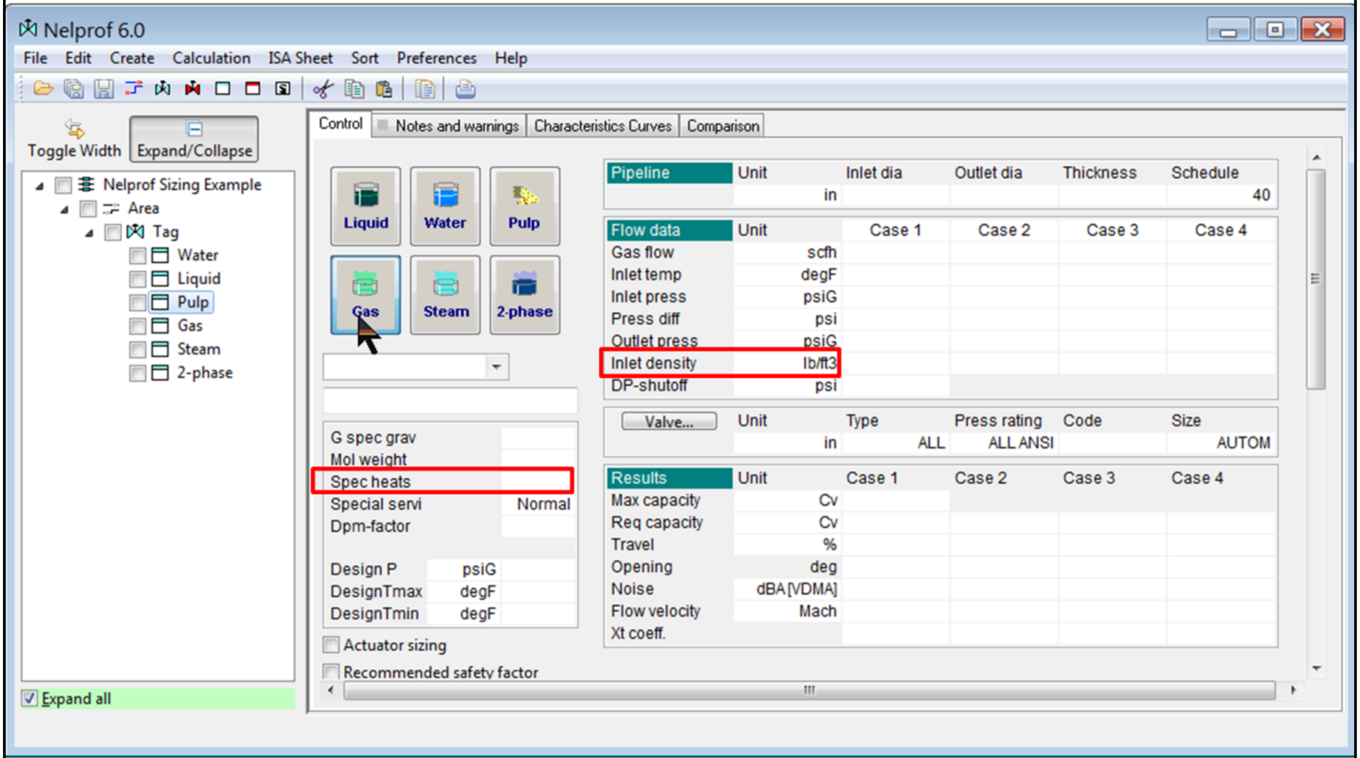
In the drop down list just below the six buttons that select the medium type, select the type of pulp, Mechanical, Kraft/chemical, or Recycled.

The program needs to know the consistency of the pulp.

Below the drop down list is a field where you can type anything you want to have appear near the top of the printout under “Description.”

The “Special service” field on the left side of the screen is discussed on the page “Actuator sizing” and the “Dpm-factor” is used when installed curves are desired when only one set of process data is entered and is an approximation at best.

Gas sizing



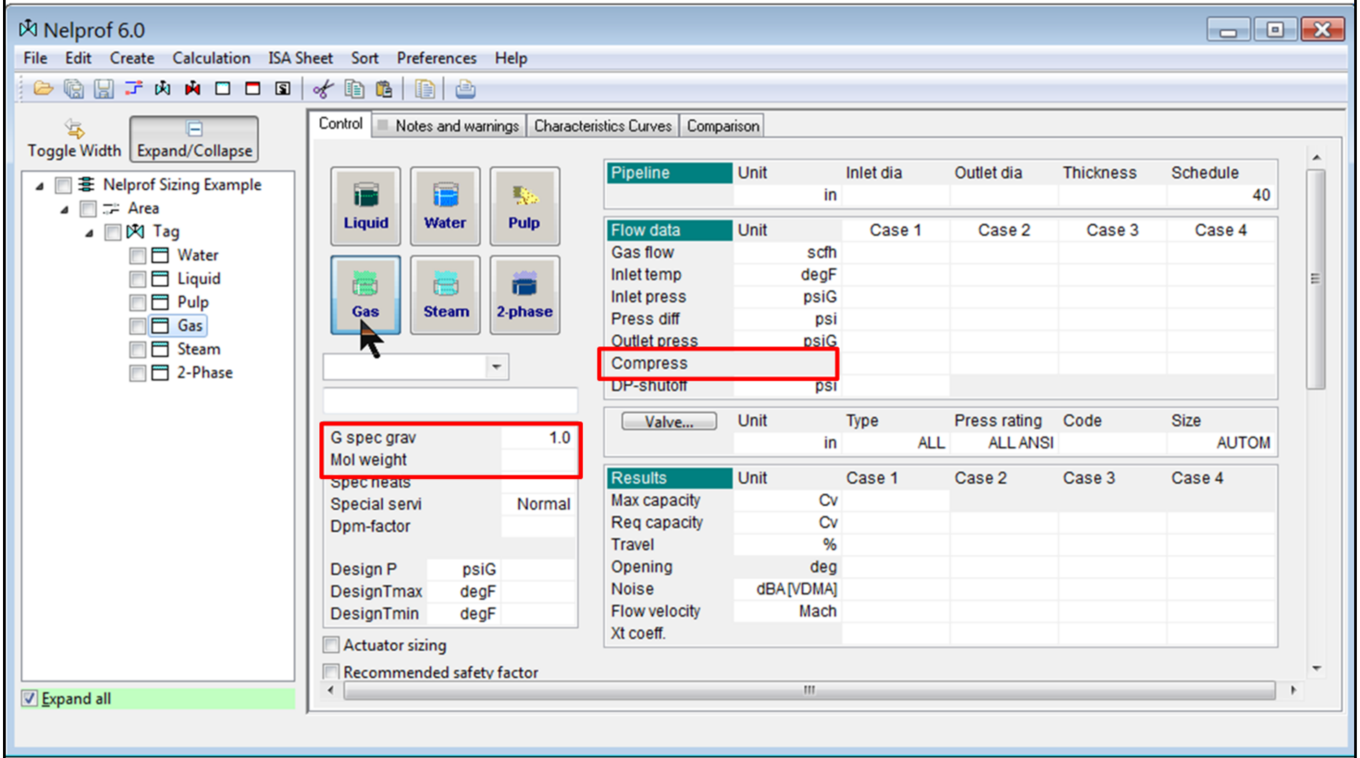
The gas sizing calculation wants to know the inlet density of the gas and the ratio of specific heats of the gas.

If you know the actual density of the gas, do not enter the specific gravity or the molecular weight.

If you don’t know the ratio of specific heats for your gas, leave the field blank and when you click the calculate button the program will insert a value of 1.4 which is a good guess.

If you don’t know the inlet density, go to the next page.

Gas sizing



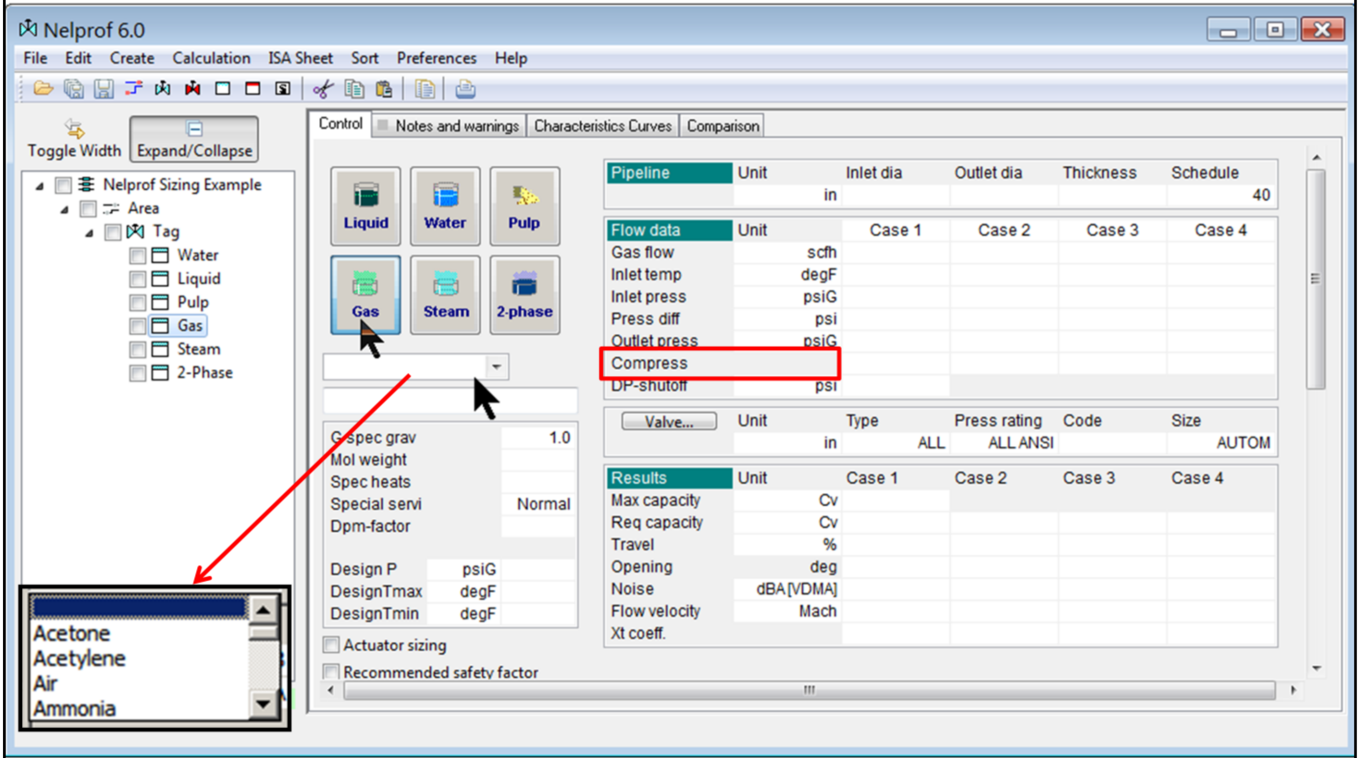
For most gasses, you probably won't know the inlet density of the gas, but will know either its specific gravity or molecular weight. From either of these, the ISA/IEC gas sizing equations include a method that approximates the density from the specific gravity or molecular weight and the upstream pressure and temperature.

As soon as you enter a value for specific gravity or molecular weight, the title of the field that was inlet density changes to "Compress" which really means "Compressibility factor."

The Compressibility Factor corrects the sizing calculation by the amount the actual density of the gas at process conditions will vary from the density of a perfect gas at the same conditions.

Continued on the next page.

Gas sizing



There is a drop down list of a number of common gasses and if your gas is on the list, select it and the program will inset the molecular weight and ratio of specific heats and will calculate an approximation of the Compressibility factor.

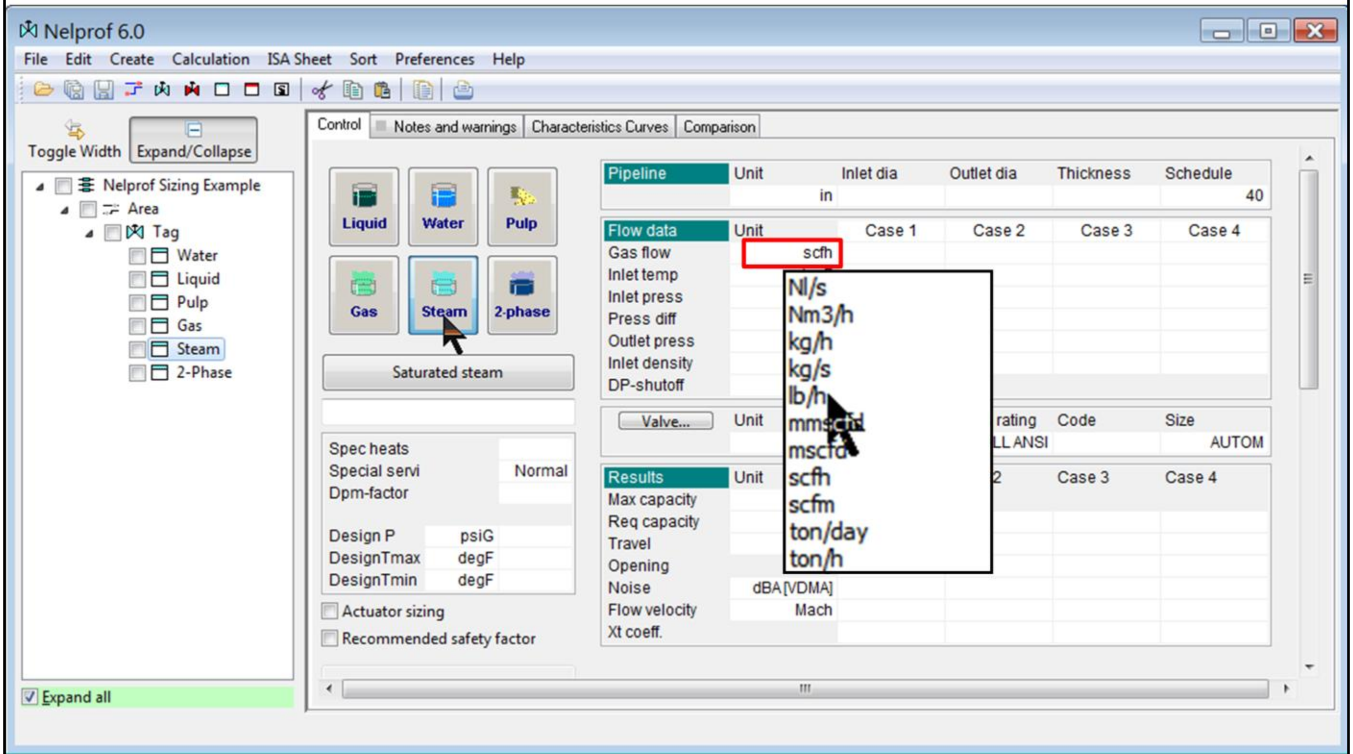
If you do not select a gas from the drop-down list, but instead enter a known value for either specific gravity or molecular weight, the program inserts the compressibility factor for air, which will be very close to 1. A compressibility factor of 1 is usually satisfactory (for valve sizing purposes) for most gasses at the pressures and temperatures usually encountered in industrial processes. You have the option of overwriting a computer inserted compressibility factor. However, if you change the inlet temperature or inlet pressure, the program will replace your value with its newly calculated value for the compressibility factor of air, based on the revised pressure and/or temperature.

If you know the ratio of specific heats of your non-listed gas, enter it below the Molecular weight field. If you don't enter a ratio of specific heats, the program will insert a value of 1.4, which is not a bad guess for valve sizing purposes.

Below the drop down list is a field where you can type anything you want to have appear near the top of the printout under "Description."

The "Special service" field on the left side of the screen is discussed on the page "Actuator sizing" and the "Dpm-factor" is used when installed curves are desired when only one set of process data is entered and is an approximation at best.

Steam sizing



The steam calculation sheet has an annoying "undocumented feature" that has an easy work-around, but you can easily miss it if you are not watching out for it.

Even though the "Default" US units for steam flow is set to lb/h (pounds per hour) the sheet opens with the default flow units set to "scfh" which is not appropriate for steam.

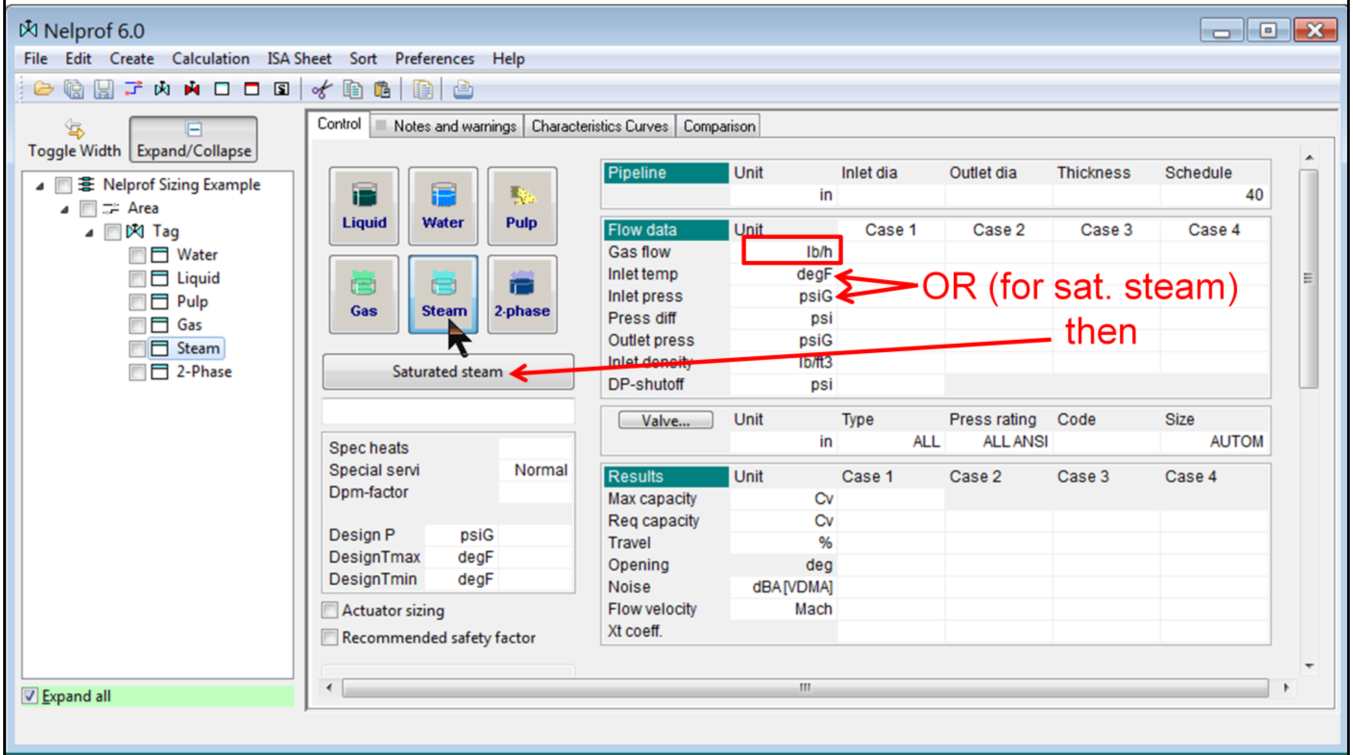
The work-around is that after opening the calculation sheet, change the units for flow to lb/h using the procedure described on the page titled "Changing units for an individual calculation."

In this case, left click in the field where the "scfh" is shown, then from the list that appears, select "lb/h".

NOTE that the engineering units of any other parameter on any of the six sizing sheets can be changed in the same manner as above. A change made in this way applies only to the sizing you have made the change on and any **new** duplicates of it.

If you are using SI units as your default, the flow units for steam will be, by default, kg/h which is appropriate for steam.

Steam sizing



The other thing you need to know about the steam sizing sheet is that for saturated steam, you can enter either the pressure or the temperature, then click the “Saturated steam” button and the program will input the other for you. It then enters the resulting inlet density. For superheated steam, if you enter both pressure and temperature, Nelprof will calculate the density. If you have a value for density that you think is more accurate, you can overwrite the program’s value with yours. Even if you enter your own value for density, you must still enter the inlet temperature and inlet pressure. After manually overwriting the value of density you change the pressure or temperature, the program will recalculate the density to agree with the new temperature and pressure.

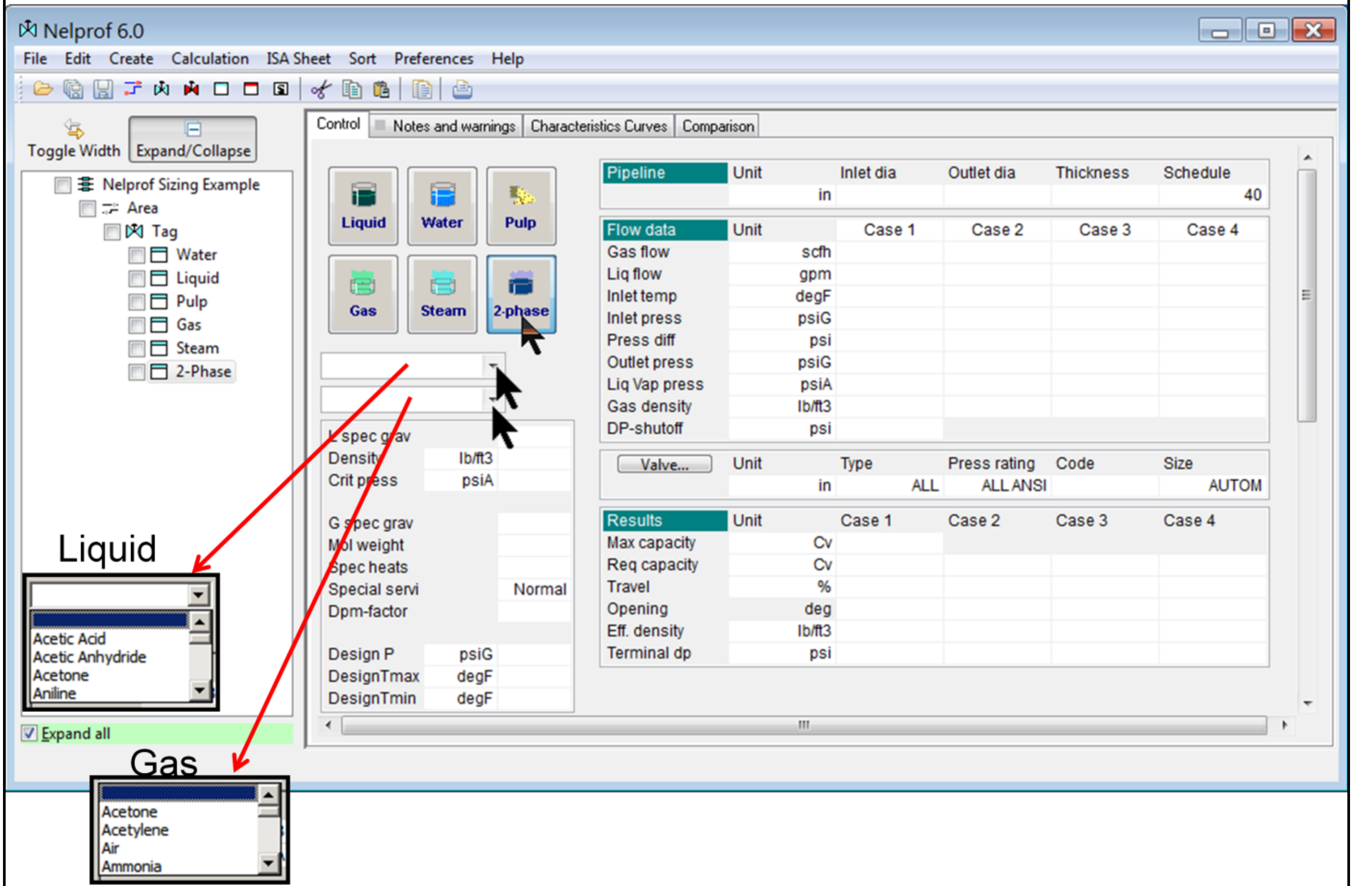
For steam pressures above 1,500 psi or temperatures above 1,000 degrees F, look up the steam density in a steam table rather than using the value that the Nelprof program provides. Neles and Jamesbury do not furnish valves for these pressures and temperatures.

Leave the “Spec heats” (the ratio of specific heats) blank. When you click the Calculate button the program will fill it in for you.

Below the “Saturated steam” button is a field where you can type anything you want to have appear near the top of the printout under “Description.”

The “Special service” field on the left side of the screen is discussed on the page “Actuator sizing” and the “Dpm-factor” is used when installed curves are desired when only one set of process data is entered and is an approximation at best.

Two – phase sizing



The two-phase calculation sheet is used for either mixtures of a liquid and a non-condensable gas, or mixtures of a liquid and its own vapor. Here you enter properties for both the liquid and the gas.

All the comments about entering the various liquid properties that were mentioned in the discussion of the water sheet apply to the liquid portion of this sheet and all the comments about entering the various gas properties that were mentioned in the discussion of the gas sheet apply to the gas portion of this sheet.

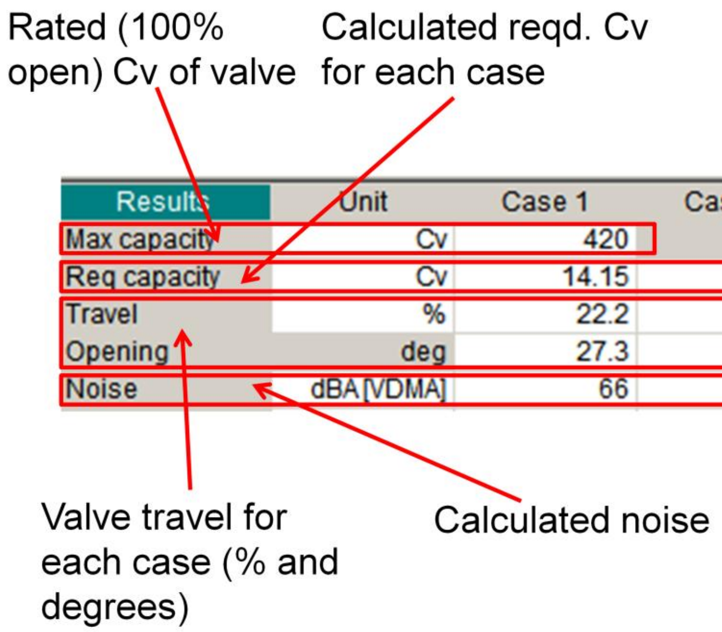
There are two drop down list boxes, the upper one for liquids and the lower for gasses. If your liquid is on the list, selecting it will enter the density at 60 degrees F and the critical pressure. If it is not on the list you will need to manually enter either the specific gravity of density. If your gas is on the list, selecting it will enter the molecular weight and the ratio of specific heats. If it is not on the list you will need to manually enter either the specific gravity or the molecular weight and the ratio of specific heats. If you have selected fluids from the drop down lists, their names will appear on the print-out in the Description field at the top of the print-out.

The “Special service” field on the left side of the screen is discussed on the page “Actuator sizing.”

The Dpm-factor field is not active on the two-phase sheet.

Nelprof cannot make installed flow characteristic and installed gain graphs for two-phase flow.

Results – common to all media



Now we will talk about the calculated results.

Shown here are the calculated results that are common to the sizing sheets for all six medium types.

The “Max capacity” field is the rated or 100 percent open Cv of the selected valve. (Assuming that when you set up the program you selected units of Cv for valve capacity as recommended in the section: “Set default engineering units (continued).)

The “Req capacity” field contains the calculated required CV for each of the up to four cases.

The “Travel” and “Opening” fields show how far open the selected valve will be for each of the four cases, in percent of full travel and degrees of rotation respectively. (Degrees of rotation is only applicable to rotary motion valves.) More detail on this on the next page.

If the minimum and maximum valve openings are outside the range that Nelprof finds acceptable, the value for the offending result will be in red with an asterisk next to it. (In the print out it will be black with an asterisk.) There will also be a note or warning (depending on how seriously the value is outside the acceptable range) on the “Notes and warnings” tab.

The opening range that Nelprof finds acceptable is:

Ball & Segment ball valves: Minimum opening greater than 3%, maximum opening between 40% and 90%.

Globe valves: Minimum opening greater than 10%, maximum opening between 40% and 90%.

Eccentric rotary plug valves: Minimum opening greater than 5%, maximum opening between 40% and 90%.

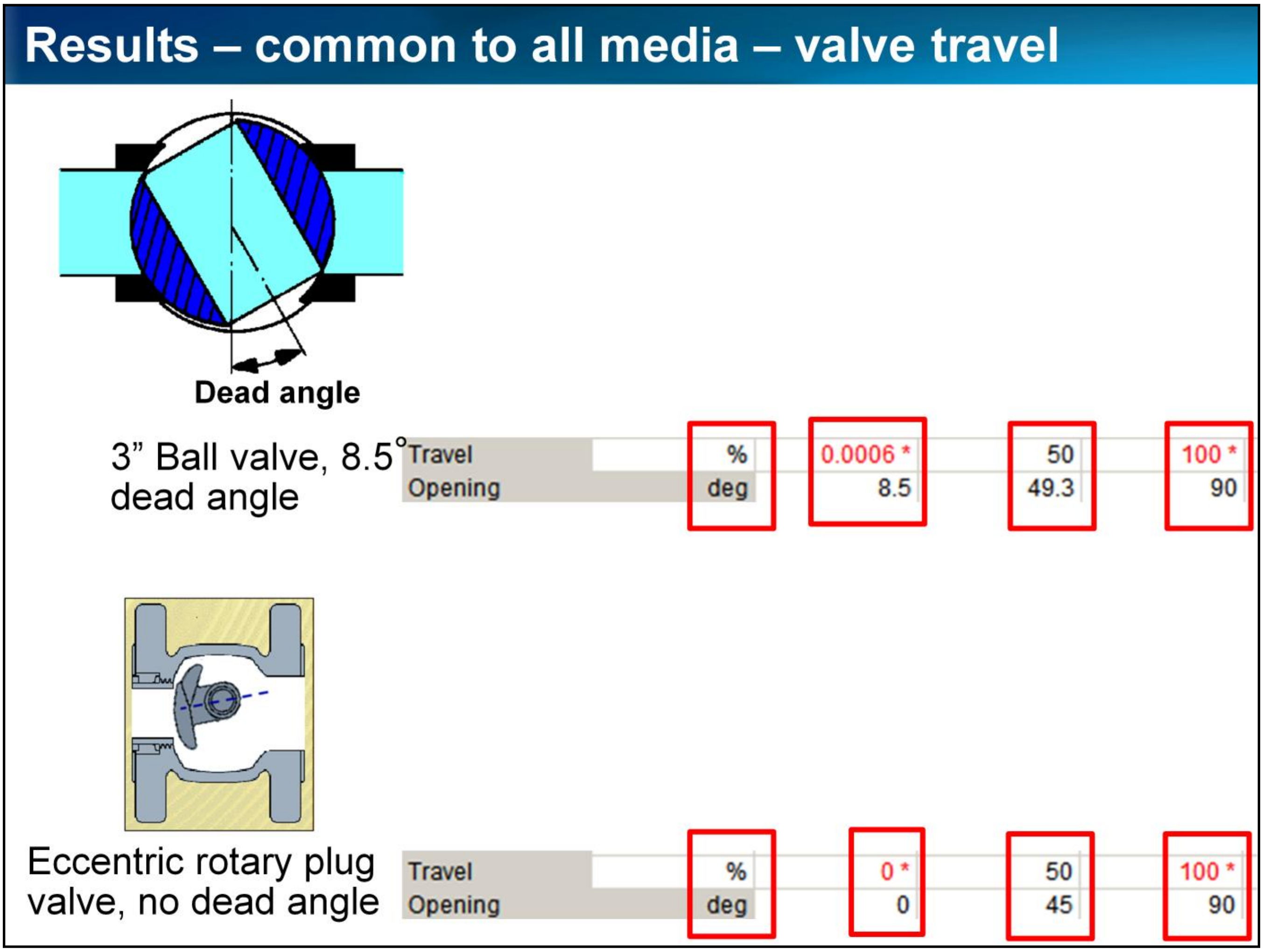
High performance butterfly valves: Minimum opening greater than 10%, maximum opening between 30% and 80%.

Neles Rotary Globe: Minimum opening greater than 5%, maximum opening between 40% and 90%.

Note that selections at the extremes of these ranges may be less than ideal. Be sure to check the notes and the graphs.

The “Noise” field contains the calculated noise (or Sound Pressure Level) for each case. The user can select the calculation method to be either IEC or VDMA for Neles and Jamesbury valves. The user can select which method he prefers from the “Preferences > Unit Defaults” selection on the menu bar for a global preference, from the Project Info screen using the “Edit” button for just one project, or by left clicking in the “Units” field for “Noise” for a single sizing calculation. For “Generic” valves the noise calculation is only available for the VDMA method. There is no noise calculation for two-phase flow. For liquids (Water, Liquid & Pulp) the calculated noise also serves as a predictor of the potential for cavitation damage. More on this when we talk about results specific to liquids.

For gas and steam, whenever the noise, calculated by the VDMA method (regardless of which method the screen is displaying), exceeds 95 dBA, the value will be displayed in red with an asterisk next to it.



Something that brings up questions from time-to-time is that for most of the Neles and Jamesbury rotary valves the percent of travel and the degrees of opening do not appear to match up. That is, the percent of travel doesn't agree with the percentage of 90 degrees of a given degree of opening.

The explanation is that many rotary valves, most notably ball valves, have a dead angle. When a ball valve is fully closed (the waterway in the ball is rotated 90 degrees from the axis of the pipeline, and then starts rotating in the opening direction, it must rotate until the waterway in the ball is no longer covered by the seat. In the case of a three inch Jamesbury soft seated ball valve the dead angle is 8.5 degrees.

The percentages of opening (0% to 100%) listed in the Metso *Flow Coefficient Manual* for a 3 inch soft seated ball valve represent the percentages of the valve’s active rotation of 81.5 degrees. The upper screen shot was made by entering process conditions that would result in percentages of opening of 0%, 50% and 100%. With and input of the barest amount of flow, the valve would have rotated 8.5 degrees or essentially zero % of its active 81.5 degrees. With an input of enough flow to make the valve travel through 50% of its active 81.5 degrees, it would have rotated a total of 49.3 degrees from the fully closed position, and with an input of enough flow to make the valve travel through 100% of its 81.5 degrees of active rotation, it would have rotated a total of 90 degrees from the fully closed position.

For comparison, the lower screen shot is based on a Metso “Finetrol” eccentric rotary plug valve. This valve has no dead angle, so its active rotataion is the full 90 degrees that it can rotate. So at zero percent open, it has rotated zero degrees, at 50% open it has rotated 45 degrees, and at 100% open it has rotated 90 degrees.

Linear motion valves, such as globe valves will have no results in the “Opening” field.

Results – water, liquid & pulp

Noise predicts the potential for cavitation damage

Results	Unit	Case 1	Case 2
Max capacity	Cv	420	
Req capacity	Cv	14.15	132.07
Travel	%	22.2	72.6
Opening	deg	27.3	71.2
Noise	dBA [VDMA]	66	75

Metso makes recommendations for evaluation of the potential for cavitation damage based on calculated noise levels using the VDMA calculation method. The recommended noise limits for avoiding cavitation damage are given in Table 1, Section 3.3.2 of the Metso *Flow Control Manual*, copied below.

Whenever a calculated noise (calculated based on the VDMA method) exceeds the recommended limits, the value will be in red with an asterisk next to it. Regardless of whether you are viewing the VDMA noise or the IEC noise, it is the VDMA calculation that determines whether the value appears in red with the asterisk.

Valve size		Noise limit
DN	Inch	
up to 80	up to 3	80 dB(A)
100 - 150	4 - 6	85 dB(A)
200 - 350	8 - 14	90 dB(A)
400 and larger	16 and larger	95 dB(A)

Note that the Metso *Flow Control Manual* can be accessed from the Nelprof Help menu.

Results – water, liquid & pulp

Results	Unit	Case 1	Case 2
Max capacity	Cv	420	
Req capacity	Cv	14.15	132.07
Travel	%	22.2	72.6
Opening	deg	27.3	71.2
Noise	dBA [VDMA]	66	75
Flow velocity	ft/s	3.29	22.65
Terminal dp	psi	48.54	28.56
Fl coeff.		0.93	0.78

Liquid velocity in the valve inlet port

Pressure drop beyond which flow will become choked

Liquid pressure recovery factor, F_L, used to calculate Terminal dp

In addition to the results that are common to all media and the information discussed on the previous page regarding noise and cavitation, the water, liquid and pulp sizing sheets have the three rows of results in common that are shown below the grayed out area.

Many valve manufacturers make recommendations for the maximum liquid flow velocity in the valve inlet. Metso makes recommendations in the Metso *Flow Control Manual* in Section 3.7. if any of the values exceed the recommendation, the value appears in red with an asterisk.

The “Terminal dp” (terminal pressure drop) is the pressure drop beyond which liquid flow will become choked. Operating at or beyond the choked flow point will result either in flashing or potentially damaging levels of cavitation. Cavitation and potential valve damage usually begin before the choked flow point (terminal dp) is reached. If flashing conditions are predicted by Nelprof, no value will be shown in the “Terminal dp” field, but instead the word “flashing” appears.

What Neles calls “Terminal dp” or ΔP_T has been called different things in different literature. Some examples are: $\Delta P_{(allowable)}$, ΔP_{max} , ΔP_{crit} , and choked ΔP. For the first time, in the 2012 edition of the ISA/IEC valve sizing standard, they have given it the name “$\Delta P_{(choked)}$.”

The “Fl coeff.” (the Liquid Pressure Recovery Factor)) commonly written as “F_L“ is a valve parameter, determined by valve manufacturer’s testing, that appears in the formula that calculates the valve of Terminal dp. The formula is: $\Delta P_T = F_L^2(P_1 - F_F P_V)$

Section 3.1 of the Metso *Flow Control Manual* discusses choked flow.

You don’t really need to know what value of F_L Nelprof is using, but some users want to have F_L entered on their control valve data sheets.

Results – gas & steam

Results	Unit	Case 1	Case 2
Max capacity	Cv	420	
Req capacity	Cv	14	132.72
Travel	%	22.1	72.7
Opening	deg	27.2	71.2
Noise	dBA [VDMA]	68	82
Flow velocity	Mach	0.02	0.15
Xt coeff.		0.64	0.49

Aerodynamic noise

Flow velocity in the valve outlet (Mach number)

Gas terminal pressure drop ratio, x_T, used to predict choked flow

Shown here, below the grayed out portion of the results are those results that are common to gas and steam.

The “Flow velocity” field represents the gas or steam velocity in the valve’s outlet port expressed as a Mach number.

Metso recommends that the flow velocity be limited to 0.5 Mach for continuous throttling duty and 0.7 Mach for infrequent occasions such as gas-to-flare and blow-off valves. High valve outlet velocities can generate noise levels that are higher than what is calculated by the various noise prediction methods. Whenever the value of Mach number exceeds 0.5, the value will appear in red with a asterisk.

The “Xt coeff”, more commonly written x_T, defines the pressure drop ratio at which gas flow becomes choked. Choked gas flow is not associated with valve damage as is the case with liquid choked flow, but it is necessary for the valve sizing program to know if flow is choked to be able to accurately calculate the required valve Cv.

You don’t really need to know what value of x_T Nelprof is using, but some users want to have x_T entered on their control valve data sheets.

Results – two-phase

Results	Unit	Case 1	Case 2
Max capacity	Cv	420	
Req capacity	Cv	16.06	127.88
Travel	%	23.9	71.6
Opening	deg	28.8	70.3
Eff. density	lb/ft3	7.02	7.04
Terminal dp	psi	48.25	28.66

The calculated density of the liquid-gas mixture

The pressure drop at which the two-phase flow will choke

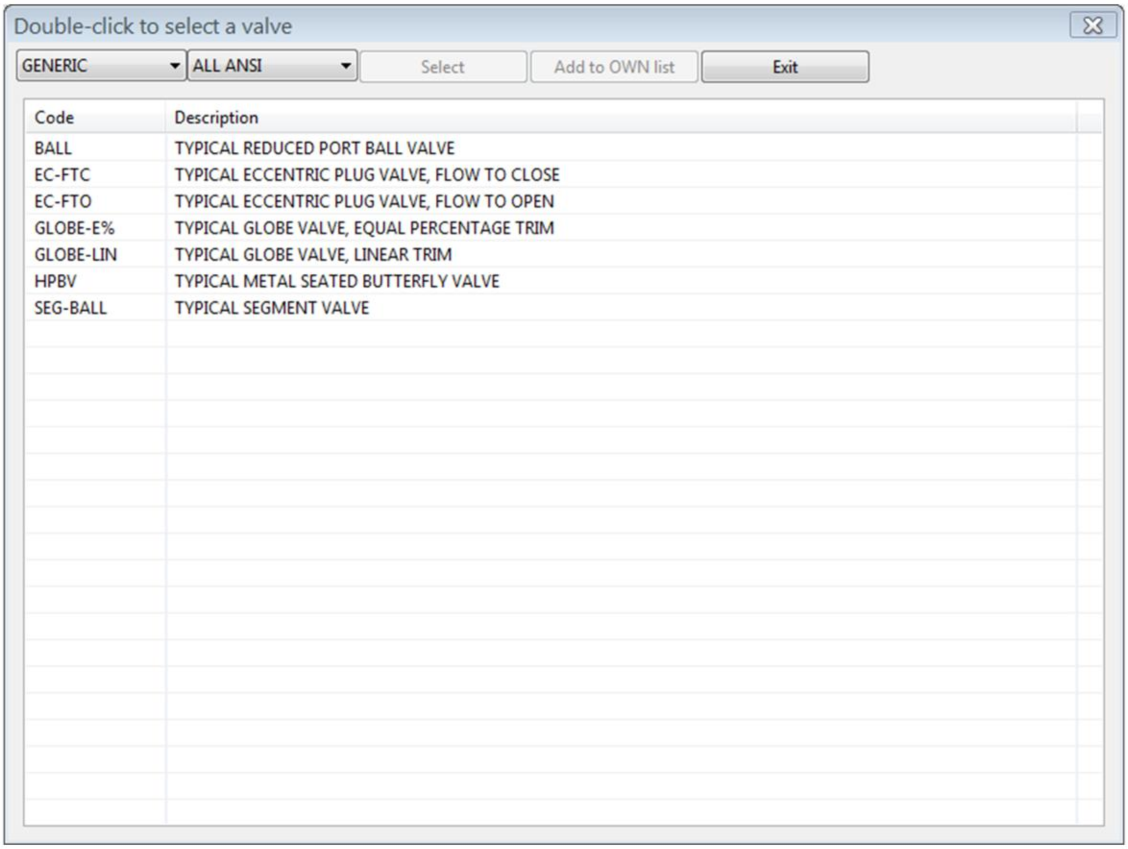
Shown here, below the grayed out portion of the results are those results that apply to the two-phase sizing results.

The “Effective density” of the two phase flow stream is needed by Nelprof to calculate the required Cv. It is determined from the upstream densities of the liquid and gas components, along with the mass fractions of the two, taking into account the expansion and resulting density change of the gas component as it accelerates toward the vena contracta. You don’t really need to know what the effective density is.

The “terminal dp” is the pressure drop at which flow becomes choked. To the author’s knowledge, there have been no studies of whether two-phase choked flow has any damaging effects.

There is no known method for calculating noise in two-phase flow.

Sizing “Generic” (non-Metso) valves



Nelprof was designed to help its sales reps and customers size and select Metso (Neles and Jamesbury) valves, but its designers also recognized that there are times when users want to document sizing calculations without the documentation listing a specific Metso valve by name or model number. To accommodate this need, files have been provided for the sizing of “Typical” valves of the most commonly used types.

In general, if a 4 inch “Generic” segment ball valve is suitable for a particular application, then it is almost certain that a 4 inch segment ball valve from any of the leading manufacturers will also be suitable.

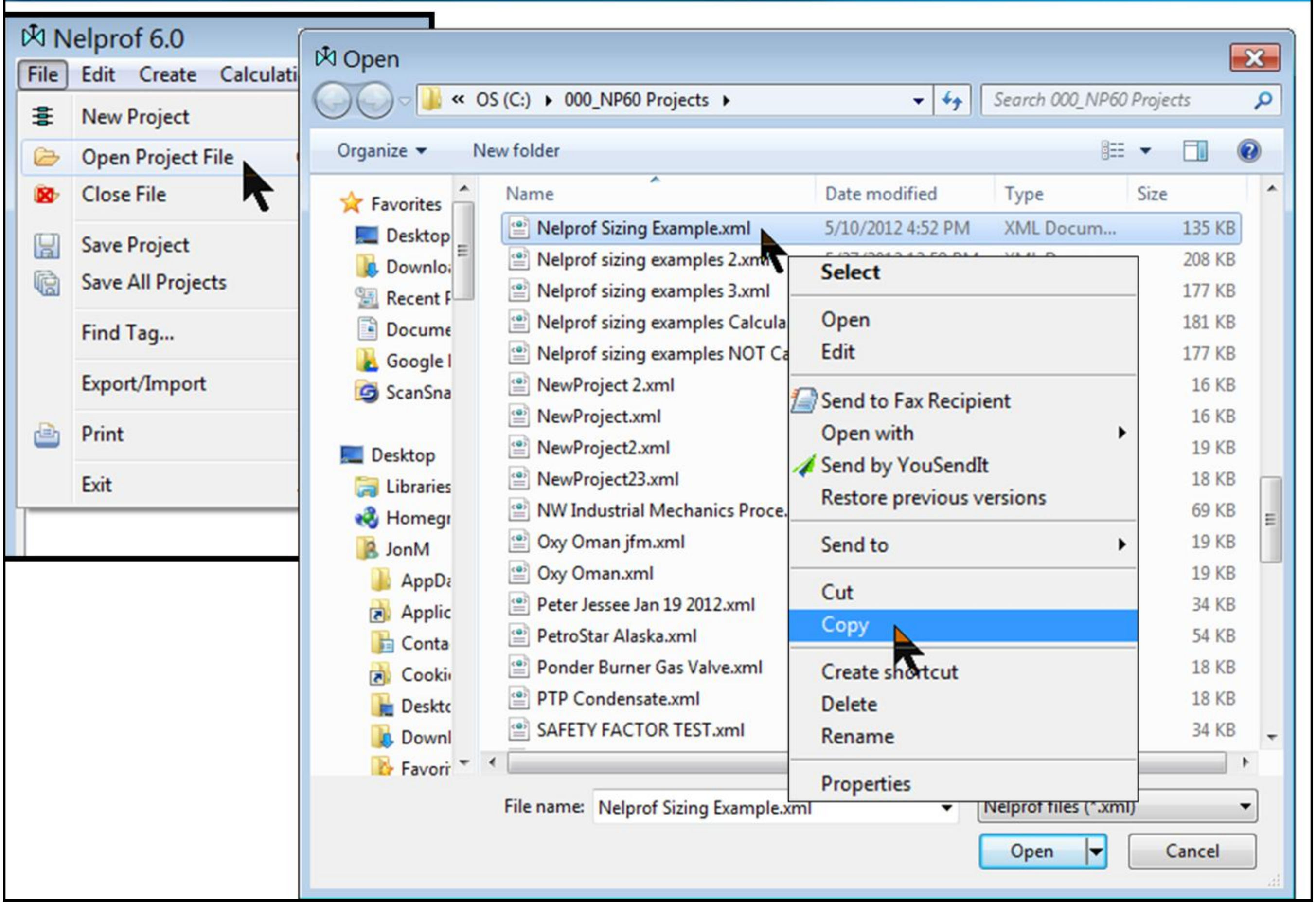
After clicking on the “Valve…” button, select GENERIC to see the list of choices pictured above.

There is one minor “annoyance” that will be fixed in a future update.

Sometimes one of the calculated values will be shown in red with an asterisk, along with a warning note. If the value is within acceptable limits, the warning can be ignored.

The actuator sizing option is not available for generic valves.

Export/import data between two NP 6 computers

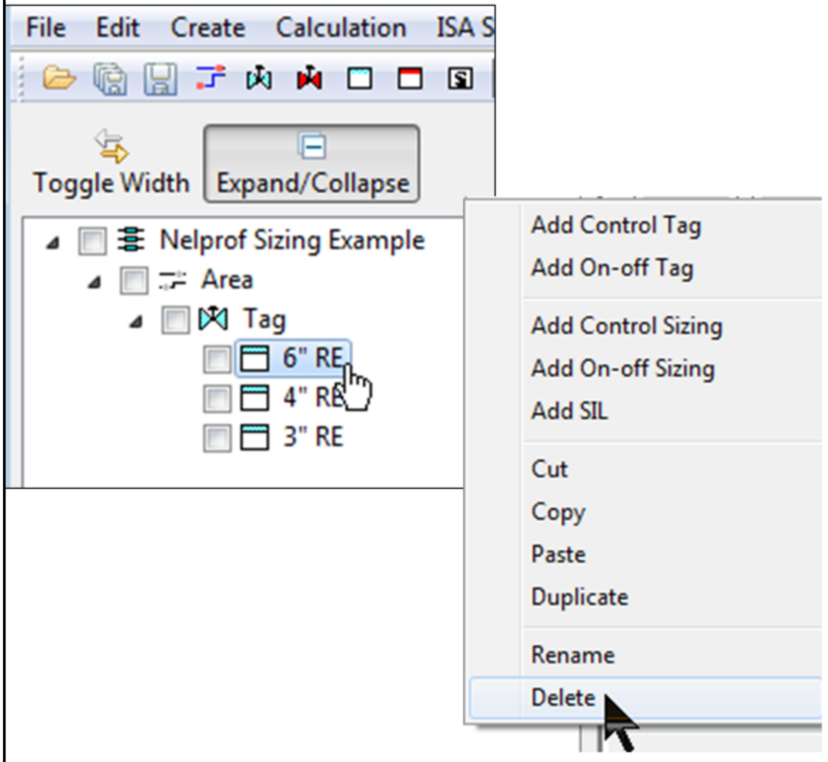


To export a Nelprof 6 project file for importing on another computer that has Nelprof 6 installed, open the folder on your computer that contains the Nelprof project files. It is simple to open this folder. Simply select from the Nelprof menu: File > Open Project File and the screen shown above opens. Right click on the project file you want and select “Copy.” Then paste it to some other location the same way you cut and past files with Windows Explorer.

If you are going to send the file using Microsoft Outlook, simply drag the file onto the e-mail message.

If you are importing a project file, simply drag it or copy it to this same folder.

Deleting sizings, tags or plant areas



To delete sizings, tags or plant areas you have to first select the object (tag, sizing or plant area) you want to delete. This is done by clicking once the object you want to delete (object will be highlighted). In 1 above the sizing 6" RE is selected for the delete function .

Right click the object and select Delete.

Note that all checked and filled in boxes must first be cleared before deleting an item.

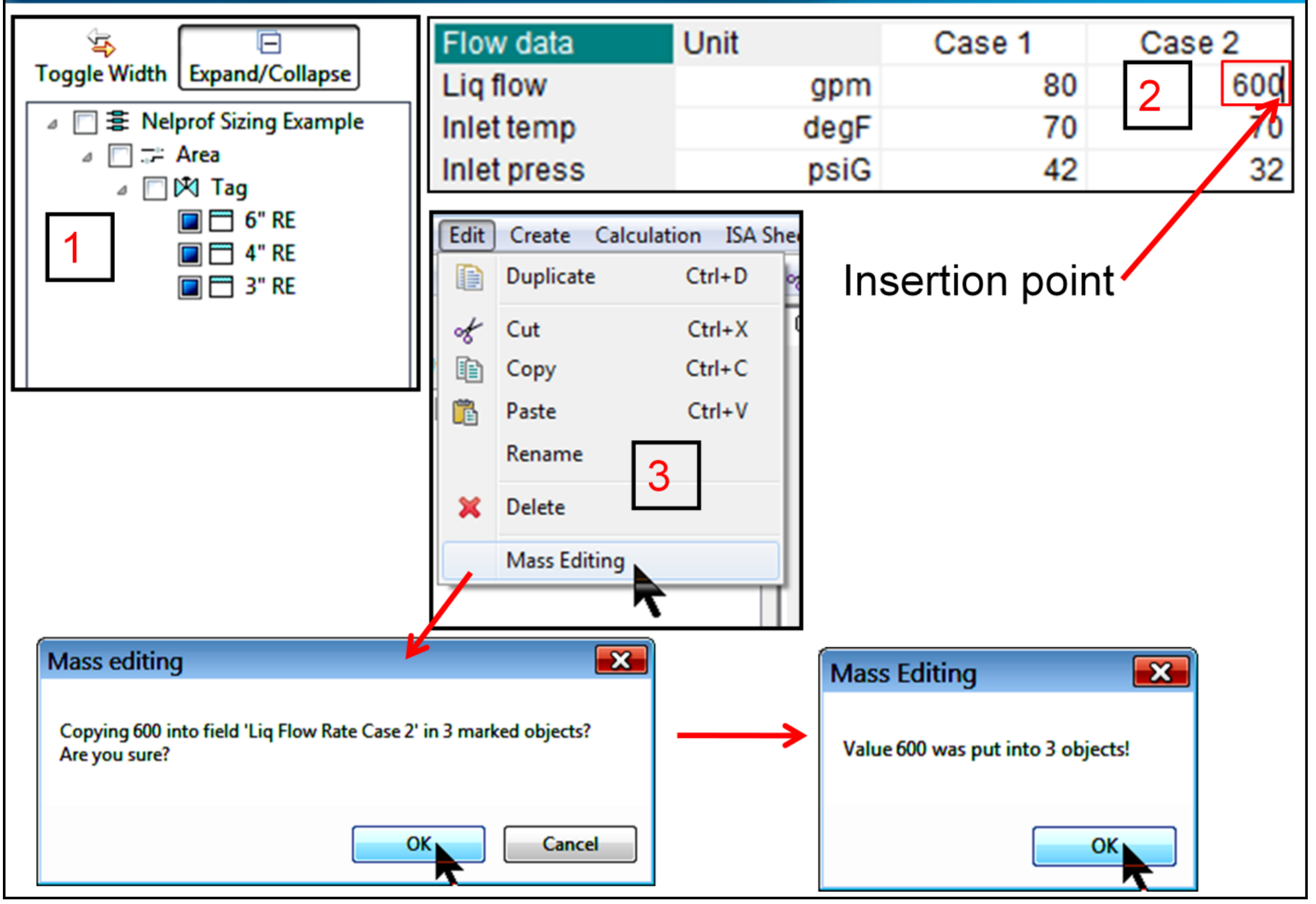
(Check marks and filled in check boxes are used for printing, and for mass calculation functions).

You cannot delete projects. You can close a project from the file menu, File > Close File

If you want to delete a file, go to File > Open Project File

Then delete the file like you would delete any file in Windows Explorer.

Mass editing and calculating



Example: Change the Liquid flow in Case 2 from 550 to 600 in the calculations for 6” RE, 4” RE and 3” RE.

To make a change to a number of sizing calculations and then recalculate them, do the following:

Step 1. Fill in the check boxes to the left of the sizings that you want this change to be applied to as in 1 above. Sizing calculations 6” RE, 4” RE and 3” RE have check boxes filled in.

Step 2. Modify the flow in Case 2 in any of the sizings that need to be modified to read 600 gpm.

Step 3. From the menu, select Edit > Mass Editing The program asks if you are sure. Click OK. Finally the program confirms that the new value (600) was put in three places. Click OK

The check boxes next to all three sizings will have check marks in them to indicate that the operation is complete.

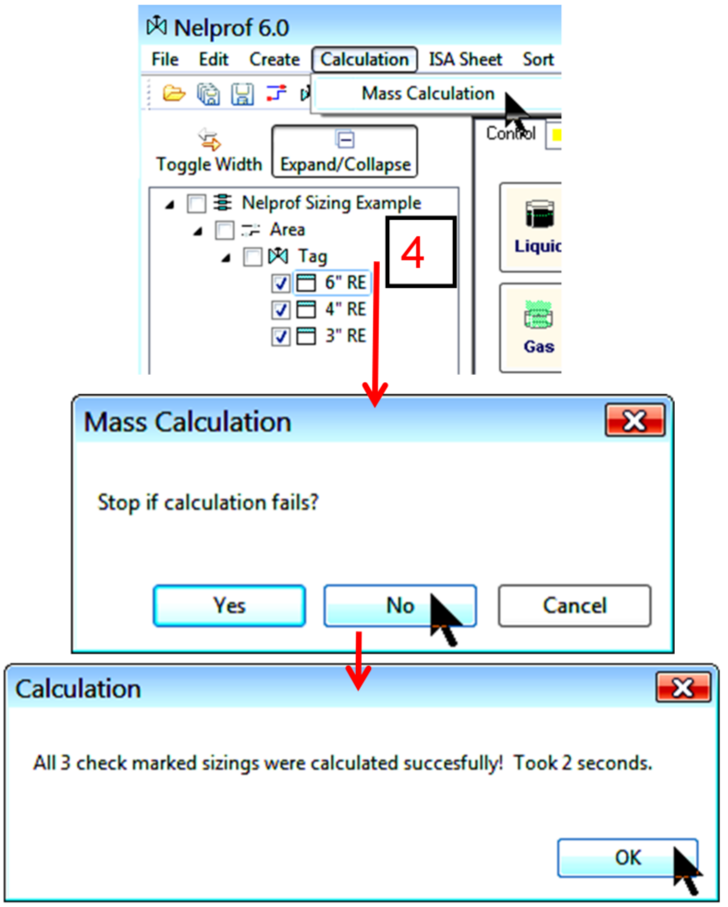
You can only edit one field at a time and the insertion point must remain in the edited field when you click Edit > Mass Editing. You can edit several fields in this way before you perform the mass calculation described on the next page.

Be aware that fields that depend on the one you have changed are NOT changed. For example, when you change Inlet pressure, Outlet pressure is automatically changed on the sheet where you are doing the editing, but does not carry over to the rest of the sheets you have checked off. Another example is on the Water and Pulp sizing sheets, vapor pressure depends on temperature. The changed temperature will carry over but the corresponding vapor pressure does not. The new vapor pressure (or other dependent fields) can be transferred to the other sheets by clicking in the dependent field of the sheet you are doing the editing in, then again select Edit > Mass Editing.

If you were only changing a field in three calculations it would probably be faster to just click on the sizings on at a time and make the change to each one, but if you had to make the change to 50 calculations, the procedure described above would be much easier.

Continued on next page.

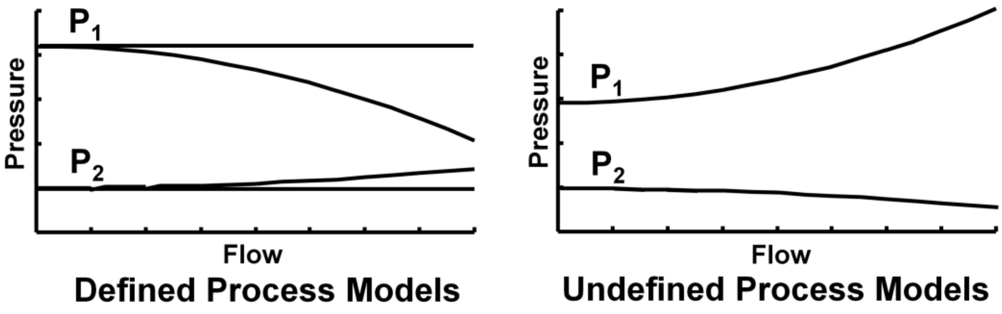
Mass editing and calculating (continued)



Step 4. Then we calculate selected sizings by selecting from the menu Calculation > Mass Calculation The program asks if you want it to stop if one of the calculations fails. (If you have 500 sizings, you might want to calculate them all first and then see which ones did not complete, so then select No.) In the Project tree you will see the three sizings that you have put check marks for briefly highlighted sequentially while each is calculated. Assuming that all three calculations were completed successfully you will get the message that all were successful.

If any of the calculations fails, there will be a message box telling you how many calculations failed and how many completed successfully. The check boxes for the calculations that were successful will have a grey background and the ones that failed will have a white background.

Installed flow characteristics have not been analyzed



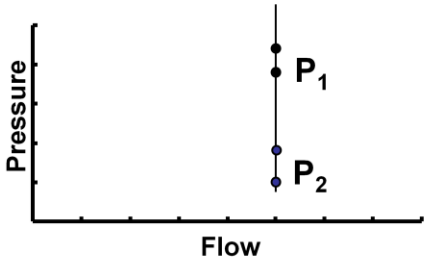
There are several situations in which Nelprof cannot create a model of the process, and therefore it cannot generate the installed graphs. In these cases you will get a note on the “Notes and warnings” tab: “Installed flow characteristics have not been analyzed.”

In a physical system with significant piping and/or a centrifugal pump, P_1 must decrease with flow and P_2 must increase with flow. If there is very little piping, then it is possible for P_1 and/or P_2 to remain constant. In a system where pumps and piping are the only effects, P_1 CANNOT increase with flow and P_2 CANNOT decrease with flow. If the data you input shows this happening, NELPROF cannot construct a mathematical model of the piping system, and therefore will not be able to draw the installed graphs.

It is possible to have valid data that does not meet the above criteria, but it will be the result of designing the system for unrelated circumstances.

For example a low flow and low value of P_1 may be specified for the way the plant will operate for the first several years. A higher flow and higher P_1 may be specified for the situation several years in the future when higher flow rates are anticipated, and it is planned to install a higher capacity and HIGHER PRESSURE pump. For purposes of obtaining the graphs, these two unrelated situations must be treated as two separate systems, evaluated separately.

Installed flow characteristics have not been analyzed



A flow rate associated with more than one value of P_1 and/or P_2 cannot generate a process model.

For turbulent flow:

$$h_L \propto q^2$$

For laminar flow:

$$h_L \propto q$$

For two phase flow:

h_L calculation is very complex

Nelprof cannot construct a mathematical model of the piping system if two sets of pressure conditions are given for a single flow rate.

Here, it is possible to have such a system (for example a flow control system where load disturbances change the upstream or downstream pressure). Nelprof, however, cannot construct graphs.

Nelprof only knows the relationship between flow and piping pressure loss for turbulent flow where pressure loss is proportional to flow squared.

The relationship between flow and pressure loss for laminar or transitional flow is NOT included in Nelprof.

Nelprof will draw the installed graphs if a value of viscosity has been entered, but the graphs are based on turbulent flow, which may or may not actually be the case.

To test for the validity of the graphs, do the calculations with the value of viscosity entered and note what percentage open the valve is. Then repeat the calculation, but with the viscosity deleted. If the percentage of valve opening changes by less than, say, 5 or so percentage points, you can assume that viscosity has negligible effect on the sizing calculation.

The piping pressure drop calculations for two phase flow are very complex, and Nelprof does not attempt to draw graphs for two phase flow.