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## Control Simulator 8

Interlink Systems continues to improve the newest version of its subsea control system simulator, Control Simulator 8 (CS8). This completely rewritten product has features users need for today's complex subsea control applications. CS8 is available now for a free trial and licensing.

The following table summarizes the main differences between Control Simulator 8 and the CSI software that is currently in use. All of these features are described in more detail in the text following the table.

<b>Feature</b>	<b>The new CS8</b>	<b>CSI</b>
Branching of supply lines	Branch off of a manifold with any number of infield umbilicals. Infield umbilicals may also branch to whatever extent is needed.	Cannot do it
Built in plotting of simulation results	Fast, flexible, and easy to use Define as many plots as you want Easy mixing of flow, pressure, position, etc in one plot. Easily plot test data along with the simulation Easily copy a plot and paste into Word or email.	Limited to one plot per assembly Limited formatting ability
Improved HPU	Multiple pumps, each with its own start and stop pressures. Feed multiple main umbilicals, each with its own optional pressure regulator.	One constant flow pump, one air pump. Air pump has no start-stop pressure switches.
Tree or manifold having several valves of differing types and operating pressures.	No problem. Any number of valves can be shifted on a time schedule, or one valve may trigger another. Valve movements may overlap. All in one simulation.	One valve only.
Lines in parallel	No problem	Cannot do it
Take account of pressure drops due to helical bundling of the lines or from being on a reel.	In-depth research into the state of the art in modelling flow in curved pipes allows CS8 to model helical-lay umbilicals and umbilicals wound on reels.	Straight line models only

Improved treatment of resistance elements	Complex resistances can now be stored in the library. Pressure drop in the tubing is handled more accurately. Resistance can depend on the direction of flow.	Resistances of any complexity are reduced to a simple Cv value.
Library has been reorganized	Library components are defined differently based on difficulties noted with CSI. Editing the library is a completely separate operation from editing Case parameters.	Was easy to edit shared library parameters unintentionally. Some values in the library should have been Case specific.
Work with more than one Case at a time	Case output files are completely independent of one another.	CSI output from any assembly goes to a single temporary file.
Improved numerical input fields	The number and its unit of measure are combined in one field. Changing units normally converts the numerical part to match. Each field has a built in calculator function.	
Small, easy installation	CS8 does not mess with the registry, does not install components or drivers, and has no bloated database requirements. This means that it should be relatively unaffected by changes to Windows.	Depends on Microsoft for Visual Basic, the Jet database, and data access components.
Designed for expansion	The graphical user interface and compute engine have both been redesigned and rewritten to allow for future expansion of capabilities.	CSI is difficult to expand, especially the user interface.

CS8 includes some example files and a simple tutorial showing how to construct a project with simple Cases. Companies licensing CS8 will also get a year of free updates. The latest version will always be available for download from the Interlink Systems web site.

The following sections describe the features in the table in more detail.

## 1. STRUCTURE

CS8 is built around the idea of a project. A project consists of a number of Cases and a supporting library of components that all of the Cases use. You run simulations on the individual Cases, and each Case creates its own set of output data files. For those of you who

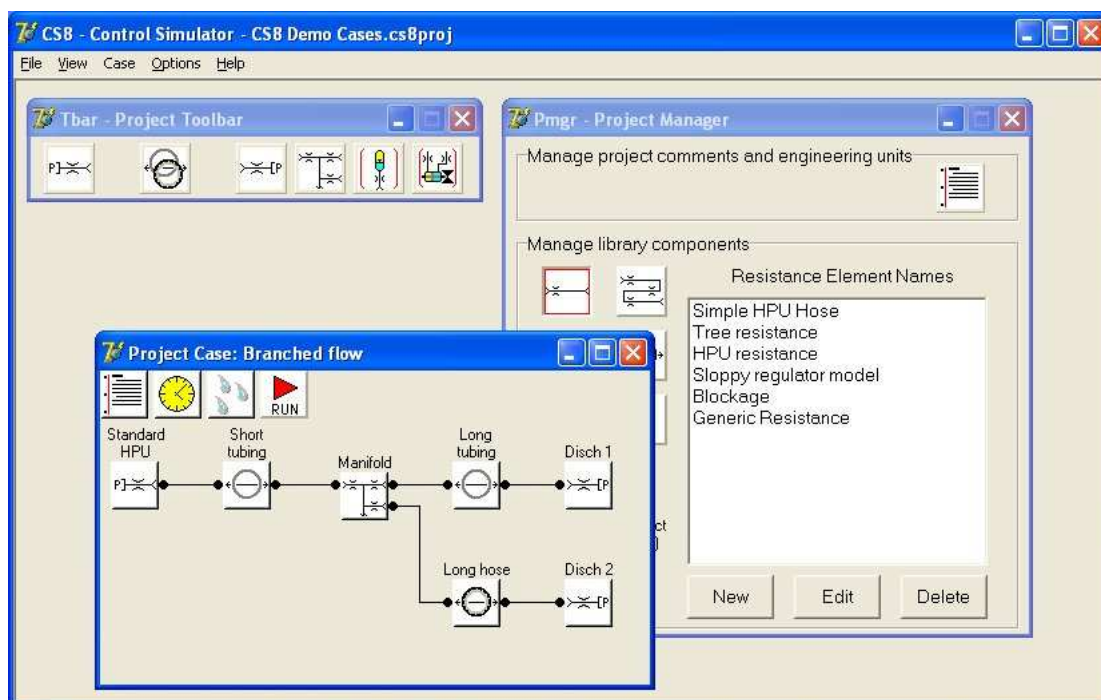
are familiar with CSI, the project is similar to a CSI database, the Case is like a CSI assembly, and the library is similar to the CSI component list.

It is possible with CSI to put together an assembly that looks reasonable and complete, but that has a structure that the compute engine cannot run. This will never happen in CS8. The CS8 operator interface exactly mirrors the capability of the new compute engine. Any complete structure you can make will run.

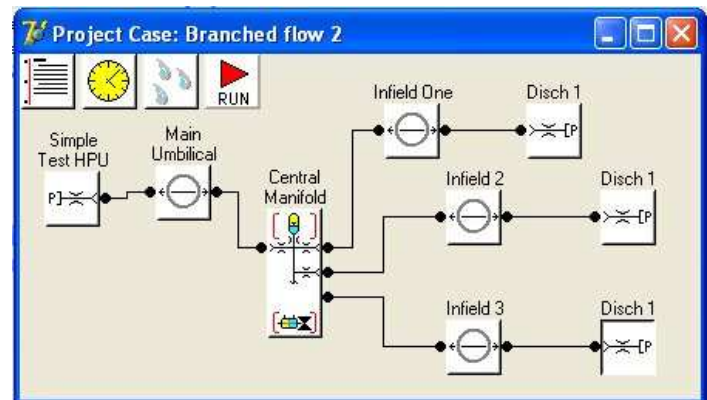
## 2. BRANCHING

Branching is the single biggest and most requested improvement to The Control Simulator. The main discharge device is a manifold. It has an inlet port to connect it to a source line. It also allows any number of outlet ports, which connect to a lines that go to other discharge devices. This feature is used to build a branched network having several relatively long infield umbilicals in addition to the main supply line.

The following picture shows the CS8 main window with a simple Case open that has branched flow.



By simply editing the manifold, you can change the number of discharge connections and add additional branches. You may also add an accumulator or a valve module to the manifold by simply dragging the module from the project toolbar and dropping it on the manifold. The picture at the right shows a Case in which an accumulator, a valve module, and three infield umbilicals were added to a simple manifold.



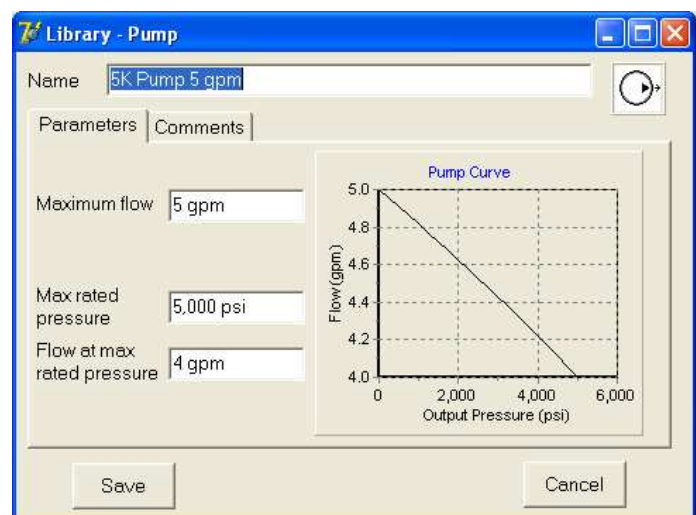
In a real field, the manifold component is used for umbilical termination units, trees, and any other use having some combination of umbilicals, accumulators, and valves.

### 3. HPU

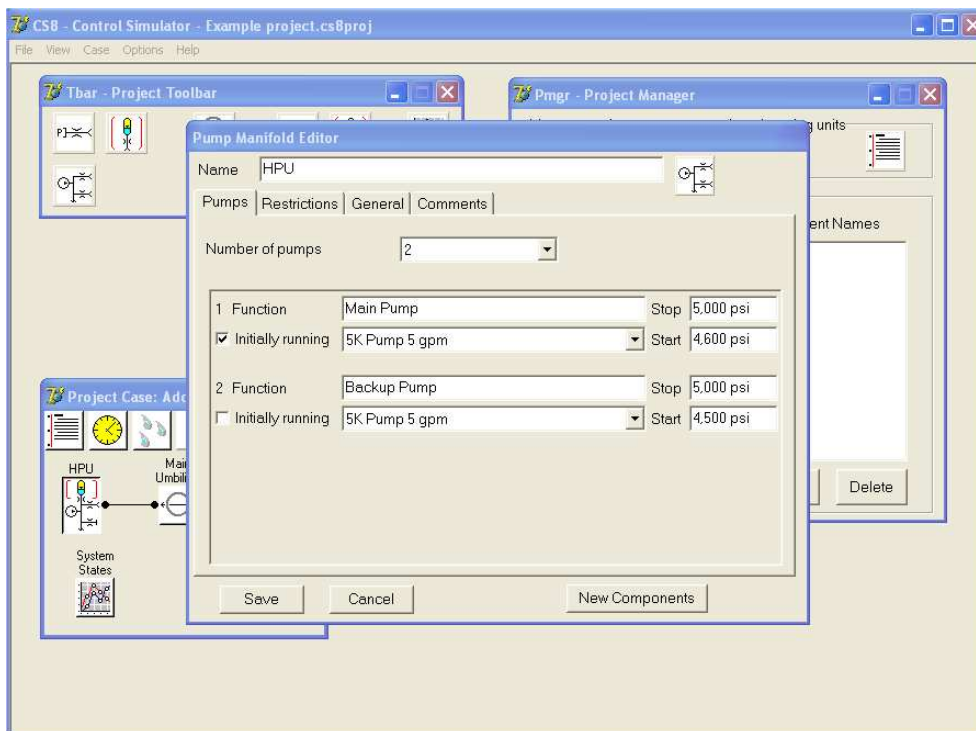
The new HPU allows multiple pumps to feed the supply header. An optional accumulator can be added to the supply header, and the supply header may feed multiple main umbilicals.

A pump is modeled as a constant pressure source in series with a fluid restriction. This can be used to approximate constant flow pumps as well as air pumps that can stall at the operating pressure.

To the right is a figure showing the definition of a pump in the CS8 library. By stating the flow at rated pressure, and the flow at zero pressure, CS8 computes the internal pump parameters and plots the resulting pump load curve.



In the figure below you see the editor for the HPU showing a case where two pumps are defined and the HPU feeds an accumulator and a single main umbilical. The HPU can feed multiple main umbilicals as described in the Branching section above. Each main umbilical can have its own pressure regulator.



#### 4. LINES IN PARALLEL

Lines in parallel are not often needed, but the capability is included in CS8. When editing a line, one of the choices is “Number of identical lines in parallel”. Simply enter a number other than 1 to get the added flow capacity.

#### 5. TREE WITH MULTIPLE VALVES

Suppose you have a tree with 5” production valves and 2” annulus valves, and you want to simulate a shutdown of the tree by bleeding the supply line. Suppose you have a special workover system for which you want to simulate an emergency shutdown including cutting tubing and starting some valves before others are finished moving. Suppose you want to operate a big valve and see what effect it has on accumulators and other valves that are on the same manifold. CS8 will do all of these functions easily.

When you drop a valve module onto a manifold, you get the ability to add any number of valves. You may define a mixture of different types of valves. Each valve has its own starting time, before which it is not allowed to move. More flexibility in the operation of the valve module is increased by the use of triggers. A valve can set a trigger upon opening or closing. Other valves can watch that trigger to tell when to start.

As an example of how this can be used, assume you want to model a shear ram cutting tubing. There is a portion of the valve movement before contact with the tubing. Then the friction goes way up as it cuts the tubing. Finally the friction goes down again after the cut for the remainder of the valve movement. You model those three conditions by defining three different valve models in the library. You then add the three models to a manifold, and define two triggers: FirstContact, and TubingIsCut (you give them any name you want). So, the first stage sets "FirstContact" when its movement is complete, and the second stage is triggered to start when FirstContact is set. The second stage valve then sets TubingIsCut when it finishes, triggering the start of movement in the last stage valve. The simulation then proceeds smoothly from one stage to the other for the entire cut in one simulation.

For modelling systems where there is some question about the effects of the vent path, the outlets of all of the valves are brought together into a common header and discharged to the environment through a restriction. Each valve also has its own outlet restriction feeding the vent header. By manipulating the various resistances, you can simulate valves discharging independently to the sea, or through a common header.

The header may be set up to discharge into a fluid column other than sea water. This allows modelling valves that discharge into a column of heavy fluid like drilling mud. A future enhancement will be to allow connecting a return line to the vent header.

## **6. PRESSURE DROP DUE TO CURVATURE**

A curved pipe induces secondary flows in the curves that cause more pressure drop than would be found in straight pipe of the same length. Over the last two years, Interlink Systems has researched the available scientific and technical literature on the flow of fluids in curved pipes. That research, combined with some original work, resulted in a very good model for handling curved lines. This effect can be large for Reynold's numbers of 10,000 or less. There are two conditions where this affects subsea simulations: umbilicals and reels.

In many drilling, workover, coiled tubing, and test situations, all or a portion of the hydraulic line may be on a reel. Handling the drop due to a reel is as simple a checking a box and entering the diameter of the reel and what portion of the line is on the reel.

Individual tubes in an umbilical are wound around the central tube in a helix. This helix introduces a curvature similar to being on a reel. It also causes the tube to be somewhat longer

than the length of the umbilical. CS8 accounts for both effects based on the distance of the tube from the centerline and the lay angle of the helix.

Both sources of curvature can come into play at the same time if a helical umbilical is wound on a reel. CS8 easily handles this compound curvature.

## 7. IMPROVED TREATMENT OF RESISTANCE ELEMENTS

The old CSI handled resistances by defining a resistance component as a Cv in series with a piece of pipe. You could add multiple resistance components in series in a model. Internally, CSI reduced all of this down to a single “equivalent” Cv for the computations, independent of the fluid flow rate.

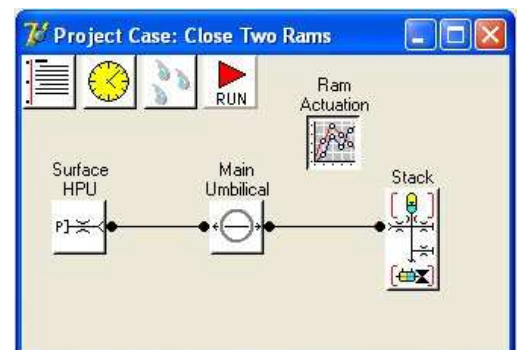
In CS8, you may define resistance elements similar to the CSI resistance components, but CS8 treats the tubing portion of a resistance as a section of tubing having laminar or turbulent flow instead of simply approximating it by a Cv. This increases the accuracy with which fairly long pipe runs can be modelled. CS8 allows the Cv to depend on the direction of fluid flow (like often happens in directional control valves).

Unlike CSI, the CS8 library allows you to define a “path”, which consists of any number of resistance elements in series. When defining a Case, you only have to select a single path or element from the library when a resistance is called for. This can greatly reduce clutter in the Case definition.

## 8. PLOTTING SIMULATION RESULTS

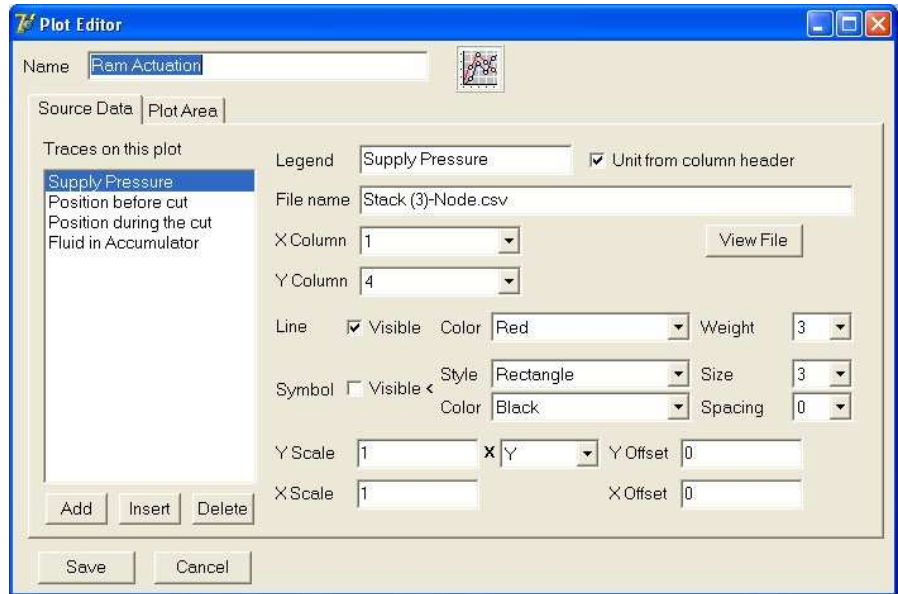
CSI had a method to plot simulation results, but CS8 improves on it by leaps and bounds. You may never be tempted to use Excel to plot results again. This is best shown by a simple example in which a BOP shear ram actuation is simulated by the operation of two valves. One has the parameters and volume of the ram before it encounters the pipe. The second valve has the volume and friction that would be present while cutting the pipe.

The model of the case is shown at the right. To get a plot, the plot component is dragged from the toolbar and placed on the case, just like a hose or a manifold. The plot component in the example to the right is labeled Ram Actuation. You may place as many of these plot components on a case as you wish. Each one produces one plot as defined by the parameters you set. As with the other components, you edit the parameters by double clicking the component.



At the right is a picture of the Ram Actuation editor window in which you define the traces that will be on a plot.

The illustration is of the tab where you define the traces. There are four traces defined and the one you are looking at is the one labeled Supply Pressure. The file name is one of the files produced by the simulation. You pick the columns that are to be used for X and Y. You can then select the appearance of the line and a symbol that will be placed at the data points. Both are optional, so you can have only points, only a line, or both.

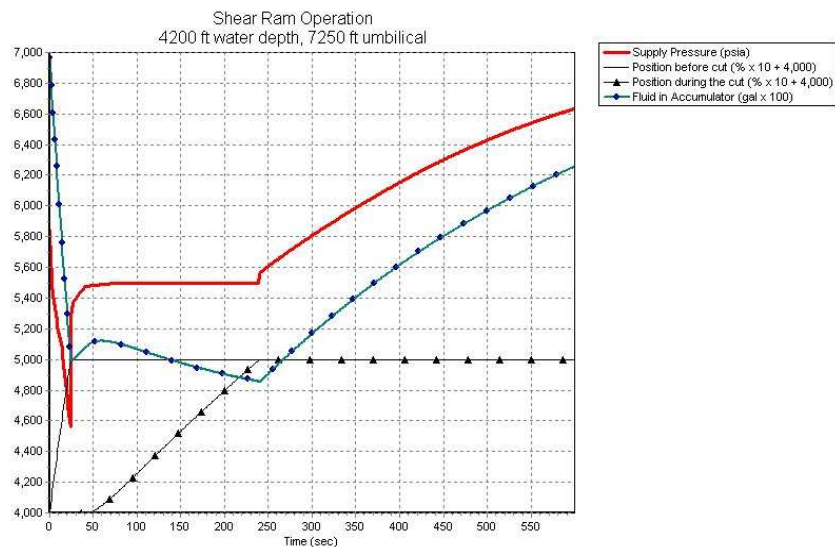


The spacing parameter is neat. Suppose you have data printed out every second for 2500 seconds. If you plot symbols at each data point, you will have a smear of overlapping data points. By setting “spacing” you can choose to see only a point every “N” pixels. The Fluid in Accumulator trace is plotted with a spacing of 25 pixels for the symbols.

The X and Y data can be scaled and offset before plotting. For instance, the ram position data ranges from 0 to 100%. In the plot below, the scale and offset are set to plot the trace between 4000 (0%) and 5000 (100%). Note that the scale and offset applied appear automatically in the legend. Scale and offset may be positive or negative as needed.

The small pull down box labeled “Y” in the picture above allows further manipulation of the Y data before scaling and plotting. You can apply the scale and offset to Y,  $\sqrt{|Y|}$ ,  $Y^2$ , or  $|Y|$ .

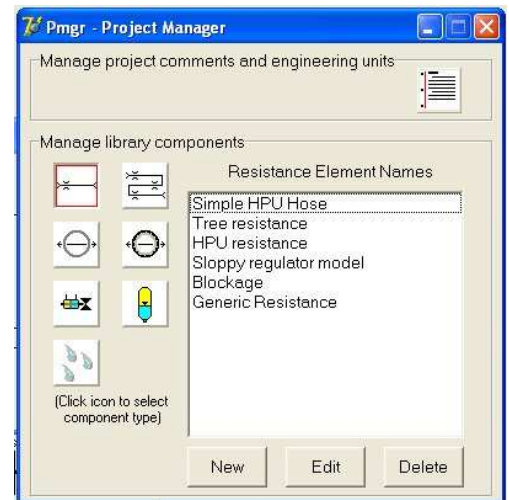
The plot produced by the plot component just defined is shown to the right.



## 9. LIBRARY HAS BEEN REORGANIZED

The CS8 library contains only device parameters that do not change depending on where the device is used. CSI had devices such as the pressure source and timing device that included parameters that really should be Case specific.

At the right is a picture of the Project Manager window through which you access the library. The icons on the left represent resistance elements and paths, steel tubing, hoses, valves, accumulators, and fluids. The icon at the top allows you to enter project-wide comments and select default units of measure for calculated outputs.



## 10. WORK WITH MORE THAN ONE CASE AT A TIME

In CSI you may have more than one assembly being displayed at one time. But if you view the simulation output, it is always the output from the simulation that was most recently run, not necessarily the selected assembly. This comes close to qualifying as a “bug”, but one that was very difficult to fix in CSI.

In CS8, Cases are completely separate from one another. If you select a Case and look at the output, you get the last available output for the selected Case. It is even possible to run simulations for different Cases simultaneously.

## 11. IMPROVED NUMERICAL INPUT FIELDS

CSI allows you to select engineering units for each input field. In CS8, the engineering unit is integrated with the number part in the same field. You can type the whole thing in or you can change units by right clicking and selecting the desired unit from a pop up menu. Most of the time, the number is converted to the new unit at the same time, so if you change “12 in” to ft, the number will change to read “1 ft” automatically.

Another useful feature is that the numeric input field functions like a calculator. If you enter  $3*(27.3 + 8)$  ft, the field will revert to 105.9 ft. The calculator understands parentheses, the symbol pi, and the operators + - \* / ^.

## **12. SMALL, EASY INSTALLATION**

While computer users today may be getting used to an installation taking up half a gigabyte, making mysterious registry entries, installing and registering dlls, drivers, and components, and having to make special provisions for different versions of the operating system, it might be comforting to know that CS8 consists of two compact executables, a license file, and a few assorted documentation files. Its footprint on your computer is very small and simple. It is very unlikely that changes to the operating system or any Microsoft product will impact the operation of CS8.

## **13. DESIGNED FOR EXPANSION**

CS8 has been rewritten completely. The CSI operator interface and database was completely discarded and replaced from the ground up. The compute engine reuses some core parts, such as the NIST-based accumulator model, but the internal structure of the discharge device models is completely redesigned with future expansion in mind.

The compute engine is a stand-alone program with its own text-based input file format. The adventurous among you may create your own input files and run simulations without going through the CS8 graphical user interface. The input file is a Windows INI file format, which makes it very easy to manipulate.