Arbor Fault Tree Analysis

Creating your First Study Tutorial

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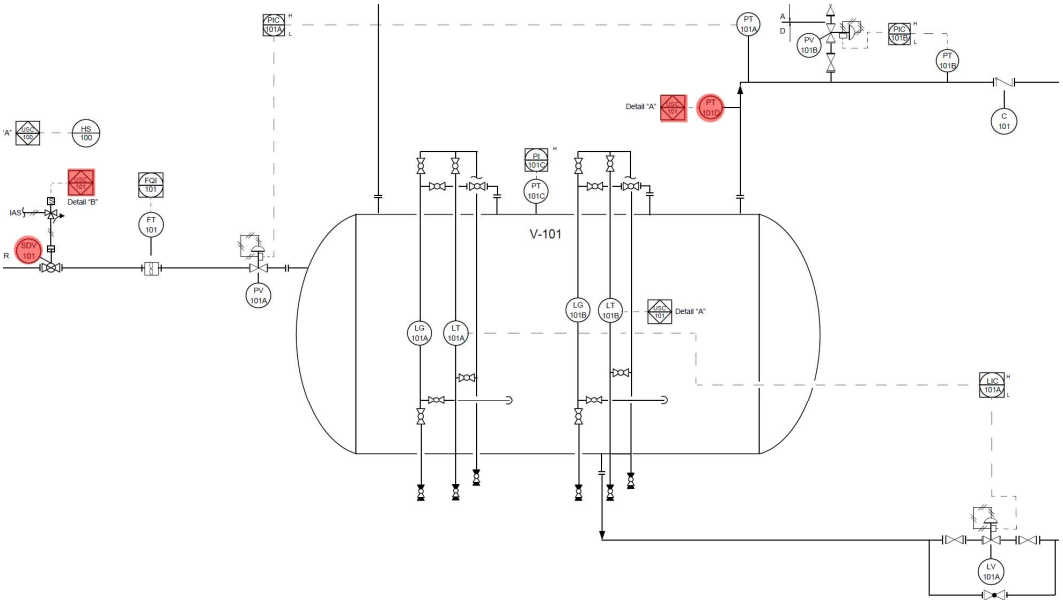
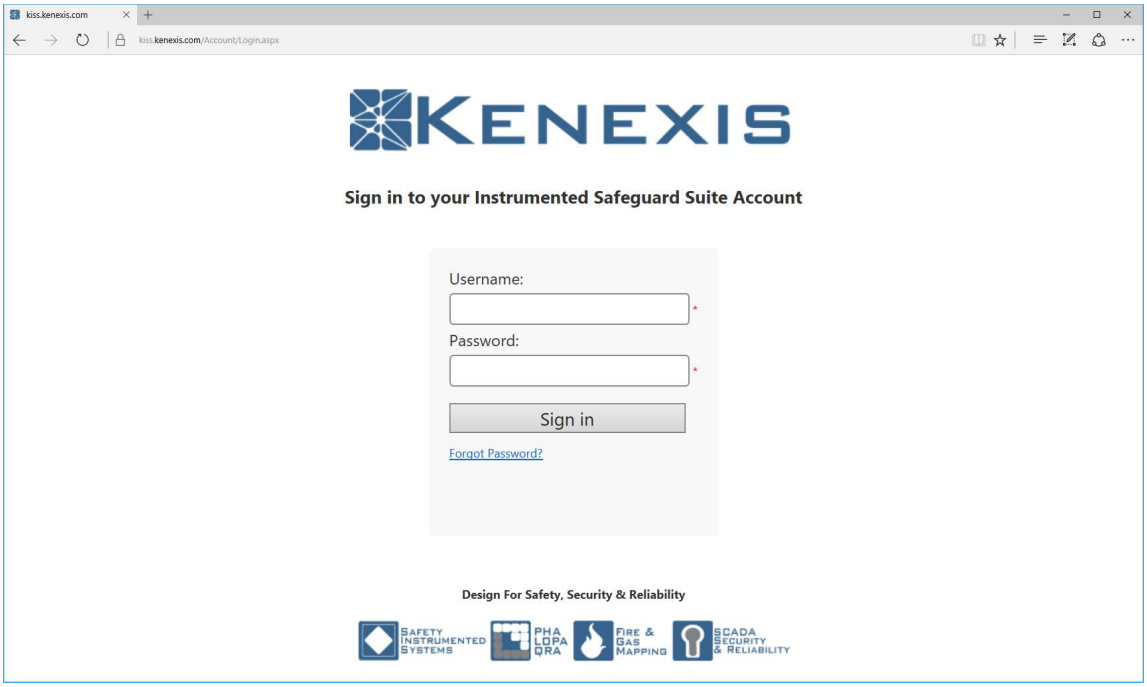
In this tutorial, we will walk through the process of creating your first study in Arbor. We'll be creating a fault tree model for a simple PFD_{avg} calculation on a Safety Instrumented Function (SIF).

The figure below shows the components on the function we'll be modeling.

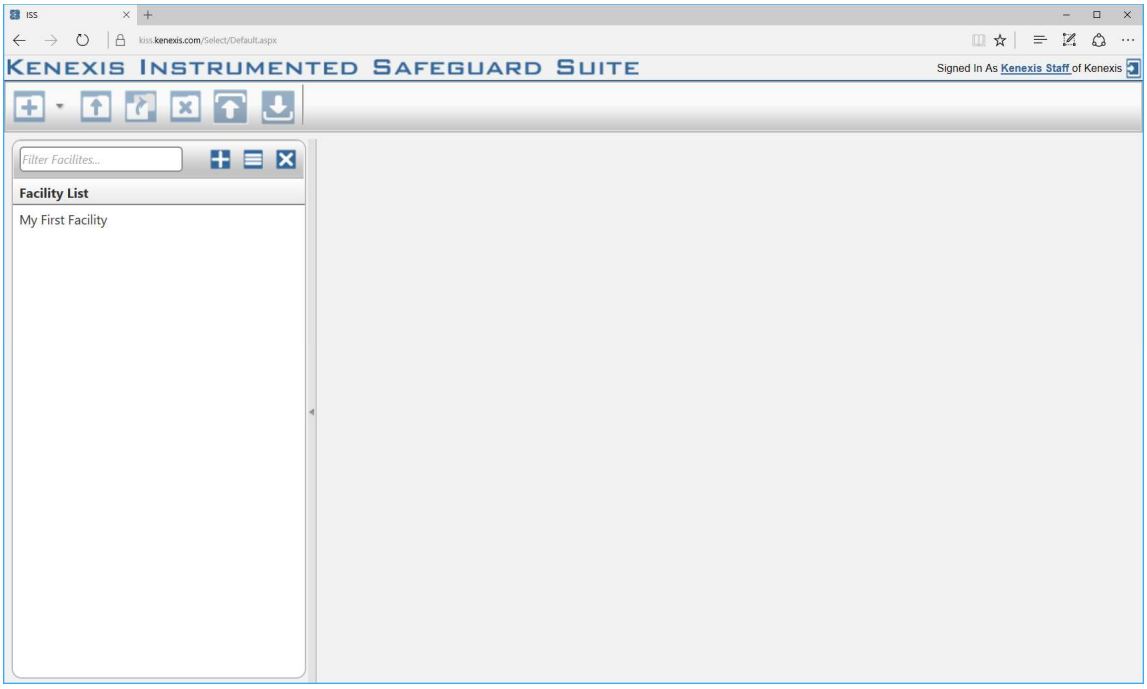


The SIF we'll be modeling is High-High pressure in V-101 (measured by PT-101D) causing closure of the input shutoff valve (SDV-101). This action is taken through interlock USC-101, which is a SIL 3 certified SIS logic solver.

First, you'll need to log into your KISS account. From your preferred web browser navigate to https://kiss.kenexis.com, this will take you to the login page where you can enter your credentials.

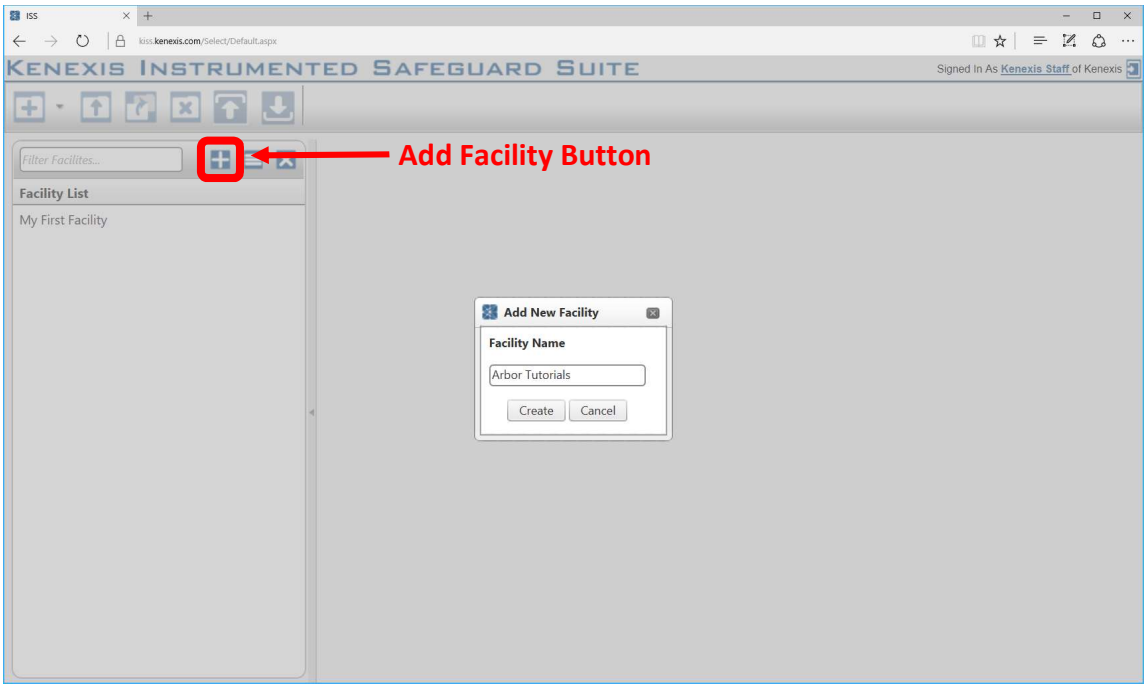


Once you login and accept the EULA, you'll reach the study manager page, shown below.



If you are new to KISS, the Facility List at the left side of the window will be empty. In order to create a new Arbor study you'll first need to create a new facility to store your

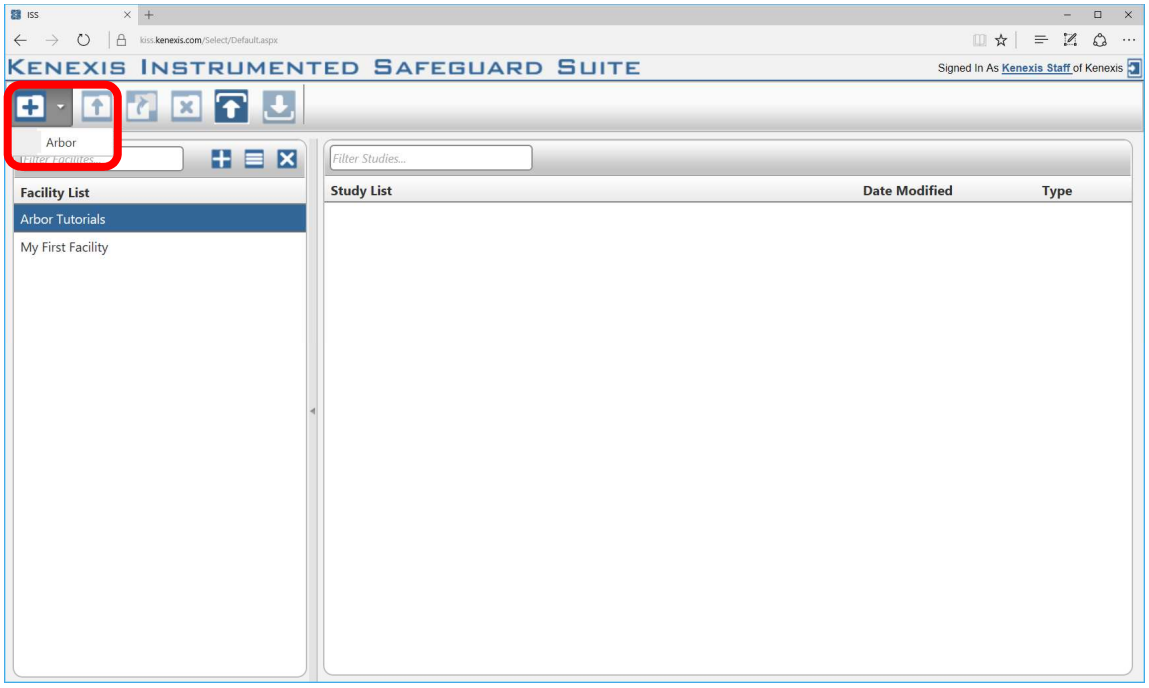
studies in. You can create a new facility by clicking on the add facility button and entering a facility name.



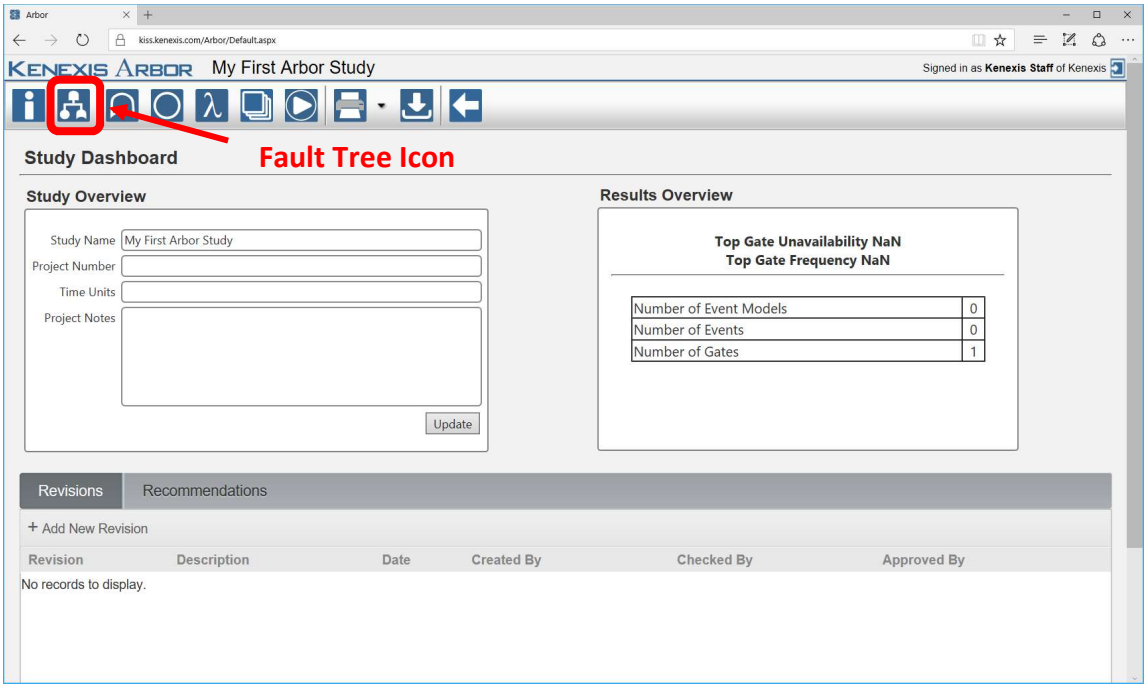
Click create in the Add New Facility window and your facility will appear in the facility list. You can select facilities from the facility list by clicking on the facility name. When a facility is selected the name will be highlighted blue and the Study List panel will appear to the right.

Because this is a new facility, there will be no studies displayed in the study list, let's fix that.

You can create a new arbor study by clicking on the add study button in the main navigation toolbar and select Arbor from the dropdown menu.

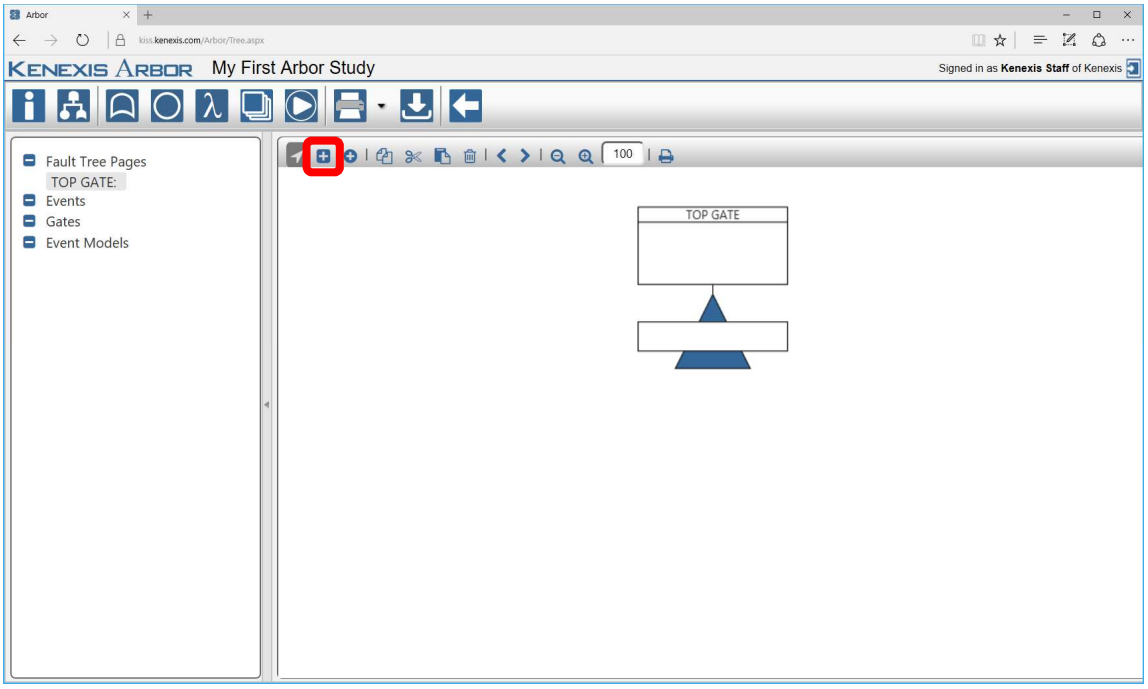


At this point you will be prompted to name your study. Give your study a meaningful name like “My First Arbor Study”. Click create and you will be navigated to the Study Dashboard.

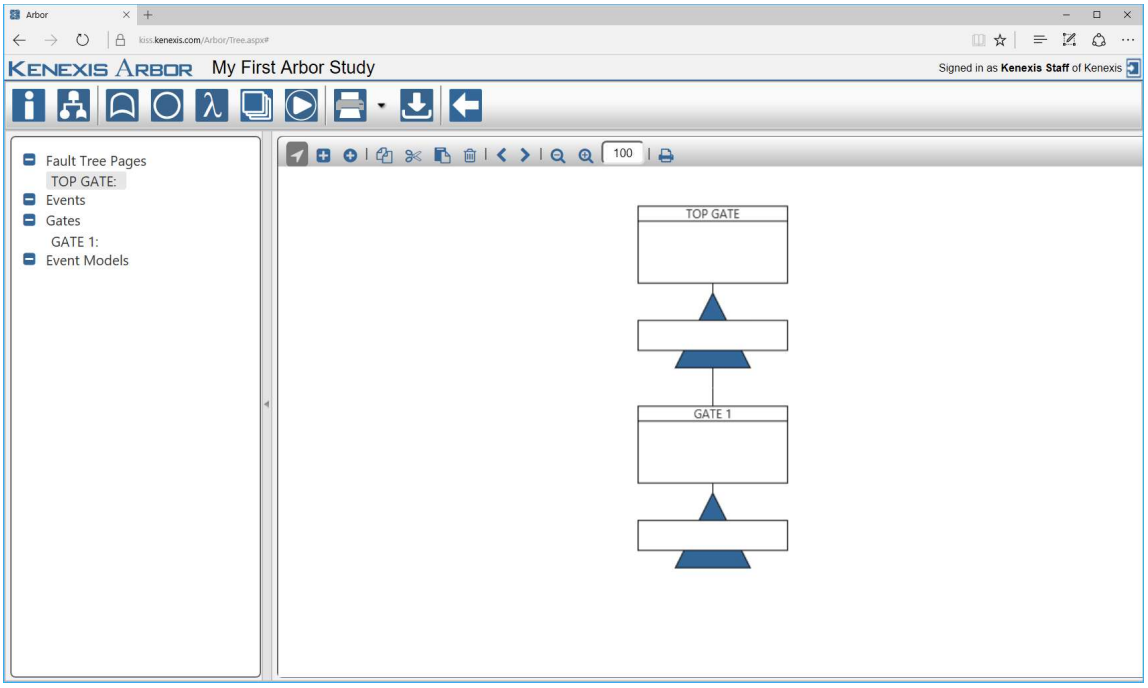


From the study dashboard, click on the fault tree icon in the main navigation toolbar to navigate to the fault tree interface.

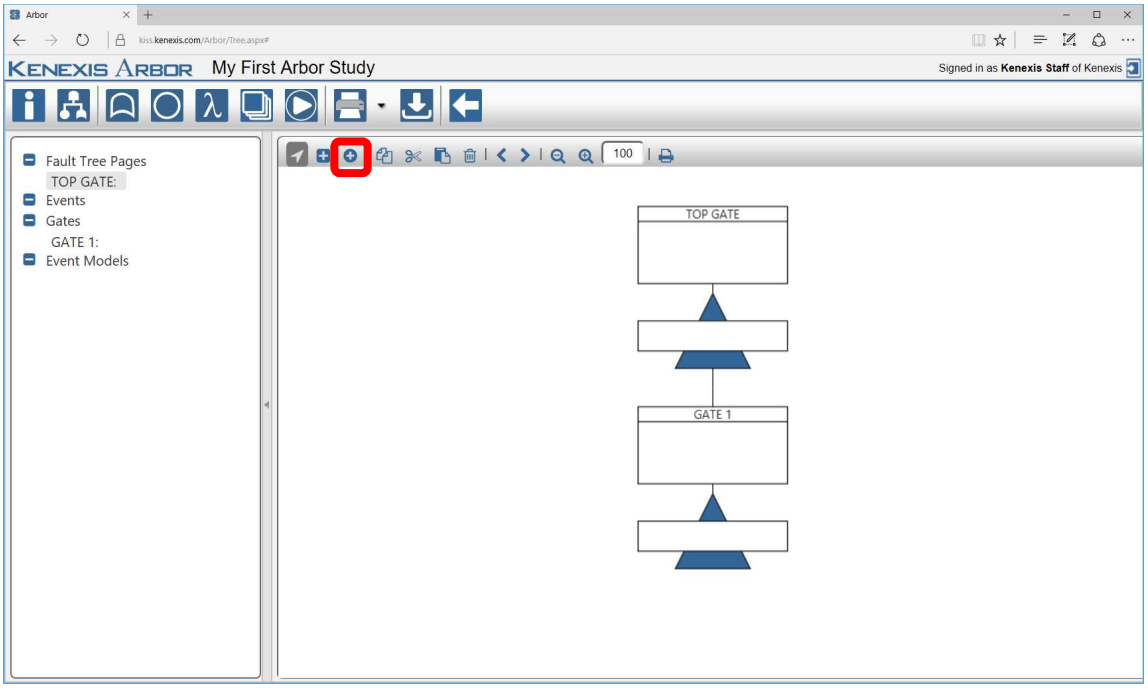
From the fault tree interface we can now start building our fault tree. We'll start by adding a gate. To add gates, you'll need to enter gate insert mode by clicking on the gate insert button in the header of the main workspace.



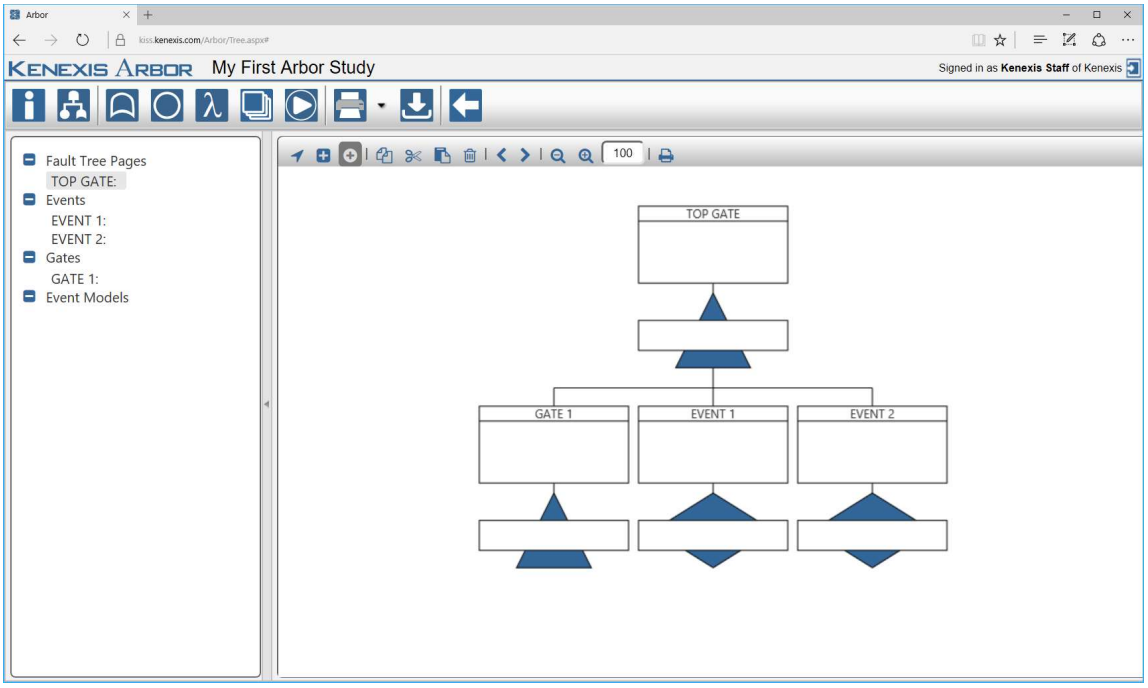
Clicking on the gate insert button will highlight it. Once the button is highlighted we can add gates below the existing gate titled "TOP GATE" by left clicking on the gate in the main workspace. Clicking once will produce a gate titled "GATE 1" as shown below.



Now let's add some events. Events can be added by entering event insert mode. Just like gate insert mode, we can enter event insert mode by clicking on the event insert button in the header of the main workspace.

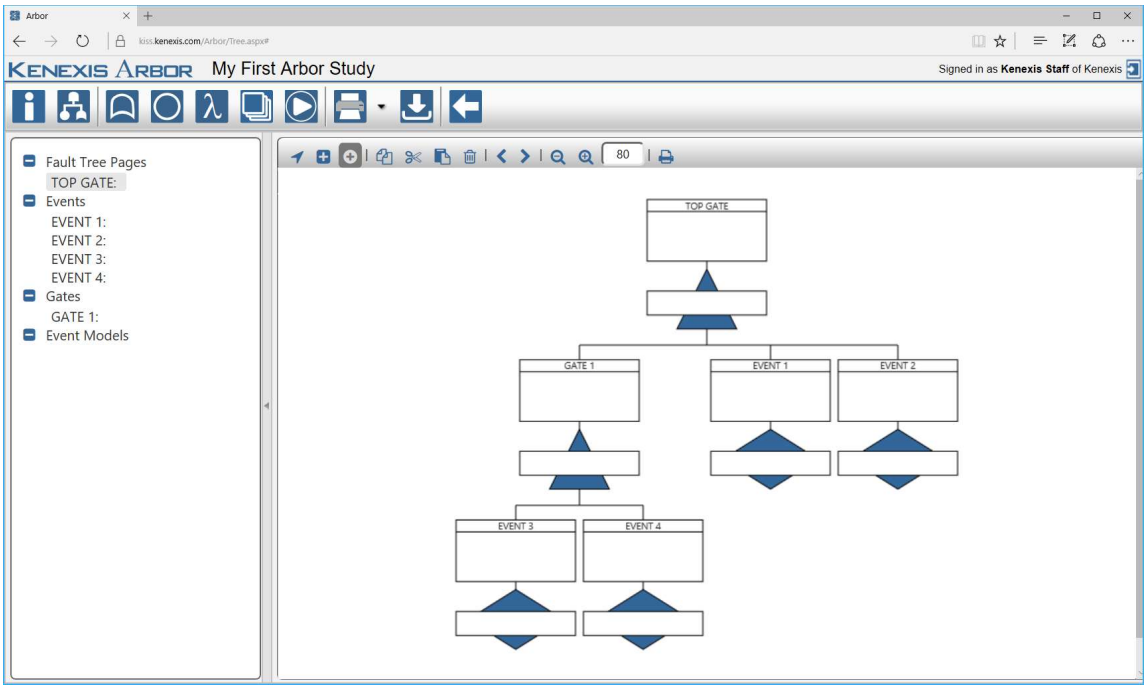


Once in event insert mode, click twice on the top gate to add two events.

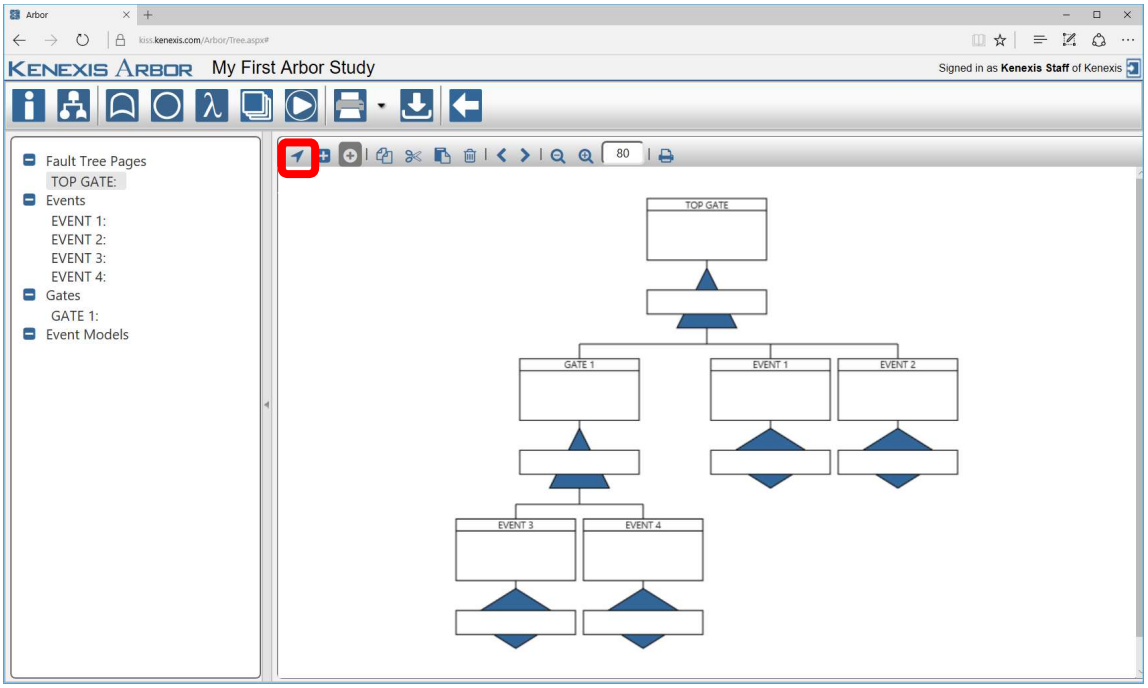


Now let's add two more events. Just like TOP GATE, events and gate can be added below GATE 1. Let's add two events below GATE 1 by clicking on it twice will in event insert mode.

Your fault tree should now look like this.

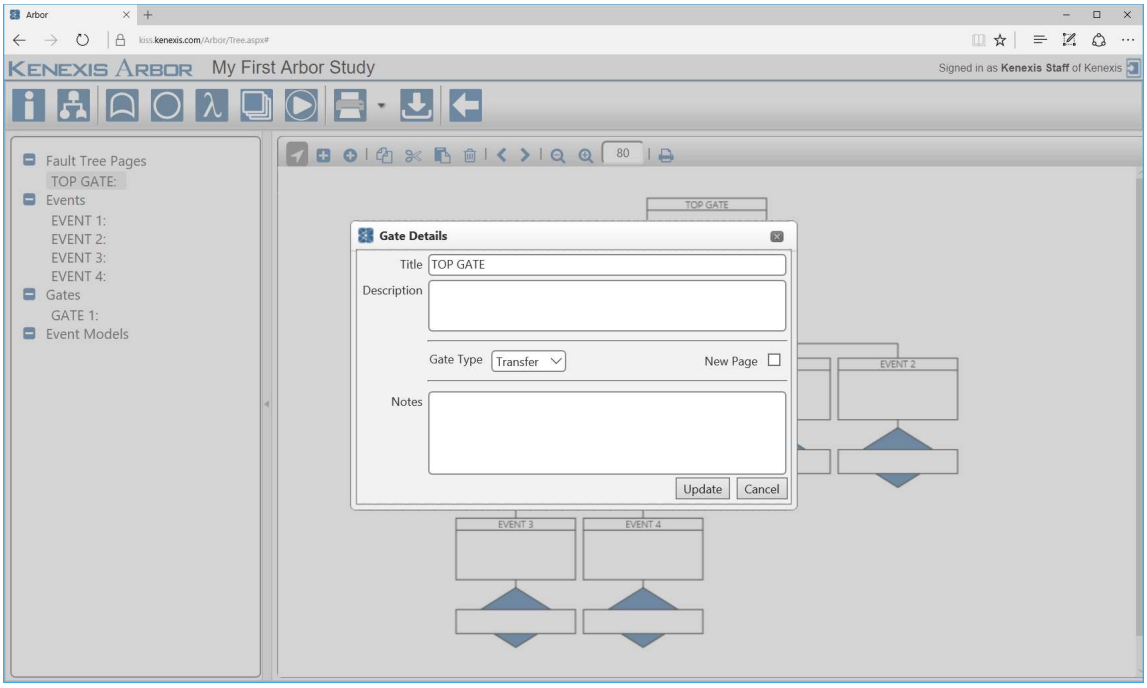


Now that we are done adding events and gates, we can return the fault tree interface to select mode. In select mode we can select gates and events with a single left click or we can open the properties window with a double-click. Enter select mode by clicking on the select mode icon in the header of the main workspace.



Naming gates and events in a fault tree are important. It's important that the reader of the tree has a good description of the gates and events so that they can understand the system being modeled.

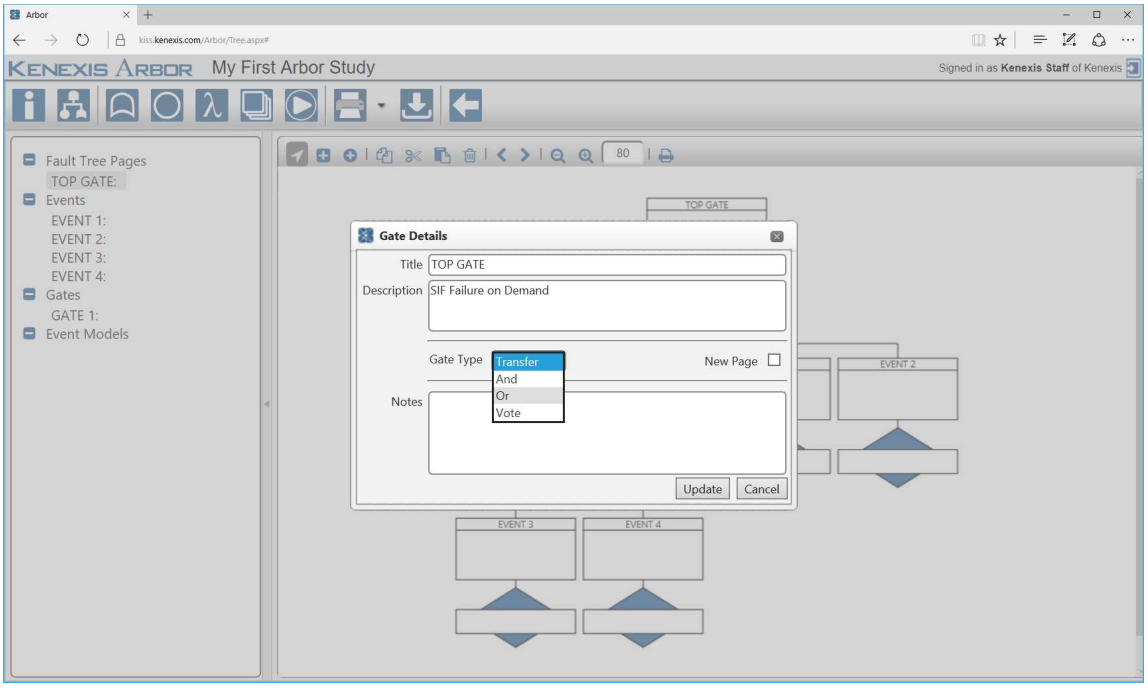
We can give our gates and events meaningful descriptions from the details window. Starting with TOP GATE. Double-click on the gate in the fault tree view. This will open the details form for TOP GATE as shown below.



In the description field we'll give TOP GATE a meaningful description. Type the following in the description field:

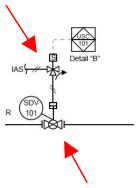
SIF Failure on Demand

From the details form we can also set the gate top. TOP GATE will be an OR gate. Select OR from the dropdown menu and click update to save your changes.



Now repeat the process for GATE 1. The description for GATE 1 should be “Final Element Subsystem Failure on Demand” and the gate type should be OR.

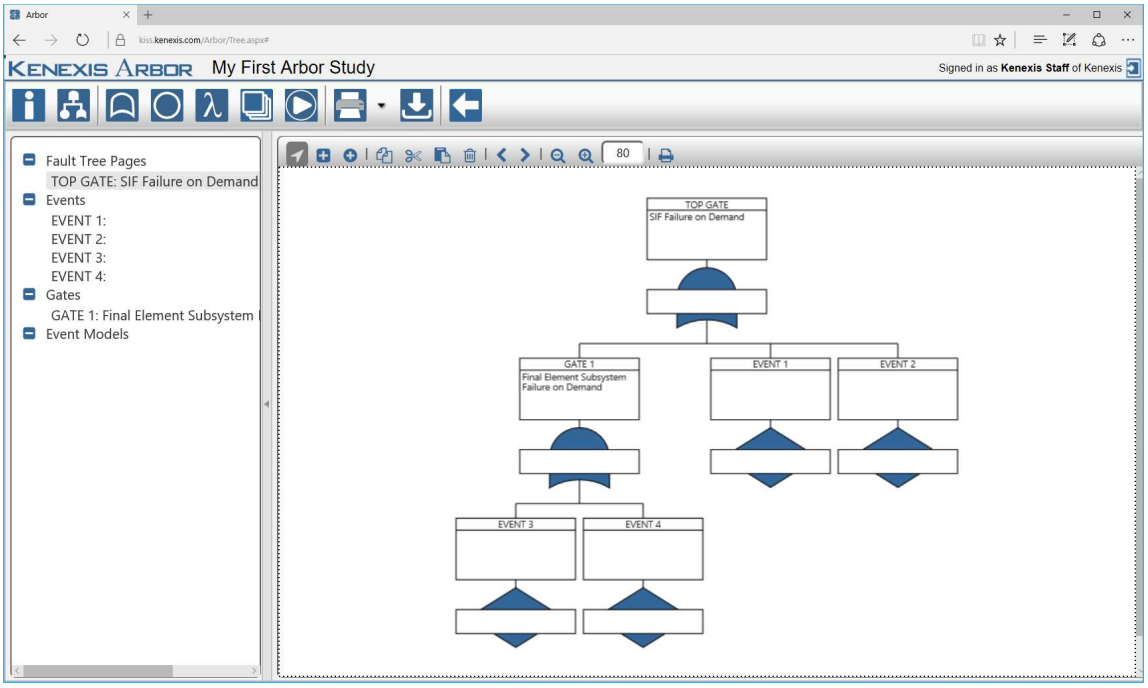
Solenoid Valve



Shutoff Valve

We’ve added a gate for the final element subsystem because our final element subsystem is comprised of two components SDV-101 and the associated solenoid valve. If we wanted to model multiple components in our sensor or logic solver subsystems it should make sense to create gates for these as well.

Now that we’ve defined our gates, the fault tree should look like this.



The next step is to give our events meaningful descriptions. We can add descriptions to events the same way as we added descriptions to gates. Add the following descriptions for each event.

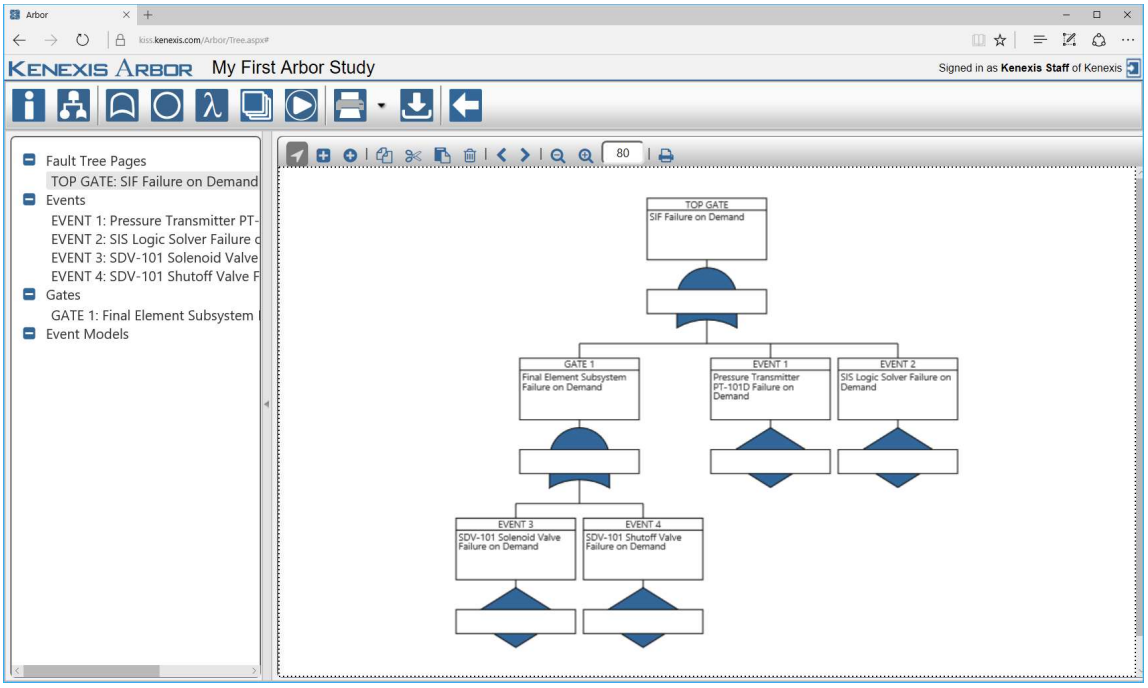
EVENT 1: Pressure Transmitter PT-101D Failure on Demand

EVENT 2: SIS Logic Solver Failure on Demand

EVENT 3: SDV-101 Solenoid Valve Failure on Demand

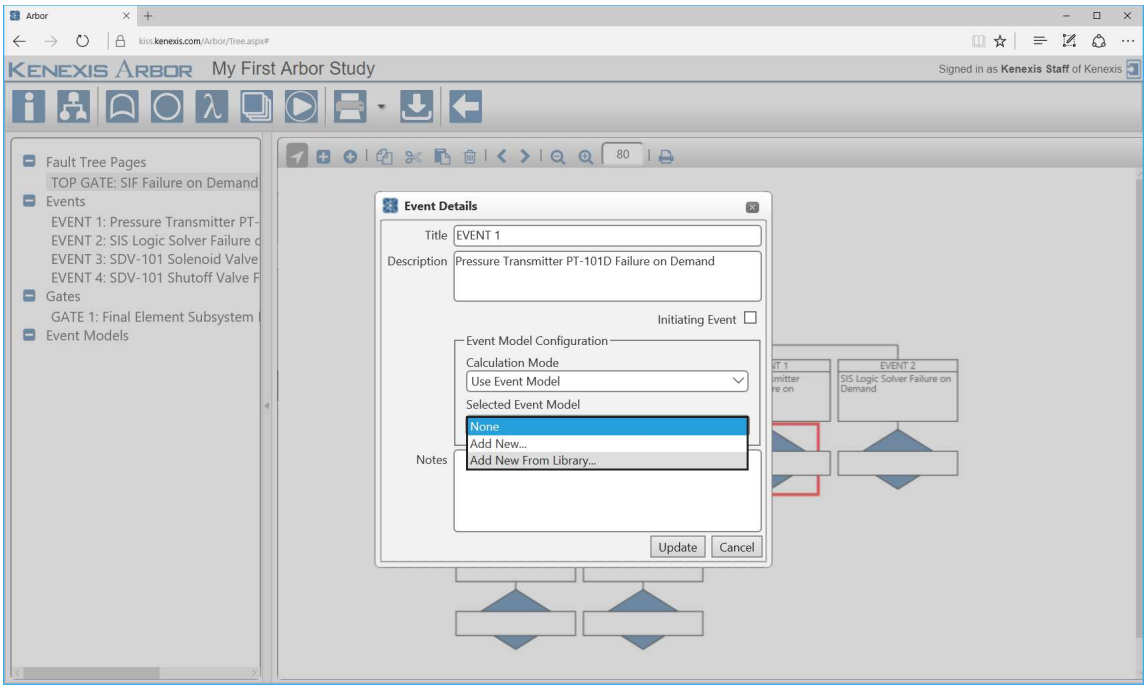
EVENT 4: SDV-101 Shutoff Valve Failure on Demand

At this point we have a descriptive fault tree. At a glance we can easily identify the components of the system, the logical relationship between those components and understand how those components fail.



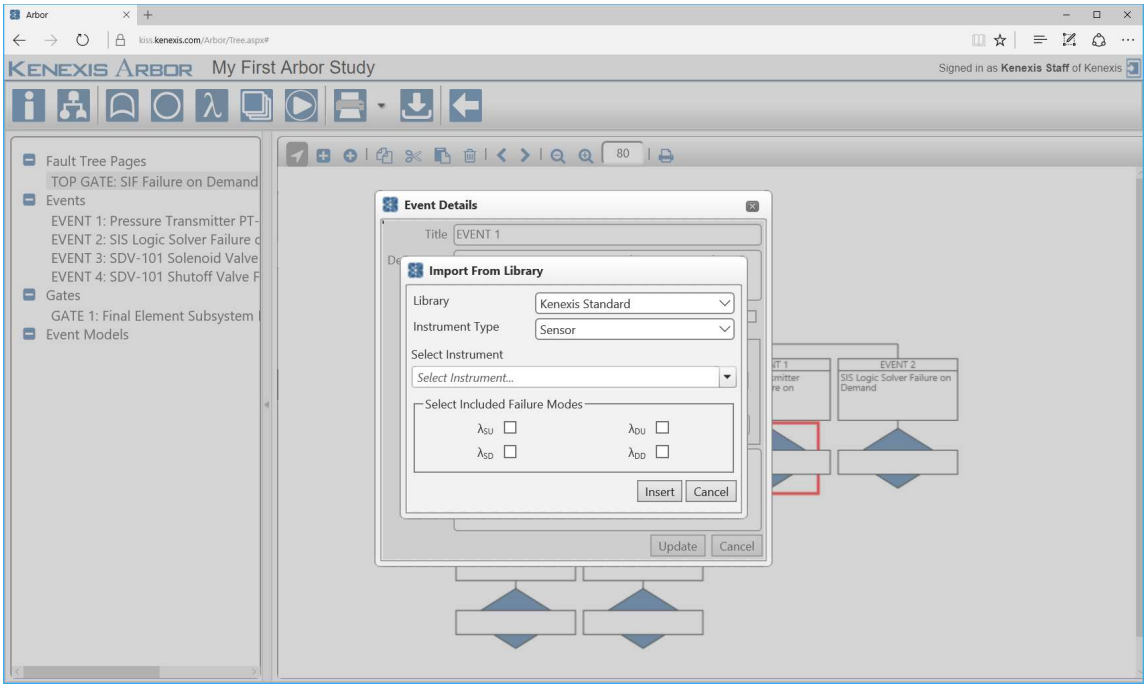
The next step is to apply Event Models to our Events. Event Models are used to characterize the failure rates and failure modes for events. We'll start with EVENT 1.

Open the details form for EVENT 1 by double-clicking on the event in the fault tree.

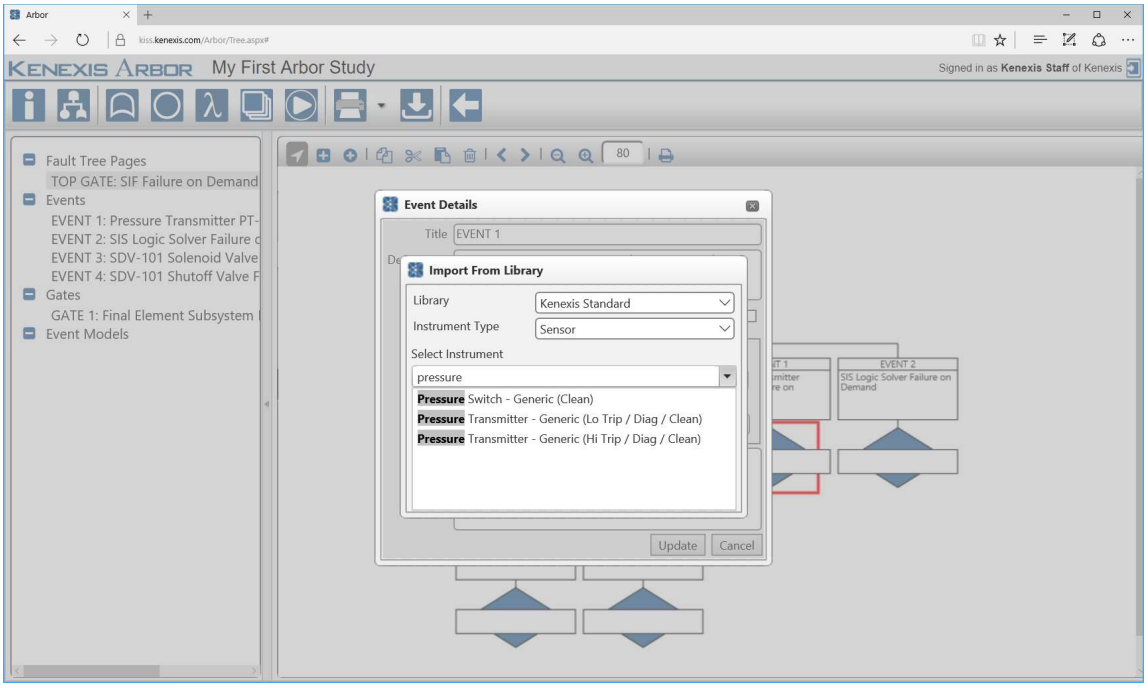


From the Selected Event Model dropdown menu, select “Add New From Library…”. This will allow us to import data from an external library of failure rates. By default you’ll have access to a library called “Kenexis Standard” but you can create your own custom libraries as well.

After Selecting “Add New From Library…” a new dialog will appear titled “Import From Library”. The Selected Library should be Kenexis Standard. Under the Instrument Type Dropdown, select “Sensor”.

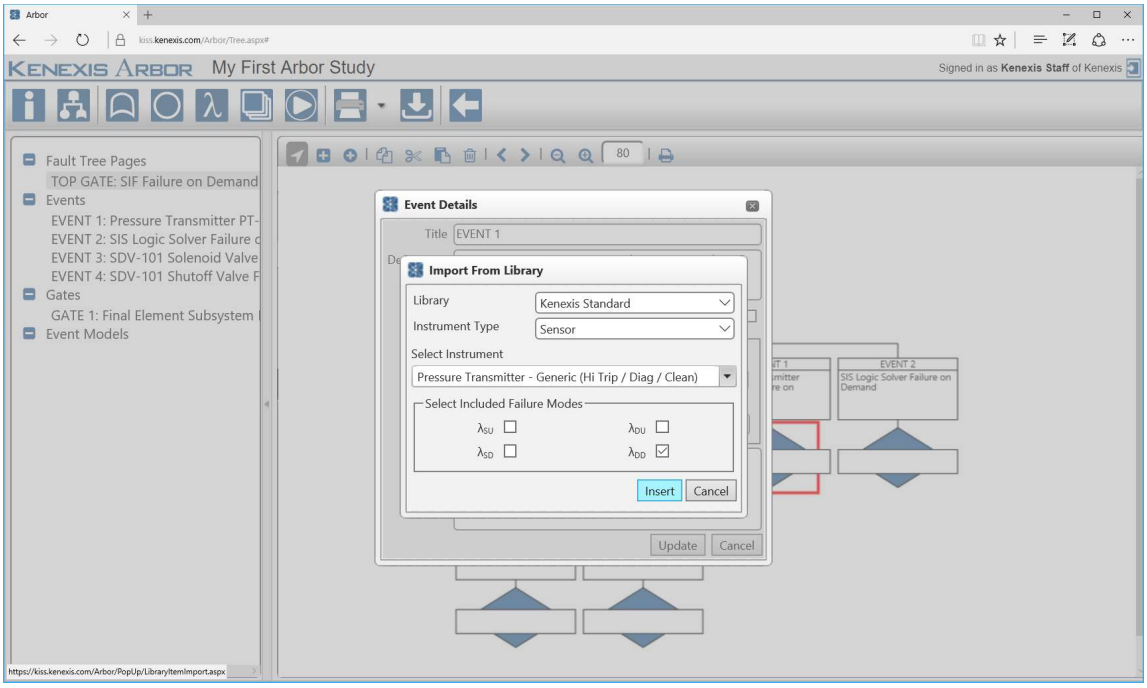


Next click inside of the Select Instrument combo-box and type “pressure”.

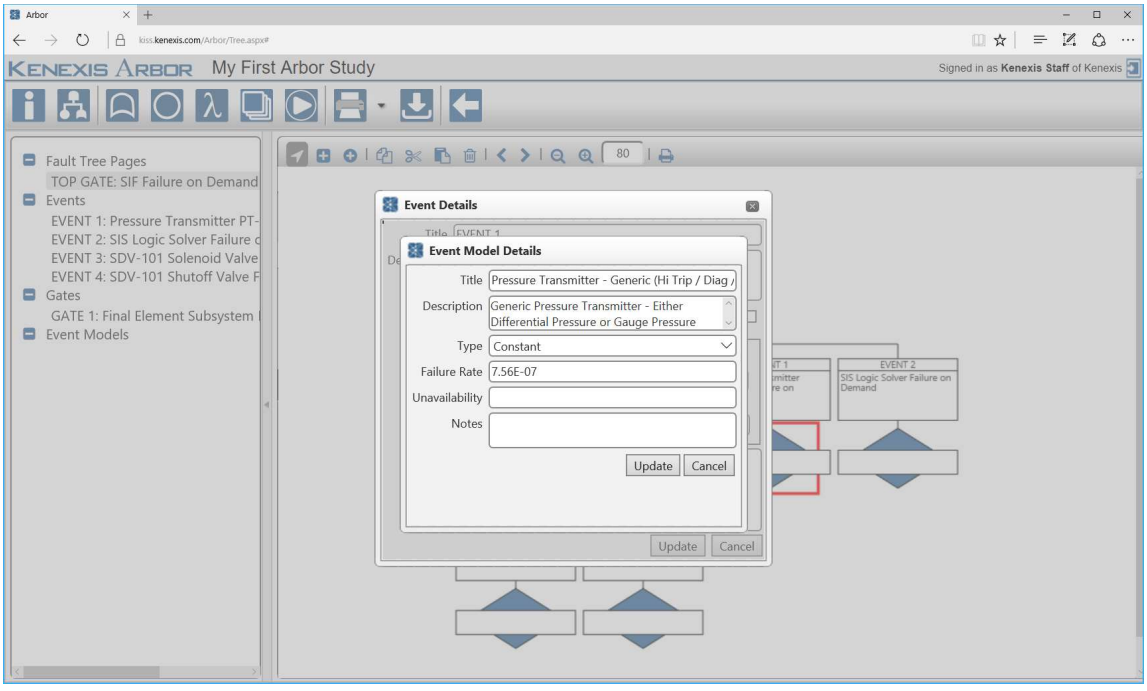


This will filter the library items to only include Sensors in the Kenexis Library where the term pressure appears. In this case, we are modeling a high pressure shutdown so we'll select "Pressure Transmitter – Generic (Hi Trip / Diag / Clean)".

Now that we've selected the instrument we need to select the failure modes to include in the library import. Because we are modeling failure of a Safety Instrumented Function, we'll be interested in the Dangerous Undetected failure modes (λ_{DU}). Check the λ_{DU} check box and click insert to save your changes.

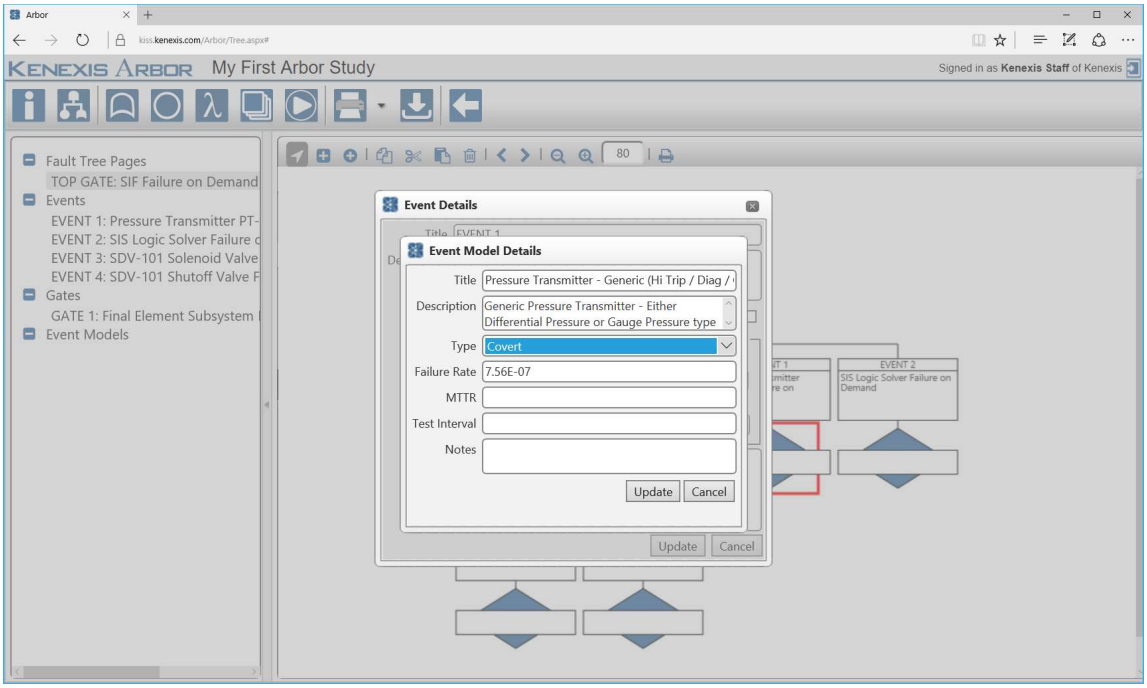


Inserting from the Library will automatically generate an Event Model in our Arbor study and populate that Event Model with data obtained from the library as shown below.



Note that failure rate from the Kenexis Standard library is in units of failures per hour. Calculations in Arbor are unitless so it's our responsibility as users to ensure that units of time used throughout a study are consistent.

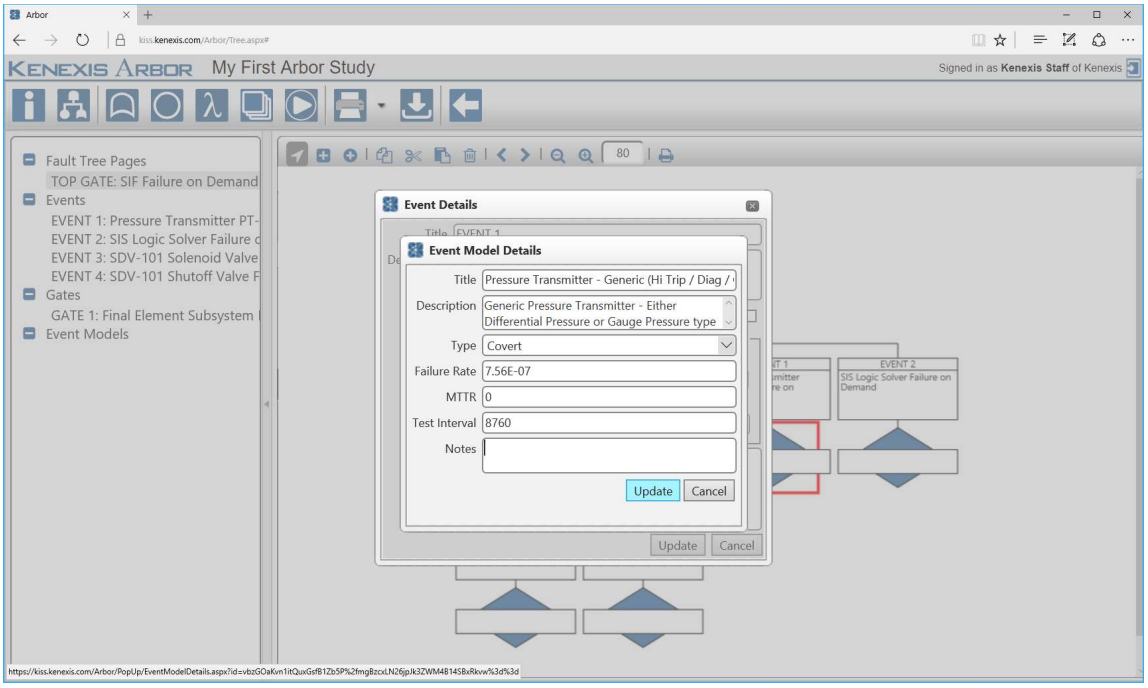
Now that we have the Event Model created we'll need to set the Model Type and define some additional properties. The model type for components in SIS service is typically "Covert". Select Covert from the Type dropdown. This will display two new properties, MTTR (Mean-Time-To-Repair) and Test Interval.



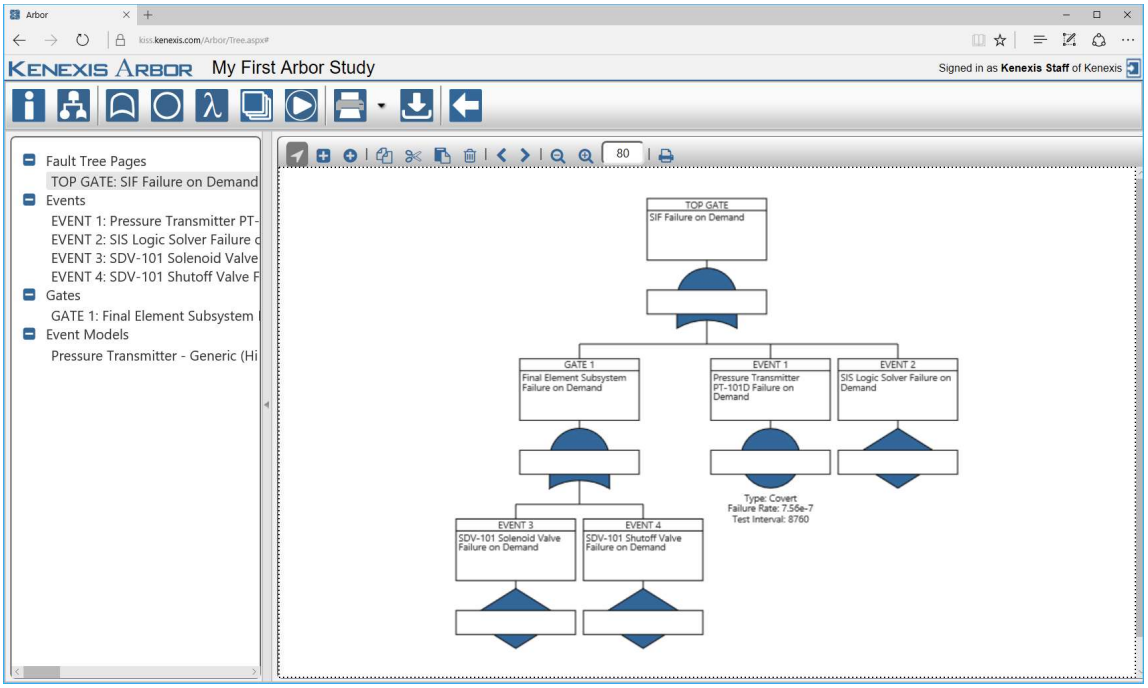
MTTR should typically be zero for SIF unless testing is performed online and a failed test does not result in a shutdown.

Because we entered our failure in units of failure per hour we also need to make sure that MTTR and Test Interval are defined in units of hours. In this case, our SIF will be tested annually (8760 hours).

Enter 0 for MTTR and 8760 for Test Interval and click update to save your changes.



Clicking update will close the Event Model Details window and save your changes. Now you should be back at the Event Details window. You'll notice that the Selected Event Model dropdown has been populated with the Event Model we just created, which is what we want. Click Update on the Event Details Form to save change to the Event and you'll be taken back to the fault tree.



In the fault tree you'll notice that EVENT 1 has changed shape from a diamond to a circle and some additional information is rendered below the event. Diamond Events represent undefined events, meaning an event model has not been applied. Circle Events are basic event which have been defined. Before running calculations you typically want to make sure that all events are basic events otherwise the results of your calculations may not match the system you intended to model.

The next step is to repeat the process of adding an event model for each of the remaining event EVENT 2, EVENT 3 and EVENT 4. Repeat the process for these events using the following information.

EVENT 2:

- Import From Library Form
    - Library: Kenexis Standard
    - Instrument Type: Logic Solver
    - Selected Instrument: Generic SIL 3 Certified PLC
    - Included Failure Modes: λ_{DU}
- Event Model Details Form
    - Type: Covert
    - MTTR: 0
    - Test Interval: 8760

EVENT 3:

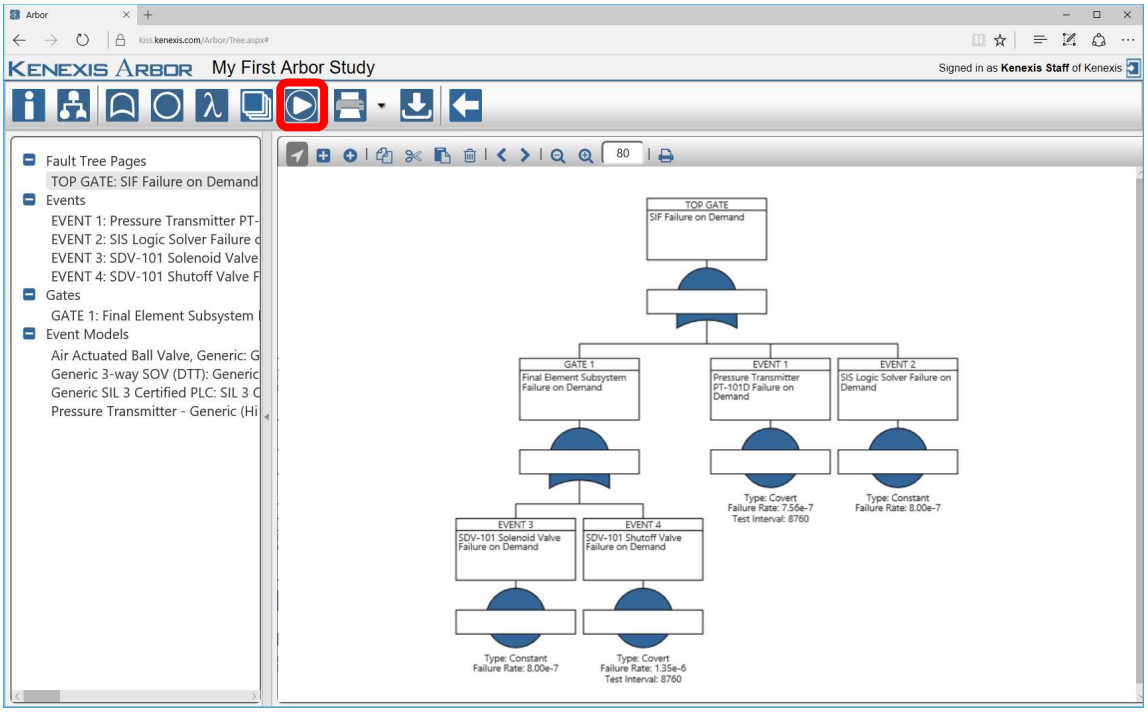
- Import From Library Form
    - Library: Kenexis Standard
    - Instrument Type: Final Element Interface
    - Selected Instrument: Generic 3-way SOV (DTT)
    - Included Failure Modes: λ_{DU}
- Event Model Details Form
    - Type: Covert
    - MTTR: 0
    - Test Interval: 8760

EVENT 4:

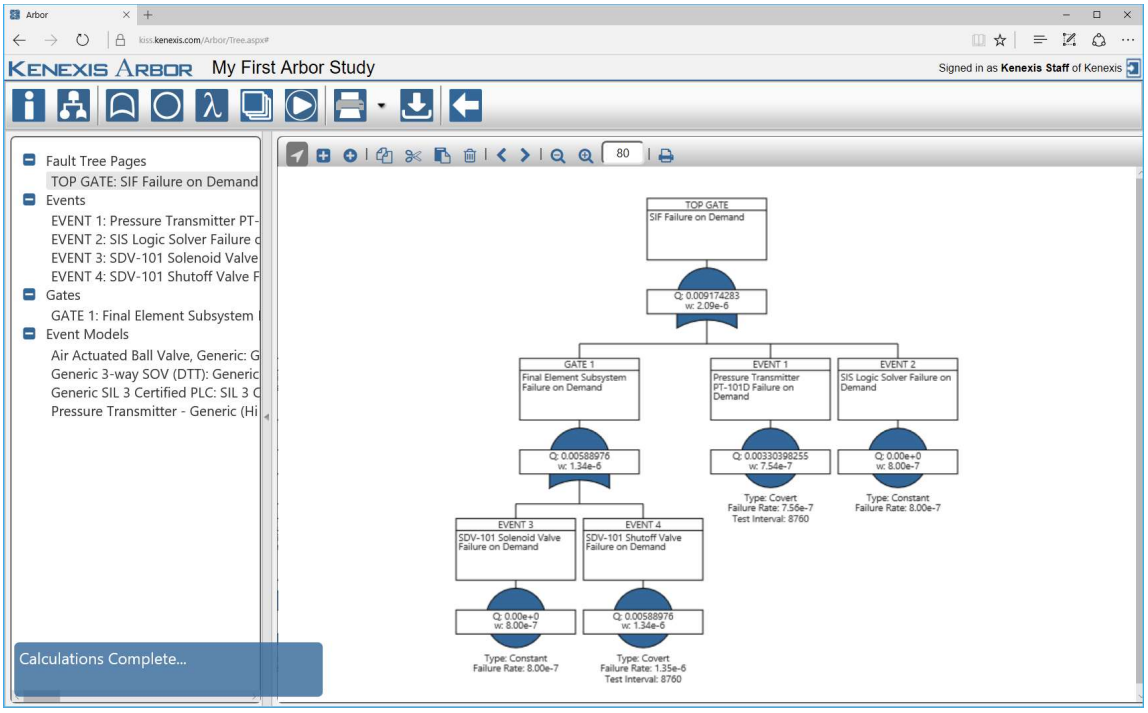
- Import From Library Form
    - Library: Kenexis Standard
    - Instrument Type: Final Element
    - Selected Instrument: Air Actuated Ball Valve, Generic
    - Included Failure Modes: λ_{DU}

- Event Model Details Form
    - Type: Covert
    - MTTR: 0
    - Test Interval: 8760

At this point our fault tree is fully defined. All of the events have been assigned event models and the logic for each gate has been applied. We are ready to run the calculations. To run the calculations, click on the run icon in the main navigation toolbar as shown below.



After clicking run you should receive a user message in the lower left corner informing you that calculations are complete. The fault tree will update with appropriate unavailability (Q) and frequency (w) data for all gates and events.



At this point our analysis is complete. We have calculated a top gate unavailability of 9.1E-03. The unavailability of our top gate is another way of describing the PFD_{avg} for a Safety Instrumented Function. In this case our SIF has achieved a risk reduction factor (RRF) or 109, which is 1 divided by the PFD_{avg}.

We hope you found this tutorial helpful and enjoyable. If you have any questions about the steps performed in this tutorial or need any further assistance please don't hesitate to contact Kenexis support staff at support@kenexis.com.