SOFTWARE

Vertigo SIS Lifecycle Management Software

User’s Manual

V 2

PREFACE

Introduction

This guide describes how to use the Vertigo SIS Lifecycle Management Software. Vertigo is a module in the Kenexis Instrumented Safeguard Suite (KISS). KISS provides designers of engineering safeguards with a cloud-based multi-user platform for the design of Safety Instrumented Systems (SIS) and Fire and Gas Systems (FGS).

Vertigo is the KISS module which provided a platform for SIS Lifecycle Management. This module includes functionality for every stage of the SIS lifecycle from conceptual design and project inception through to decommissioning.

Because new features are added frequently, you are encouraged to check the version number on the cover page of this manual to ensure that you are reading the most current version of this manual, which corresponds with the active version of Vertigo.

About Kenexis

Kenexis is an independent engineering consulting firm. We ensure the integrity of instrumented safeguards and industrial networks. Using skills in risk analysis, reliability engineering, and process engineering, we help establish the design and maintenance specification of instrumented safeguards, such as safety instrumented systems (SIS), alarm systems, fire and gas systems. We use the same skills for industrial control systems (ICS) network design, cyber security assessments, and industrial network performance analysis.

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Section 0 - Definitions

0.1 Definitions

Term	Definition	Acronym
Architectural Constraint Type	Either "A" or "B" as defined by IEC 61508-2 section 7.4.3.1. The architectural constraint type for sensors and final elements effects the required hardware fault tolerance of a subsystem related to the Selected SIL for a SIF.	
Beta Factor	The percent of the failures for a specified device that attributed to common cause failure modes.	
Common Cause	Refers to failures that render two or more devices in a failed state based on a single failure event. The single failure event may be either internal or external to the system.	
Dangerous Coverage	Diagnostic coverage of dangerous failures. The ability of a system to detect and diagnose failures that have or will cause a device to fail to a dangerous state.	
Deenergize-To-Trip	SIS outputs and devices are energized under normal operation. Removal of the source of power (e.g., electricity, air) causes a trip.	DTT
Demand	A condition or event that requires the SIS to take action to prevent a hazardous event from occurring.	
Diagnostic Coverage	A measure of a system's ability to self-detect failures. For SIS with active fault detection capabilities, this is a ratio between the failure rate for detected failures to the failure rate for all failures in the system.	

Section 0 - Definitions

Term	Definition	Acronym
Energize-To-Trip	SIS outputs and devices are de-energized under normal operation. Application of power (e.g., electricity, air) causes a trip.	ETT
Fault Tolerance	Ability of a subsystem (sensors, logic solvers, final elements) to continue to perform a required function in the presence a limited number of equipment faults.	FT
Hardware Fault Tolerance	Limitations imposed on the components and architecture selected for implementation of a safety-instrumented function, regardless of the performance calculated for a subsystem in terms of PFD_{avg}. Constraints are specified (in IEC 61508-2-Table 2 and IEC 61511-Table 5) and require minimum degrees fault tolerance. Architectural constraints are established according to the required SIL of the subsystem (i.e., sensors, logic solvers, final elements), "type" of components used, and Safe Failure Fraction (SFF) of the subsystem's components. Type A components are simple devices not incorporating microprocessors whose failure modes are well understood, and Type B devices are complex devices such as those incorporating microprocessors.	HFT

Section 0 - Definitions

Term	Definition	Acronym
Instrumented Protective Function	An instrumented safeguard used to protect against hazardous process conditions. Instrumented Protective Functions are typically comprised of three subsystems (sensors, logic solvers, and final elements), although may be comprised of fewer subsystems. Safety Instrumented Functions are a subset of Instrumented Protective Functions.	IPF
Input Group Logic	Defines the voting between multiple groups of sensors. 1oo1 implies a single sensor group. 1ooX implies multiple sensors groups, only a single group must function properly for the associated IPF to remain functional. XooX implies multiple sensor groups, all of which are required to be functional to maintain functionality of the associated IPF.	
Mean Time to Fail	Mean Time to Failure is the average amount of time that elapses between putting a system into service and when that system fails.	MTTR
Mean Time to Repair	Average time to repair a failed component from the time of detection to the time to complete the repair and restore the component to service.	MTTR

Section 0 - Definitions

Term	Definition	Acronym
Output Group Logic	Defines the voting between multiple groups of final elements. 1oo1 implies a single final element group. 1ooX implies multiple final element groups, only a single group must function properly for the associated IPF to remain functional. XooX implies multiple final element groups, all of which are required to be functional to maintain functionality of the associated IPF.	
Percent Safe	Means the factor used to divide the overall failure rate for a device into safe failures (i.e., failures of a device that tend toward initiating a trip condition) and dangerous failures (i.e., failures of a device that tend toward inhibiting a trip condition). This is different from the Safe Failure Fraction (SFF) as defined by IEC 61508 and IEC 61511 that includes dangerous failures that can be detected.	
Probability of Failure on Demand	Probability of Failure on Demand means the probability that a Safety Instrumented Function will fail dangerously, and not be able to perform its safety function when required. PFD can be determined as an average probability or maximum probability over a specified time period, which is usually the proof test interval. IEC 61508/61511 and ISA 84.01 use average PFD as the system metric upon which the achieved SIL for a Safety Instrumented Function is defined. PFD is related to the amount of risk reduction that is provided by a Safety Instrumented Function.	PFDavg

Section 0 - Definitions

Term	Definition	Acronym
Proof Test Coverage	The percentage failures that are detected and repaired during the proof test of equipment. A 100% proof test coverage means the system is restored to full working order, and theoretical zero probability of failure immediately after the system is restored to service.	
Risk Reduction Factor	Risk Reduction Factor for a Safety Instrumented Function is the mathematical inverse of PFDavg of that function. It is a measure of the amount of risk reduction provided by a Safety Instrumented Function given that the function is used in a preventive manner and has 100% diagnostic coverage of the process conditions that will result in a process hazard. RRF equal to 100 implies that the Safety Instrumented Function provides a calculated risk reduction of a factor of 100.	RRF
Safe Coverage	Diagnostic coverage of safe failures. The ability of a system to detect and diagnose failures that have or will cause a device to fail to a safe state.	
Safe Failure Fraction	Fraction of the overall failure rate of a device that results in either a safe failure or a diagnosed (i.e., detected) unsafe failure. The safe failure fraction calculation includes detectable dangerous failures when those failures are annunciated and either a repair occurs or the process is shutdown upon detection of the fault. This term is strictly defined in IEC 61508 and is a critical portion of safety equipment certification processes.	SFF

DEFINITIONS

Section 0 - Definitions

Term	Definition	Acronym
Safety Instrumented Function	A safety instrumented function (SIF) is a set of specific actions to be taken under specific circumstances, which will move the chemical process from a potentially unsafe state to a safe state.	SIF
Safety Instrumented System	Safety Instrumented System is the implementation of one or more Safety Instrumented Functions. A SIS is a system composed of any combination of sensor(s), logic solver(s), and final element(s).	SIS
Safety Integrity Level	Safety Integrity Level is a quantitative measure of the effectiveness of a Safety Instrumented Function. SIL is defined by ISA 84.00.01 and IEC 61511/61508 as order of magnitude bands of PFD	SIL
Safety Requirements Specification	A set of requirements to achieve functional safety for a Safety Instrumented System as defined by ISA 84.00.01 and IEC 61511.	SRS
Spurious Trip Rate	The average time until a failure of the system causes a process trip when no actual trip conditions are present. This is called a spurious trip because it implies a failure of the instrumentation and control system, but one in the "safe" direction.	STR
Subsystem	A subset of a Instrumented Protective Function (IPF). A subsystem may contain one or more devices which perform actions associated with an IPF. Subsystems are typically comprised of Sensors, Logic Solvers or Final Elements.	

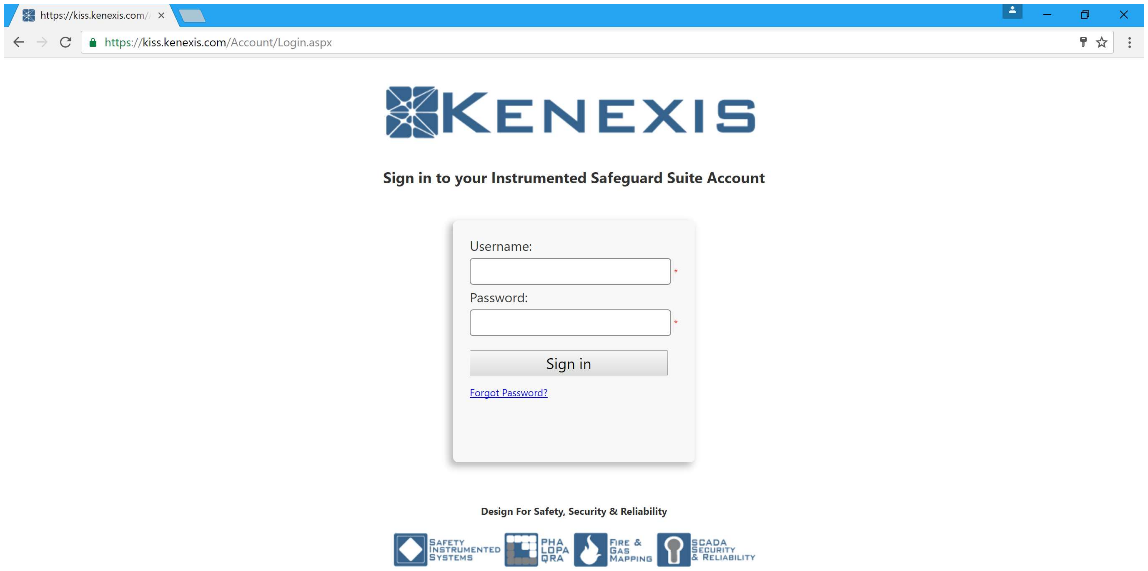
Section 0 - Definitions

Term	Definition	Acronym
Voting	The logical relationship between one or more elements which comprise a subsystem of an IPF.	

Section 1 – Getting Started

1.1 Instructions for First Time Login

Hello, and welcome to Kenexis Instrumented Safeguard Suite (KISS). If you are new to the Kenexis Instrumented Safeguard Suite (KISS) you should have received a welcome package via email with your login credentials if you are using the Kenexis public server. If your organization is using a private instance of KISS, you will need to get your login information from your software system administrator. Once you have received this package, it means that your account has been configured and is ready to use. For most users, you can access your account by directing your browser to https://kiss.kenexis.com. This will navigate your browser to the KISS login page, shown below. Private server users will have a custom domain name that you should obtain from your system administrator.



https://kiss.kenexis.com/Account/Login.aspx

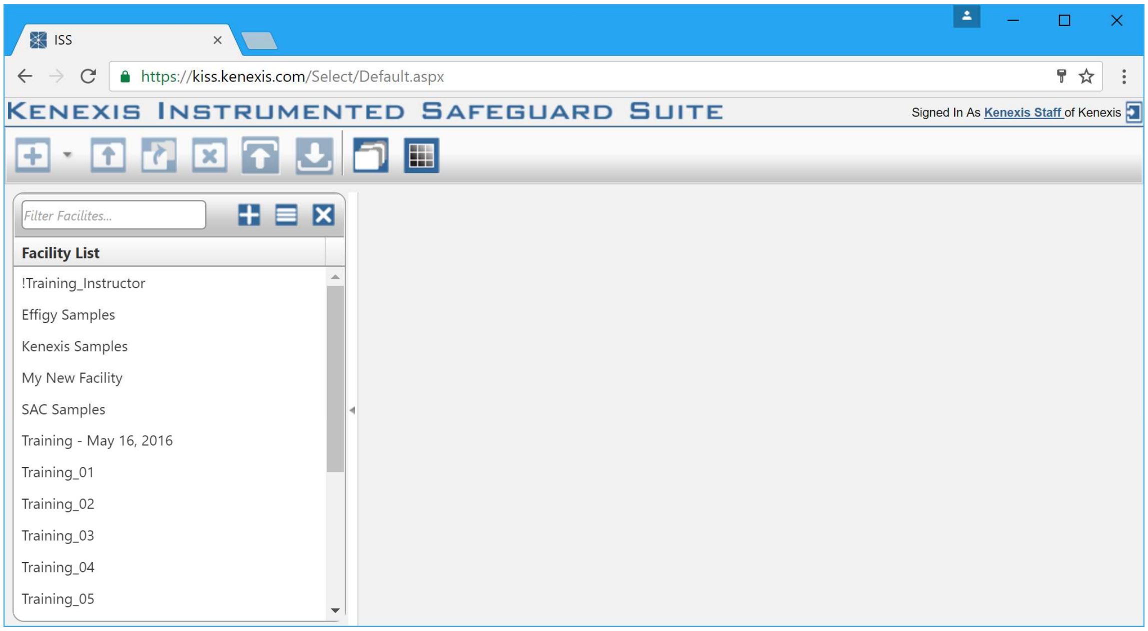
Sign in to your Instrumented Safeguard Suite Account

https://kiss.kenexis.com/
KENEXIS
Username:
Password:
Sign in
Forgot Password?
Design For Safety, Security & Reliability
Safety Instrumented Systems
PHA LOPA QRA
Fire & Gas Mapping
SCADA Security & Reliability

From here you can login using the login credentials provided in your KISS welcome email. If you've lost your temporary password, it can be restoring by using the "Forgot Password?" link. If you've lost your username, please contact support@kenexis.com for assistance.

Section 1 – Getting Started

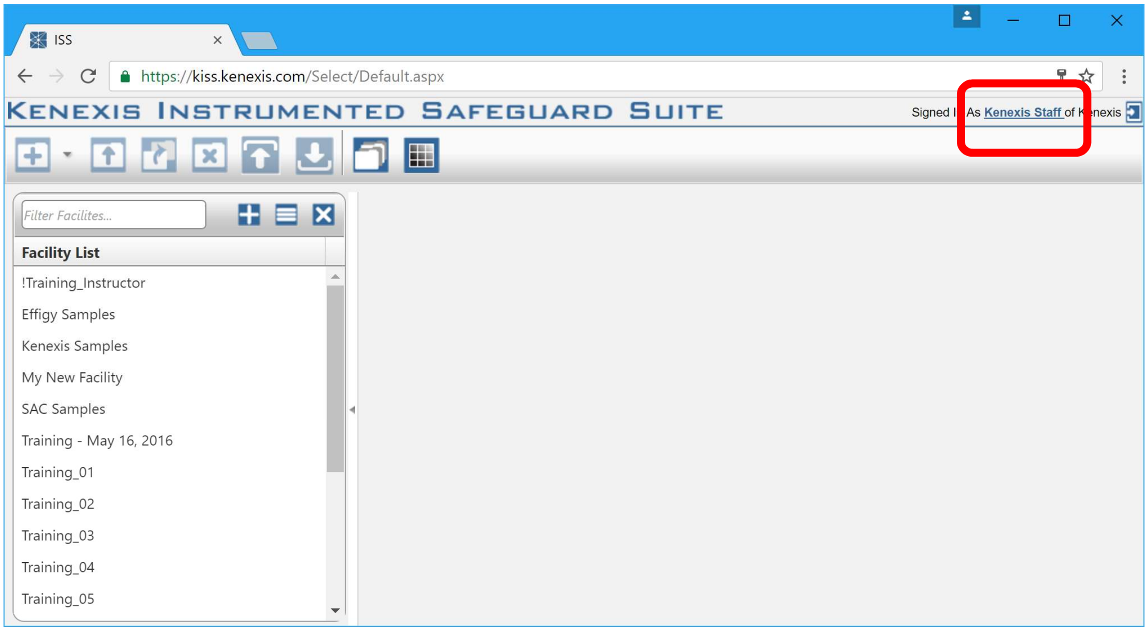
After Successful login, you should arrive at the Study Manager page, shown below.


ISS
https://kiss.kenexis.com/Select/Default.aspx
KENEXIS INSTRUMENTED SAFEGUARD SUITE
Signed In As Kenexis Staff of Kenexis
Filter Facilites...

Facility List

- !Training_Instructor
- Effigy Samples
- Kenexis Samples
- My New Facility
- SAC Samples
- Training - May 16, 2016
- Training_01
- Training_02
- Training_03
- Training_04
- Training_05

From here, it is highly recommended that you reset your temporary password. You can reset your password by clicking on your name in the top right corner.


ISS
https://kiss.kenexis.com/Select/Default.aspx
KENEXIS INSTRUMENTED SAFEGUARD SUITE
Signed In As Kenexis Staff of Kenexis
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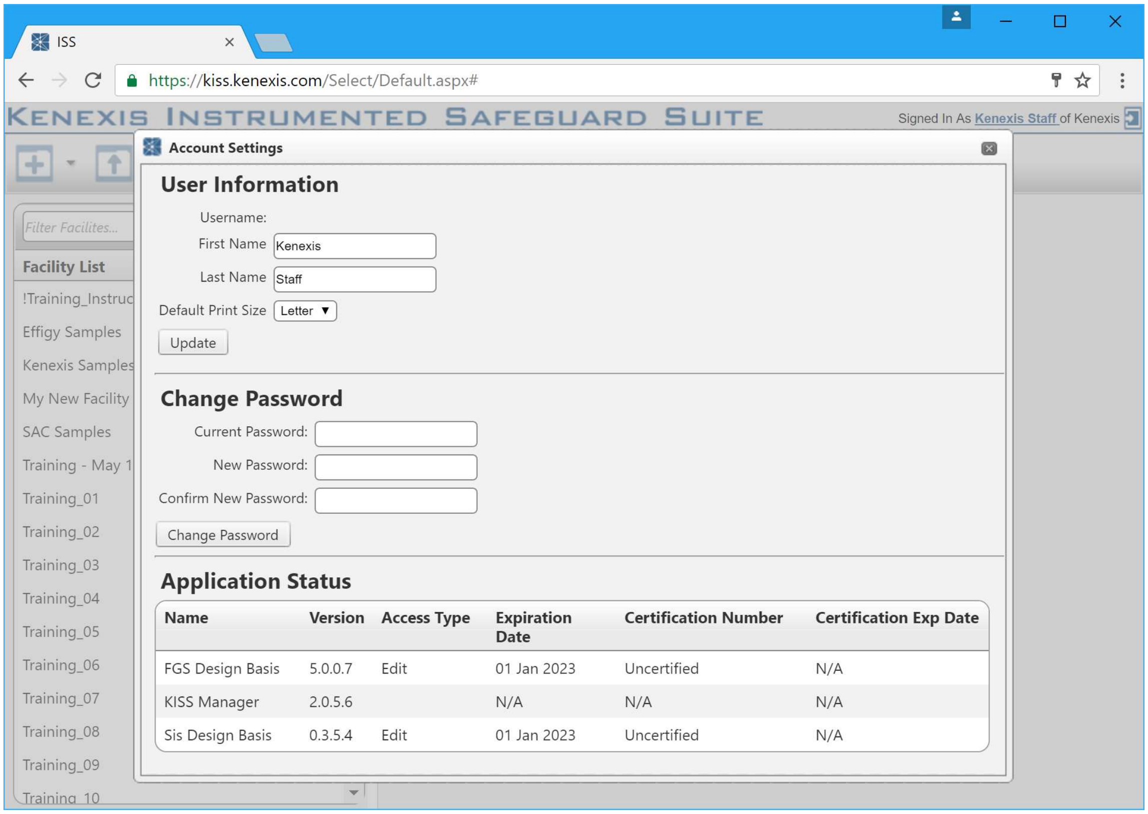
Facility List

- !Training_Instructor
- Effigy Samples
- Kenexis Samples
- My New Facility
- SAC Samples
- Training - May 16, 2016
- Training_01
- Training_02
- Training_03
- Training_04
- Training_05

This will open your account settings where you have the option to change your password.



User Information

Username:
First Name: Kenexis
Last Name: Staff
Default Print Size: Letter

Change Password

Current Password:
New Password:
Confirm New Password:

Application Status

Name	Version	Access Type	Expiration Date	Certification Number	Certification Exp Date
FGS Design Basis	5.0.0.7	Edit	01 Jan 2023	Uncertified	N/A
KISS Manager	2.0.5.6		N/A	N/A	N/A
Sis Design Basis	0.3.5.4	Edit	01 Jan 2023	Uncertified	N/A

1.2 Login Troubles

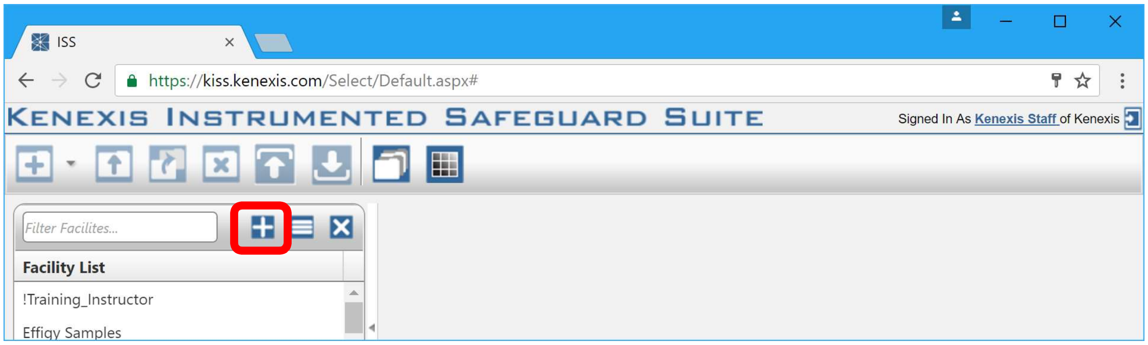
This section describes some of the common causes and solutions for trouble with logging into the Kenexis Instrumented Safeguard Suite (KISS).

Problem #1: I forgot my password
Solution: Visit Kiss.Kenexis.com a click on the "Forgot Password?" link.

Problem #2: I forgot my username
Solution: Contact Support@Kenexis.com to restore your account

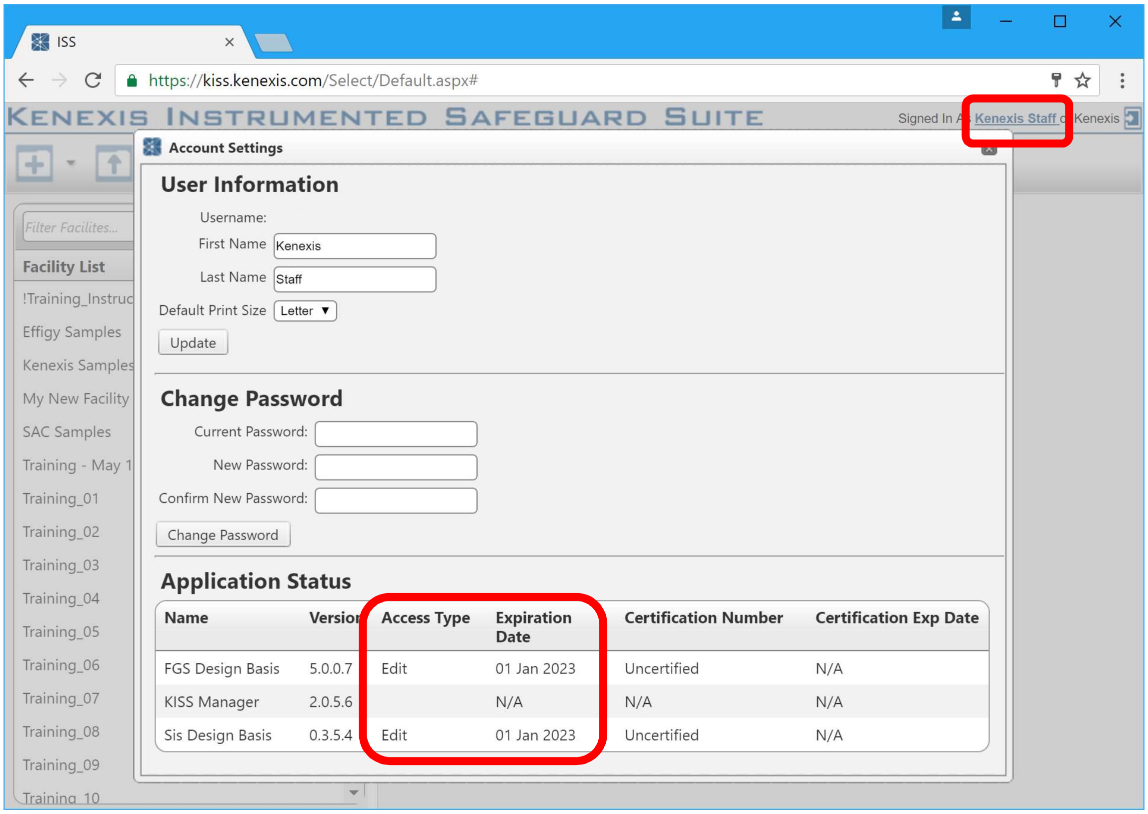
Problem #3: When I login I don't see any studies on the Study Manager Page
Solution: If you are not able to view any facilities or studies on the Study Manager

page it is because you do not have access to any study information. Depending on your roles within your company you may have privileges to create a new facility by clicking on the Add Facility button (shown below).


ISS
https://kiss.kenexis.com/Select/Default.aspx#
KENEXIS INSTRUMENTED SAFEGUARD SUITE
Signed In As Kenexis Staff of Kenexis
Filter Facilites...
Facility List
!Training_Instructor
Effigy Samples

If you are a first time user of Vertigo and unfamiliar with the data structure you may want to consider following the "Creating Your First Study " tutorial.

Alternatively, if your account has been assigned read-only permissions you will need to contact your project manager/company administrator to grant you access to the desired studies. You can view your account permissions on your account settings window, which is accessed by clicking on your name in the top right corner.



User Information

Username:

First Name: Kenexis

Last Name: Staff

Default Print Size: Letter ▼

Update

Change Password

Current Password:

New Password:

Confirm New Password:

Change Password

Application Status

Name	Version	Access Type	Expiration Date	Certification Number	Certification Exp Date
FGS Design Basis	5.0.0.7	Edit	01 Jan 2023	Uncertified	N/A
KISS Manager	2.0.5.6		N/A	N/A	N/A
Sis Design Basis	0.3.5.4	Edit	01 Jan 2023	Uncertified	N/A

1.3 Other Resources

In addition to the information provided in this user's manual, help and support for use of the Vertigo SIS Lifecycle Management Software can also be obtained from the following resources:

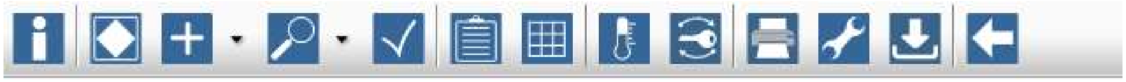
- Online or Instructor Based Training Course - A full list of these available courses can be found at www.kenexis.com/training.
  - Front End Engineering Design (FEED)
    Safety Lifecycle, SIL Selection, Safety Requirements Specification
  - Conceptual Design and SIL Verification
  - Bypassing Safety Instrumented Systems
  - Using Vertigo (coming soon…)

- Books and other Kenexis publications relating to Safety Instrumented System design methodologies, including:
  - Books
    - Kenexis Safety Instrumented Systems Engineering Handbook
  - Papers and Magazine Articles

    - Kenexis Employee Blog Posts
- Live Support from Kenexis Staff. Support requests can be submitted to Kenexis staff via the Kenexis support system, which can be accessed from https://support.kenexis.com.

Section 2 - Interface

2.1 The Navigation Toolbar



The navigation toolbar serves as the primary means for navigating the Vertigo study editor interface and appears on all pages in the editor. This section details the available buttons on the toolbar:

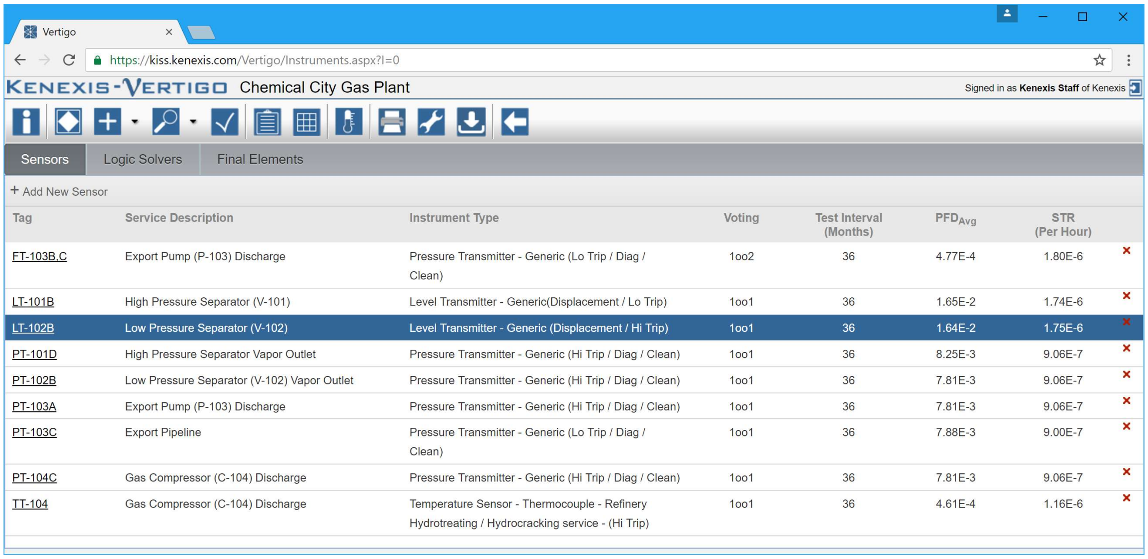
Button	Description
i	The Overview button will navigate to the Study Overview page for the active study.
◇	The IPF button will navigate to the IPF List grid. The IPF list grid displays a list of all Safety Instrument Functions (SIF) within a study as well as all the I/O associated with each SIF.
+ ▾	The add dropdown is used to create various types of new objects in Vertigo. Selecting an object type from the dropdown list will open a details form to insert a new object.
🔍 ▾	The View dropdown allows you to quickly navigate to various grid views which summarize lists of objects in your Vertigo study.
✓	The validation button will cause a complete recalculation of all SIL Verification calculations contains within your Vertigo study. The Validation log will detail any missing or invalid data which was identified during the calculations.
📋	The SRS button will open the Safety Requirements Specification (SRS) grids. From these grids SRS details, can be documented in a variety of ways. Details are provided in *Section 4*.
▦	The C&E button will open the Cause & Effect Matrix interface. The Cause & Effect Matrix is used to depict the functional description of the Safety Instrumented System in a simple, graphical format.

Section 2 - Interface

Button	Description
🌡	The testing button will open the functional test tracking grids. These grids are used to track commissioning, testing and decommissioning for SIS instrumentation.
🔑	The bypass button will open the bypass tracking grids. These grids are used to track the authorization and activation of bypasses for SIS instrumentation.
🖨	The report button will open an instance of the report generation wizard. The report generation wizard is used to generate the various preformatted report templates contained by Vertigo.
🔧	The Study Settings button will navigate to the settings page for the active study. The study setting page contains various study-specific parameters such as selected applicable standards for SIL verification calculations and the failure rate database linked to the study.
⬇	The export study button will allow you to export all the study data for your Vertigo study as worksheets in a Microsoft Excel file (.xlsx file format). Exported studies can be modified in excel and imported back into Vertigo from the Study Manager Interface.
⬅	The Back to Study List button will navigate to the Study Manager page . Navigating to the Study Manger page will require leaving the Vertigo study editor interface.

2.2 Working with Grids

The data grid is a staple of the Vertigo interface and is used extensively to summarize data for a collection of related objects. An example is shown below for a collection of sensors.


Vertigo
https://kiss.kenexis.com/Vertigo/Instruments.aspx?I=0
KENEXIS-VERTIGO
Signed in as Kenexis Staff of Kenexis
Sensors
Logic Solvers
Final Elements

Chemical City Gas Plant

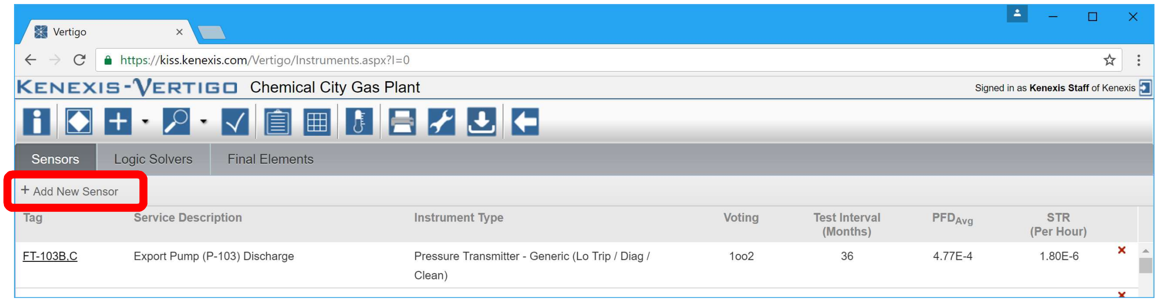
+ Add New Sensor

Tag	Service Description	Instrument Type	Voting	Test Interval (Months)	PFD_{Avg}	STR (Per Hour)	
FT-103B,C	Export Pump (P-103) Discharge	Pressure Transmitter - Generic (Lo Trip / Diag / Clean)	1oo2	36	4.77E-4	1.80E-6	✕
LT-101B	High Pressure Separator (V-101)	Level Transmitter - Generic(Displacement / Lo Trip)	1oo1	36	1.65E-2	1.74E-6	✕
LT-102B	Low Pressure Separator (V-102)	Level Transmitter - Generic (Displacement / Hi Trip)	1oo1	36	1.64E-2	1.75E-6	✕
PT-101D	High Pressure Separator Vapor Outlet	Pressure Transmitter - Generic (Hi Trip / Diag / Clean)	1oo1	36	8.25E-3	9.06E-7	✕
PT-102B	Low Pressure Separator (V-102) Vapor Outlet	Pressure Transmitter - Generic (Hi Trip / Diag / Clean)	1oo1	36	7.81E-3	9.06E-7	✕
PT-103A	Export Pump (P-103) Discharge	Pressure Transmitter - Generic (Hi Trip / Diag / Clean)	1oo1	36	7.81E-3	9.06E-7	✕
PT-103C	Export Pipeline	Pressure Transmitter - Generic (Lo Trip / Diag / Clean)	1oo1	36	7.88E-3	9.00E-7	✕
PT-104C	Gas Compressor (C-104) Discharge	Pressure Transmitter - Generic (Hi Trip / Diag / Clean)	1oo1	36	7.81E-3	9.06E-7	✕
TT-104	Gas Compressor (C-104) Discharge	Temperature Sensor - Thermocouple - Refinery Hydrotreating / Hydrocracking service - (Hi Trip)	1oo1	36	4.61E-4	1.16E-6	✕

All grids are provided with a consistent set of controls to allow you to interface with the data in various ways. This section provides a summary of the controls which are typical for data grids in Vertigo.

2.2.1 Adding new Records to a Grid

Records can be added to a grid by clicking on the “add new” button located at the top left corner of the grid, above the headers as shown below. This will open a details form for the object type being displayed in the grid.


Vertigo
https://kiss.kenexis.com/Vertigo/Instruments.aspx?I=0
KENEXIS-VERTIGO
Signed in as Kenexis Staff of Kenexis
Sensors
Logic Solvers
Final Elements

Chemical City Gas Plant

+ Add New Sensor

Tag	Service Description	Instrument Type	Voting	Test Interval (Months)	PFD_{Avg}	STR (Per Hour)	
FT-103B,C	Export Pump (P-103) Discharge	Pressure Transmitter - Generic (Lo Trip / Diag / Clean)	1oo2	36	4.77E-4	1.80E-6	✕

Alternatively, items can be added to grids by using the “add” button in the navigation ribbon (described in Section 2.1).

2.2.2 Editing Existing Records of a Grid

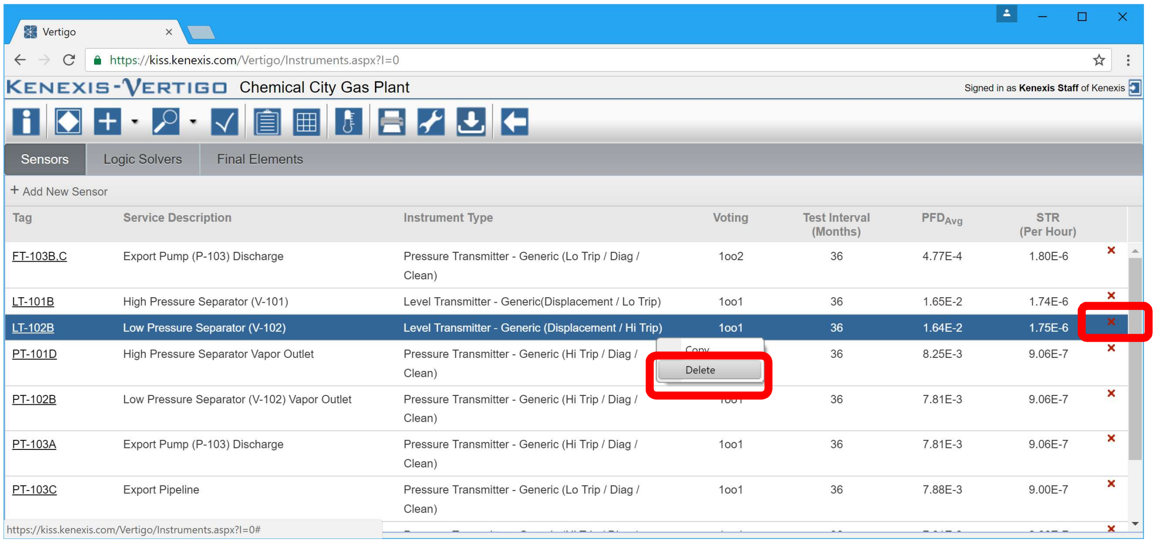
Editing of existing records is done for a details form view, which will open in a separate window from the grid. Opening a details form window can be done in one of two ways.

- Double click anywhere on the row for the desired record
- Single click on the Underlined field for the desired record. In the case on Sensors, this is the “tag” field.

Once the details form window is closed, the grid will be updated with any changes made during the edit.

2.2.3 Deleting a Record from a Grid

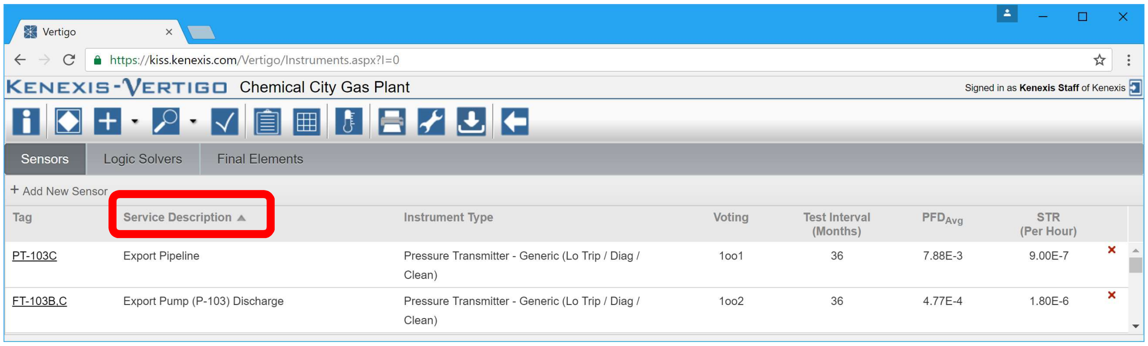
Records can be deleted either by right-click on the red x on the right side of the grid or by using the delete command in the grid row context menu (described in Section 2.2.6).


Vertigo
https://kiss.kenexis.com/Vertigo/Instruments.aspx?I=0
KENEXIS-VERTIGO
Chemical City Gas Plant
Signed in as Kenexis Staff of Kenexis
Sensors
Logic Solvers
Final Elements
+ Add New Sensor
Copy
Delete
https://kiss.kenexis.com/Vertigo/Instruments.aspx?I=0#

Tag	Service Description	Instrument Type	Voting	Test Interval (Months)	PFD_{Avg}	STR (Per Hour)	
FT-103B,C	Export Pump (P-103) Discharge	Pressure Transmitter - Generic (Lo Trip / Diag / Clean)	1oo2	36	4.77E-4	1.80E-6	×
LT-101B	High Pressure Separator (V-101)	Level Transmitter - Generic(Displacement / Lo Trip)	1oo1	36	1.65E-2	1.74E-6	×
LT-102B	Low Pressure Separator (V-102)	Level Transmitter - Generic (Displacement / Hi Trip)	1oo1	36	1.64E-2	1.75E-6	×
PT-101D	High Pressure Separator Vapor Outlet	Pressure Transmitter - Generic (Hi Trip / Diag / Clean)		36	8.25E-3	9.06E-7	×
PT-102B	Low Pressure Separator (V-102) Vapor Outlet	Pressure Transmitter - Generic (Hi Trip / Diag / Clean)	1oo1	36	7.81E-3	9.06E-7	×
PT-103A	Export Pump (P-103) Discharge	Pressure Transmitter - Generic (Hi Trip / Diag / Clean)	1oo1	36	7.81E-3	9.06E-7	×
PT-103C	Export Pipeline	Pressure Transmitter - Generic (Lo Trip / Diag / Clean)	1oo1	36	7.88E-3	9.00E-7	×

2.2.1 Grid Sorting

Grid Items can be sorted by left clicking on a header. The grid will be sorted alpha-numerically based on the selected field. A sorted column is indicated by a small arrow located next to the header as shown below.



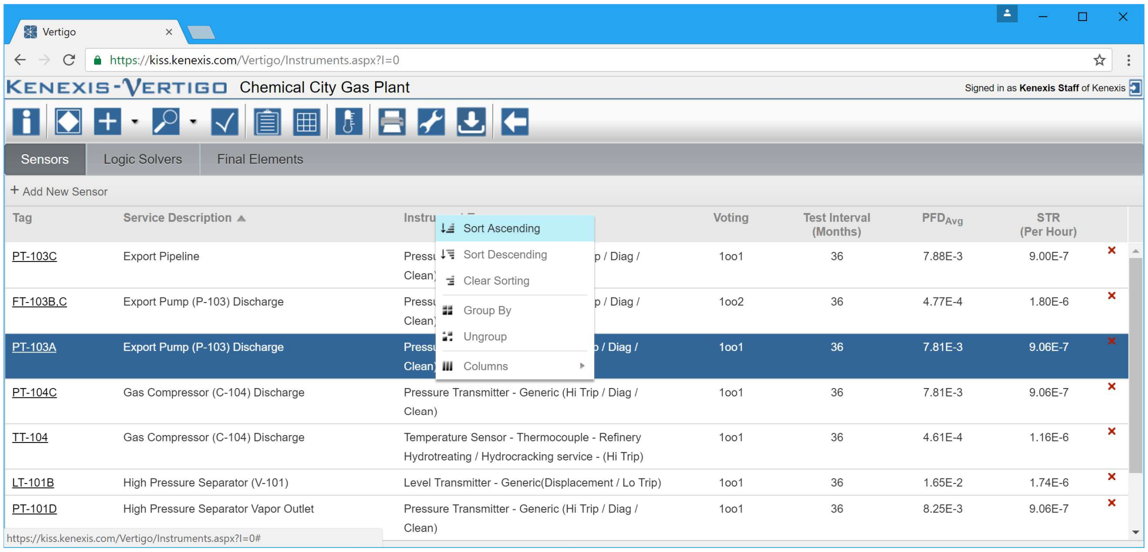
Tag	Service Description ▲	Instrument Type	Voting	Test Interval (Months)	PFD$_{Avg}$	STR (Per Hour)
PT-103C	Export Pipeline	Pressure Transmitter - Generic (Lo Trip / Diag / Clean)	1oo1	36	7.88E-3	9.00E-7
FT-103B.C	Export Pump (P-103) Discharge	Pressure Transmitter - Generic (Lo Trip / Diag / Clean)	1oo2	36	4.77E-4	1.80E-6

2.2.2 Grid Header Context Menu

All Data Grids are provided with a header context menu which provides several functions:

- Sorting: Alternative method to grid sorting described in section 2.2.1)
- Grouping: Group's the records of the grid based on the selected field. Allows for rows to be quickly hidden based on the grouped field.
- Show / Hide Columns: Removing columns from view to allow only the desired data to be shown.

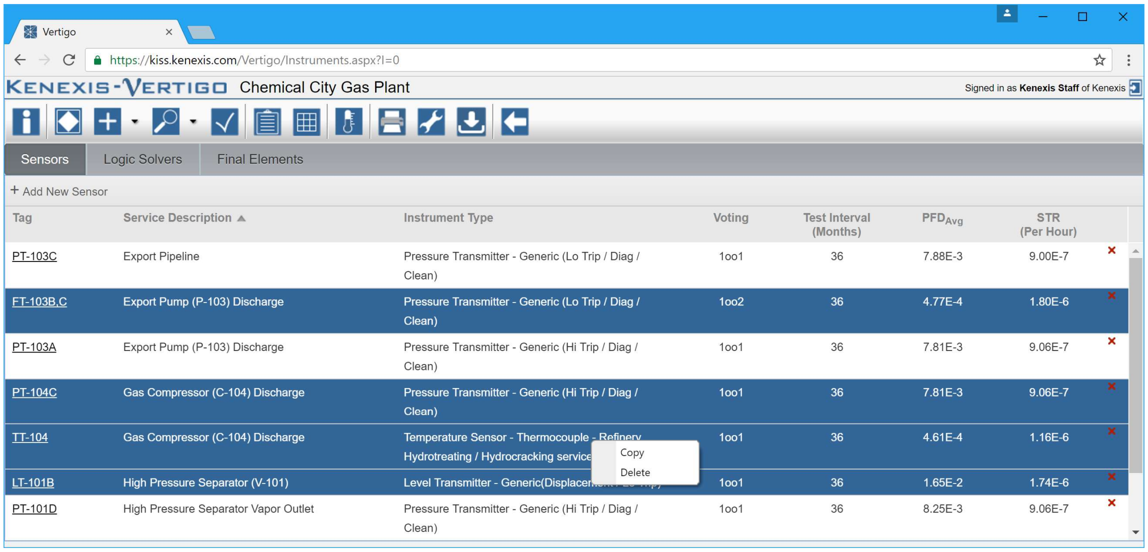
The grid header context menu is accessed by right-click on the header for the desired field as shown below for the "Instrument Type" field.



Tag	Service Description ▲	Instru	Voting	Test Interval (Months)	PFD$_{Avg}$	STR (Per Hour)
PT-103C	Export Pipeline	Pressu p / Diag / Clean)	1oo1	36	7.88E-3	9.00E-7
FT-103B.C	Export Pump (P-103) Discharge	Pressu p / Diag / Clean)	1oo2	36	4.77E-4	1.80E-6
PT-103A	Export Pump (P-103) Discharge	Pressu p / Diag / Clean)	1oo1	36	7.81E-3	9.06E-7
PT-104C	Gas Compressor (C-104) Discharge	Pressure Transmitter - Generic (Hi Trip / Diag / Clean)	1oo1	36	7.81E-3	9.06E-7
TT-104	Gas Compressor (C-104) Discharge	Temperature Sensor - Thermocouple - Refinery Hydrotreating / Hydrocracking service - (Hi Trip)	1oo1	36	4.61E-4	1.16E-6
LT-101B	High Pressure Separator (V-101)	Level Transmitter - Generic(Displacement / Lo Trip)	1oo1	36	1.65E-2	1.74E-6
PT-101D	High Pressure Separator Vapor Outlet	Pressure Transmitter - Generic (Hi Trip / Diag / Clean)	1oo1	36	8.25E-3	9.06E-7

2.2.3 Grid Row Context Menu

The grid row context menu can be used to quickly copy or delete one of more records from the grid. The grid row context menu is accessed by right-click on any row of the grid. Multiple rows can be selected by holding the [ctrl] or the [shift] key when selecting rows. The selected row(s) are indicated by the blue highlighting as shown below.


Vertigo
https://kiss.kenexis.com/Vertigo/Instruments.aspx?I=0
KENEXIS-VERTIGO Chemical City Gas Plant
Signed in as Kenexis Staff of Kenexis
Sensors
Logic Solvers
Final Elements
+ Add New Sensor
Copy
Delete

Tag	Service Description ▲	Instrument Type	Voting	Test Interval (Months)	PFD_{Avg}	STR (Per Hour)
PT-103C	Export Pipeline	Pressure Transmitter - Generic (Lo Trip / Diag / Clean)	1oo1	36	7.88E-3	9.00E-7
FT-103B,C	Export Pump (P-103) Discharge	Pressure Transmitter - Generic (Lo Trip / Diag / Clean)	1oo2	36	4.77E-4	1.80E-6
PT-103A	Export Pump (P-103) Discharge	Pressure Transmitter - Generic (Hi Trip / Diag / Clean)	1oo1	36	7.81E-3	9.06E-7
PT-104C	Gas Compressor (C-104) Discharge	Pressure Transmitter - Generic (Hi Trip / Diag / Clean)	1oo1	36	7.81E-3	9.06E-7
TT-104	Gas Compressor (C-104) Discharge	Temperature Sensor - Thermocouple - Refinery Hydrotreating / Hydrocracking service	1oo1	36	4.61E-4	1.16E-6
LT-101B	High Pressure Separator (V-101)	Level Transmitter - Generic(Displacement / Lo Trip)	1oo1	36	1.65E-2	1.74E-6
PT-101D	High Pressure Separator Vapor Outlet	Pressure Transmitter - Generic (Hi Trip / Diag / Clean)	1oo1	36	8.25E-3	9.06E-7

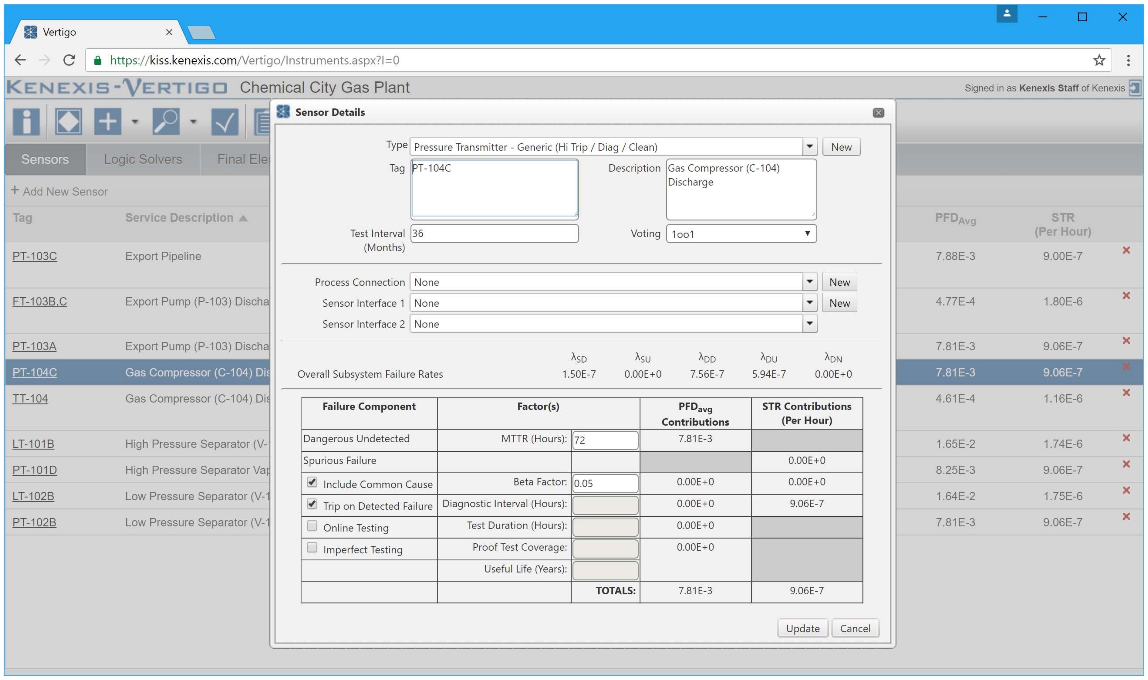
2.3 Working with Details Forms

Nearly all inserting and editing in Vertigo is done from a window called the Details Form. Details Forms are windows that are opened independently. Once a details form is opened it must be closed before returning to work of the page from which the details form was generated. This is referred to a "modal" functionality.

Each object type in Vertigo has one or more details forms to edit the data associated with a single record of that object type. Details forms can be opened in one of three ways.

- From the Navigation Toolbar (described in section 2.1) using the "add" button and selecting the object type to be added.
- From a data grid (described in Section 2.2) by clicking on the "add new" button in the header section of the grid.
- From a data grid (described in Section 2.2) by double-clicking a row or clicking on the link field within that row.

Each details form has a unique set of controls for working with a given object type. The controls for each data form type are described in more details in the *Sections 3-6*. Below is an example of a details form for a Sensor.



Chemical City Gas Plant

Signed in as **Kenexis Staff** of Kenexis

Tag	Service Description ▲	PFD_{Avg}	STR (Per Hour)
PT-103C	Export Pipeline	7.88E-3	9.00E-7
FT-103B,C	Export Pump (P-103) Discha	4.77E-4	1.80E-6
PT-103A	Export Pump (P-103) Discha	7.81E-3	9.06E-7
PT-104C	Gas Compressor (C-104) Dis	7.81E-3	9.06E-7
TT-104	Gas Compressor (C-104) Dis	4.61E-4	1.16E-6
LT-101B	High Pressure Separator (V-	1.65E-2	1.74E-6
PT-101D	High Pressure Separator Vap	8.25E-3	9.06E-7
LT-102B	Low Pressure Separator (V-1	1.64E-2	1.75E-6
PT-102B	Low Pressure Separator (V-1	7.81E-3	9.06E-7

Sensor Details

Type: Pressure Transmitter - Generic (Hi Trip / Diag / Clean)

Tag: PT-104C

Description: Gas Compressor (C-104) Discharge

Test Interval (Months): 36

Voting: 1oo1

Process Connection: None

Sensor Interface 1: None

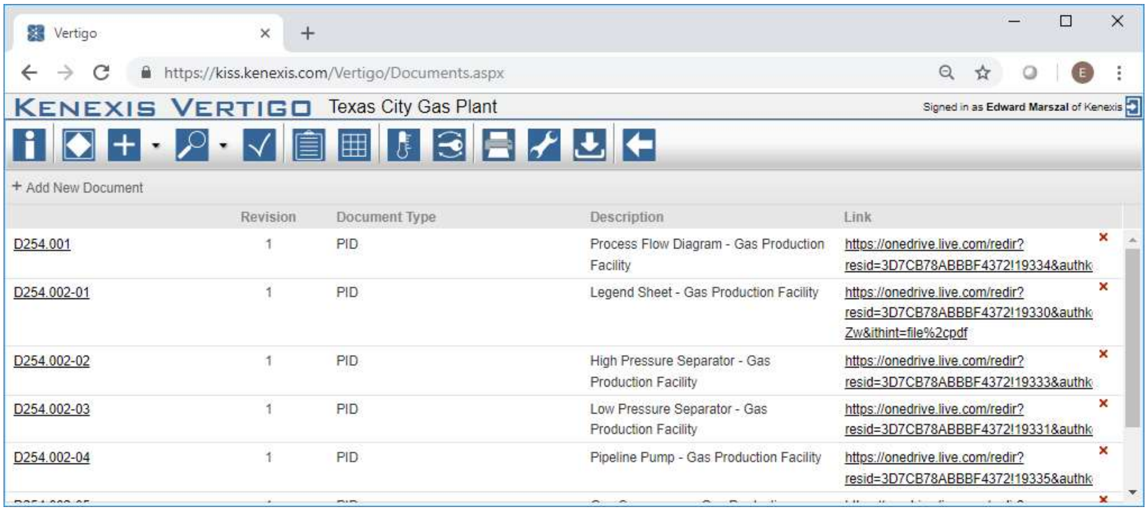
Sensor Interface 2: None

	λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	λ_{DN}
Overall Subsystem Failure Rates	1.50E-7	0.00E+0	7.56E-7	5.94E-7	0.00E+0

Failure Component	Factor(s)		PFD_{avg} Contributions	STR Contributions (Per Hour)
Dangerous Undetected	MTTR (Hours):	72	7.81E-3	
Spurious Failure				0.00E+0
☑ Include Common Cause	Beta Factor:	0.05	0.00E+0	0.00E+0
☑ Trip on Detected Failure	Diagnostic Interval (Hours):		0.00E+0	9.06E-7
□ Online Testing	Test Duration (Hours):		0.00E+0	
□ Imperfect Testing	Proof Test Coverage:		0.00E+0	
	Useful Life (Years):			
		TOTALS:	7.81E-3	9.06E-7

2.4 The Document List

SIS design studies refer to numerous documents including piping and instrumentation diagrams, equipment specifications, safety manuals, and test procedures. Vertigo provides a compact and elegant way to track all these items without unnecessary duplication of data. In several places in Vertigo the user will be prompted to enter information about reference document. This document will be a selection from the document list instead of a direct text entry.

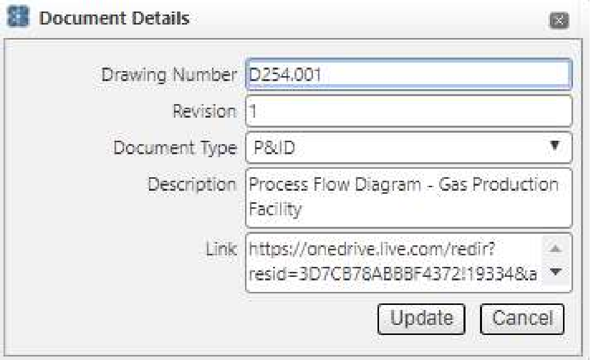


Texas City Gas Plant

Signed in as **Edward Marszal** of Kenexis

	Revision	Document Type	Description	Link
D254.001	1	PID	Process Flow Diagram - Gas Production Facility	https://onedrive.live.com/redir?resid=3D7CB78ABBBF4372!19334&authk
D254.002-01	1	PID	Legend Sheet - Gas Production Facility	https://onedrive.live.com/redir?resid=3D7CB78ABBBF4372!19330&authk Zw&ithint=file%2cpdf
D254.002-02	1	PID	High Pressure Separator - Gas Production Facility	https://onedrive.live.com/redir?resid=3D7CB78ABBBF4372!19333&authk
D254.002-03	1	PID	Low Pressure Separator - Gas Production Facility	https://onedrive.live.com/redir?resid=3D7CB78ABBBF4372!19331&authk
D254.002-04	1	PID	Pipeline Pump - Gas Production Facility	https://onedrive.live.com/redir?resid=3D7CB78ABBBF4372!19335&authk

The document list can be accessed by clicking on the View button in the Navigation Bar and Selecting “Documents” from the drop-down list. The document list contains relevant information about a document include its title, revision number, document type, description, and associated hyper-link. KISS was not designed or envisioned to be a document management system, most operating companies already have dedicated document management systems that are employed for a variety of purposes including storing process safety information. In order to avoid unnecessary duplication of document while still allowing ease of access, the document record contains a hyperlink. This hyper-link is designed to allow access to the document, from the external document management system, with a single mouse click



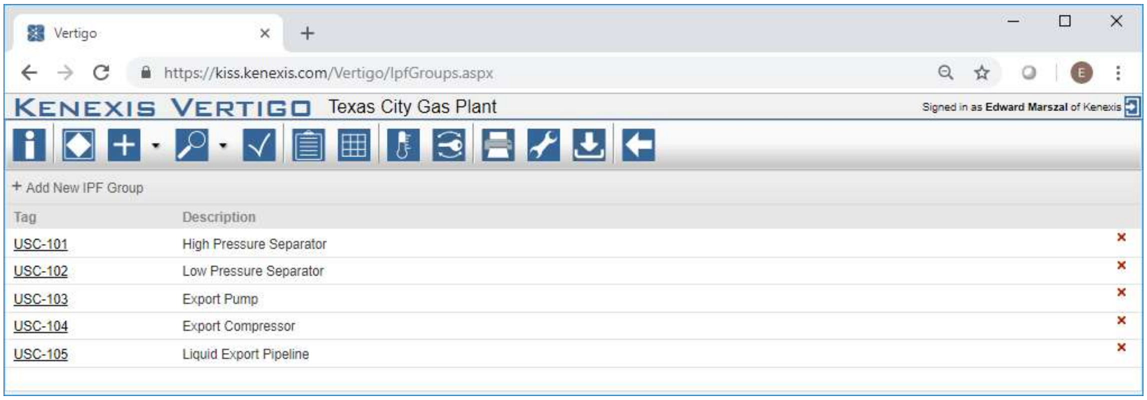
Drawing Number: D254.001
Revision: 1
Document Type: P&ID
Description: Process Flow Diagram - Gas Production Facility
Link: https://onedrive.live.com/redir?resid=3D7CB78ABBBF4372!19334&a

Each document is described using the document details dialog. The dialog allows input of the drawing number (or document number, or short description). The dialog also allows entry of the revision number that was utilized for SIS design purposes, along with a description of the document. The document type is a drop-down selection allowing the user to choose from one of several document types that are used for filtering in other portions of the application. The link field contain the hyperlink that when clicked will cause the document to be generated in the web browser by the document management system that contains the document.

2.5 The IPF List

Often, individual instruments that comprise an SIS are grouped together into collections that are wider than just a single SIF. Grouping related instruments together facilitates design, programming, maintenance, and testing of the equipment along with allowing for easier understanding of the system and documentation. Depending on user preferences, equipment can be grouped by process plant, process area, major equipment item, or sometimes not grouped at all.

In Vertigo, the mechanism for grouping instruments together is called the IPF Group. IPF Groups are listed on the IPG Groups page and input and edited on the IPF Group Details page.



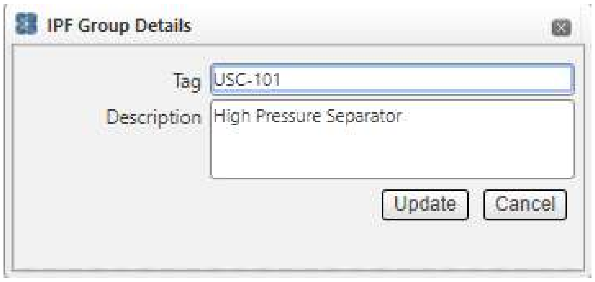
Vertigo
https://kiss.kenexis.com/Vertigo/IpfGroups.aspx
KENEXIS VERTIGO
Signed in as Edward Marszal of Kenexis

Texas City Gas Plant

+ Add New IPF Group

Tag	Description	
USC-101	High Pressure Separator	×
USC-102	Low Pressure Separator	×
USC-103	Export Pump	×
USC-104	Export Compressor	×
USC-105	Liquid Export Pipeline	×

Each IPF Groups simply contains two items, a Tag or short description, and then a longer complete description. Once the IPF Groups are defined they will be used for grouping and filtering of equipment in other areas of the Vertigo Application.



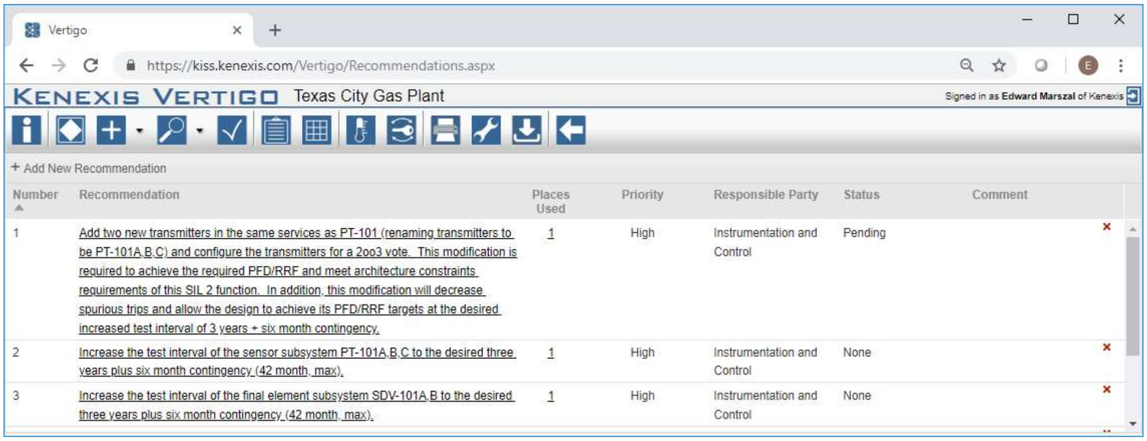
IPF Group Details

Tag: USC-101

Description: High Pressure Separator

2.6 The Recommendations List

SIS design studies have numerous recommendations for modification of the design of the plant, equipment used for the SIF, and maintenance and testing. These recommendations are usually generated because a SIF, as proposed, is not capable of achieving its assigned performed target. Since recommendations are specific to SIF and their associated equipment items the Vertigo database tracks recommendations against specific SIF, if possible. When the SIF details page for any SIF is displayed, clicking on the Recommendations tab will generate a view of the recommendations that are associated with that SIF, but filters out all the other recommendations to avoid confusion. In some cases a Vertigo user will want to see a comprehensive list of recommendations, regardless of their association with any particular SIF, and also recommendations that are general in nature and not associated with any SIF at all. This view of recommendations can be obtained by viewing the Recommendations List.

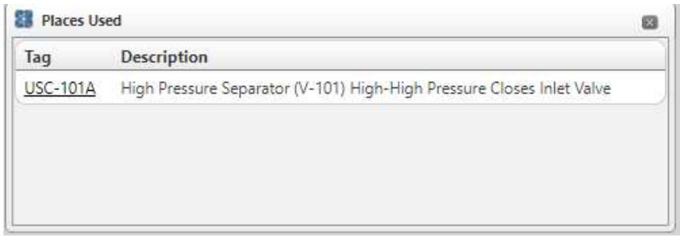

Vertigo
https://kiss.kenexis.com/Vertigo/Recommendations.aspx
KENEXIS VERTIGO
Signed in as Edward Marszal of Kenexis

Texas City Gas Plant

+ Add New Recommendation

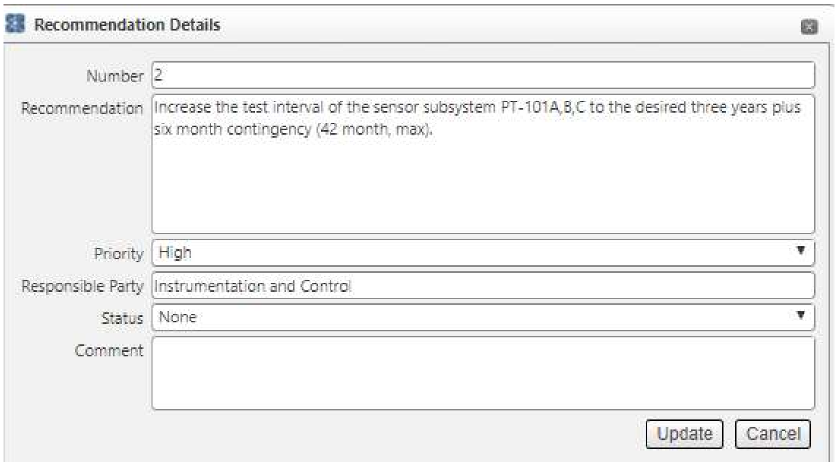
Number	Recommendation	Places Used	Priority	Responsible Party	Status	Comment
1	Add two new transmitters in the same services as PT-101 (renaming transmitters to be PT-101A,B,C) and configure the transmitters for a 2oo3 vote. This modification is required to achieve the required PFD/RRF and meet architecture constraints requirements of this SIL 2 function. In addition, this modification will decrease spurious trips and allow the design to achieve its PFD/RRF targets at the desired increased test interval of 3 years + six month contingency.	1	High	Instrumentation and Control	Pending	
2	Increase the test interval of the sensor subsystem PT-101A,B,C to the desired three years plus six month contingency (42 month, max).	1	High	Instrumentation and Control	None	
3	Increase the test interval of the final element subsystem SDV-101A,B to the desired three years plus six month contingency (42 month, max).	1	High	Instrumentation and Control	None	

The recommendations page can be viewed by clicking on the View button on the navigation bar and then clicking on Recommendations. The recommendation list will show all the recommendations in the study, regardless of association. The list includes the recommendation number, recommendation text, places used, and prioritization and assignment information. The Places Used row shows how many different SIF include the recommendation. Clicking on the number in the places used column of a recommendation record will pop up the Placed Used dialog box which will provide a list of the SIF that use the recommendation along with a link to navigate to the IPF details page for that SIF.



Tag	Description
USC-101A	High Pressure Separator (V-101) High-High Pressure Closes Inlet Valve

Double clicking on a recommendation will bring up the recommendation details page. This page allows for editing of recommendation text, numbering, priority, status, responsible party, and comments related to the recommendation.



Number: 2

Recommendation: Increase the test interval of the sensor subsystem PT-101A,B,C to the desired three years plus six month contingency (42 month, max).

Priority: High

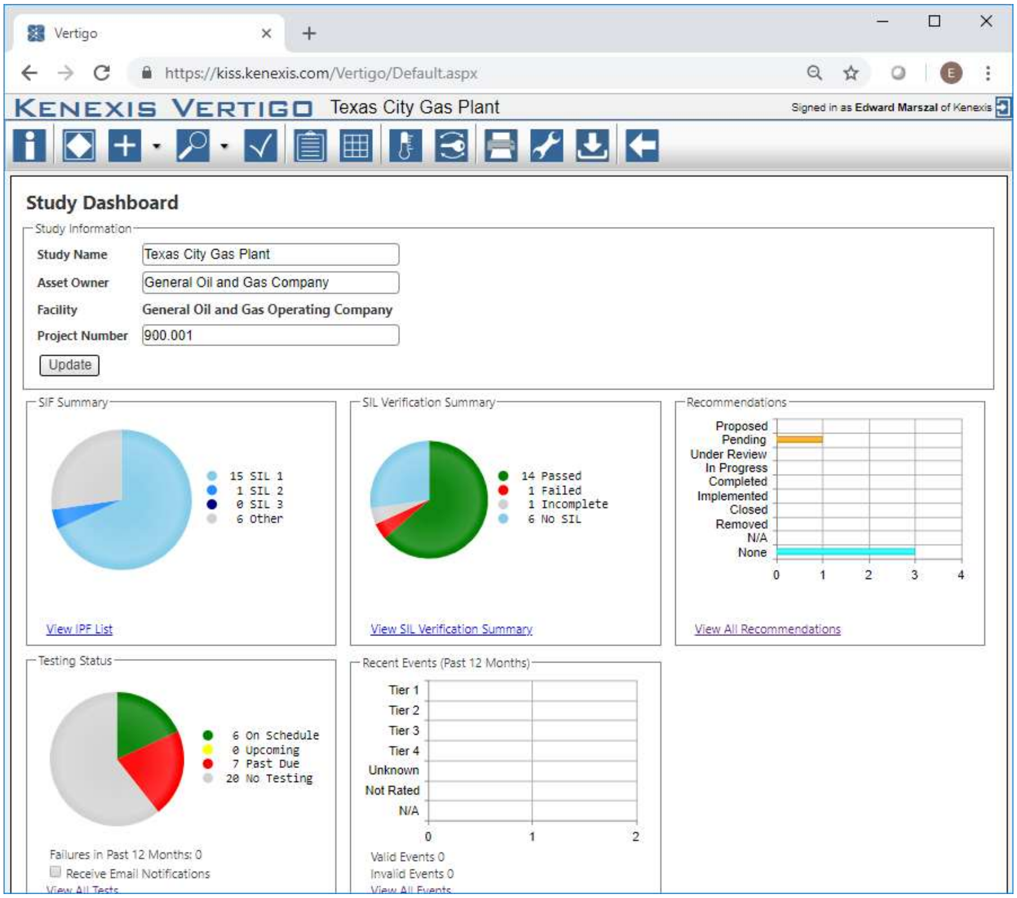
Responsible Party: Instrumentation and Control

Status: None

Comment:

2.6 Overview – Dashboard

The overview page, or "dashboard", provides an overview of all the information contained in each study. The overview page contains a Study Information section to allow editing of identification information for the study.



Study Dashboard

Study Information

Study Name: Texas City Gas Plant

Asset Owner: General Oil and Gas Company

Facility: General Oil and Gas Operating Company

Project Number: 900.001

Failures in Past 12 Months: 0

□ Receive Email Notifications

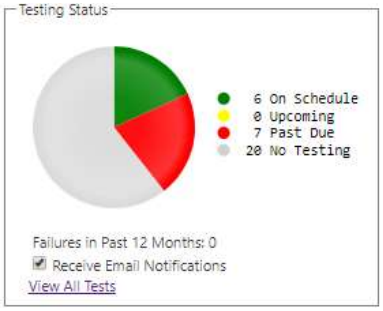
Valid Events 0

Invalid Events 0

Section 2 - Interface

In addition to the Study Information, the dashboard contains several pie and bar charts that summarize the content and status of the study. The first is a pie chart that provides an inventory of the SIF, including breakdown by SIL target. This section also gives a link to the IPF list. The second item is a pie chart the summarizes the status of SIL verification, listing the inventory of SIF that have achieved their SIL target design, those that have not, those whose design is incomplete, and those that do not have SIL targets at all. The section also includes a link to the SIL verification summary page. The third section is a bar chart indicating the number of recommendations contained in the study along with their implementation status.

The fourth item is the testing status pie chart. This chart provides an inventory of all SIS equipment broken down by testing status. Items in green are in compliance with their testing requirements, yellow items are due for testing soon, and gray items have not had testing requirements set for them. This section also shows an inventory of how many SIS items have failed function testing in the last twelve months. Finally, this section includes a check box to receive e-mail notifications about testing status – i.e., tests that are due shortly and tests that are past due. Simply checking the box is all the information that the system needs because it knows who the user is and when the tests are due.



Failures in Past 12 Months: 0

☑ Receive Email Notifications

The last item is the recent events bar chart that summarizes all of the events, or activations, of SIF that have occurred over the last 12 month period.

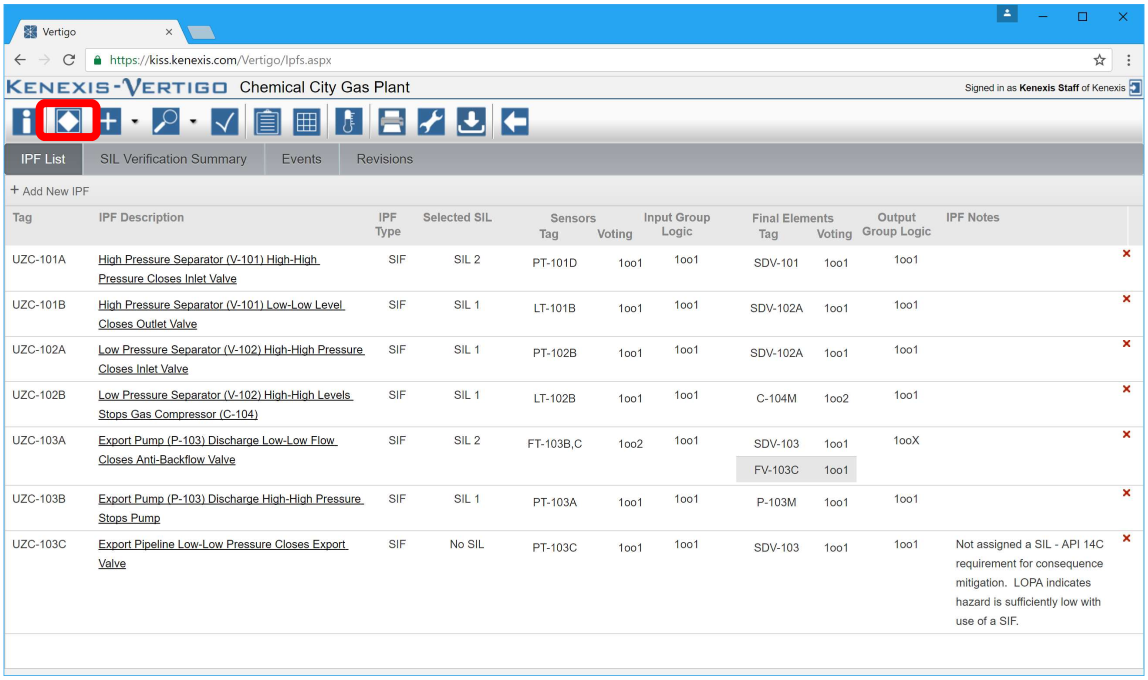
Section 3 – SIL Verification

3.1 SIL Verification Introduction

SIL Verification is a method for evaluating the conceptual design of a Safety Instrumented Function (SIF). SIL Verification is a required step of the SIS Lifecycle as defined by ISA 84.00.01 and IEC 61511.

3.2 The IPF List

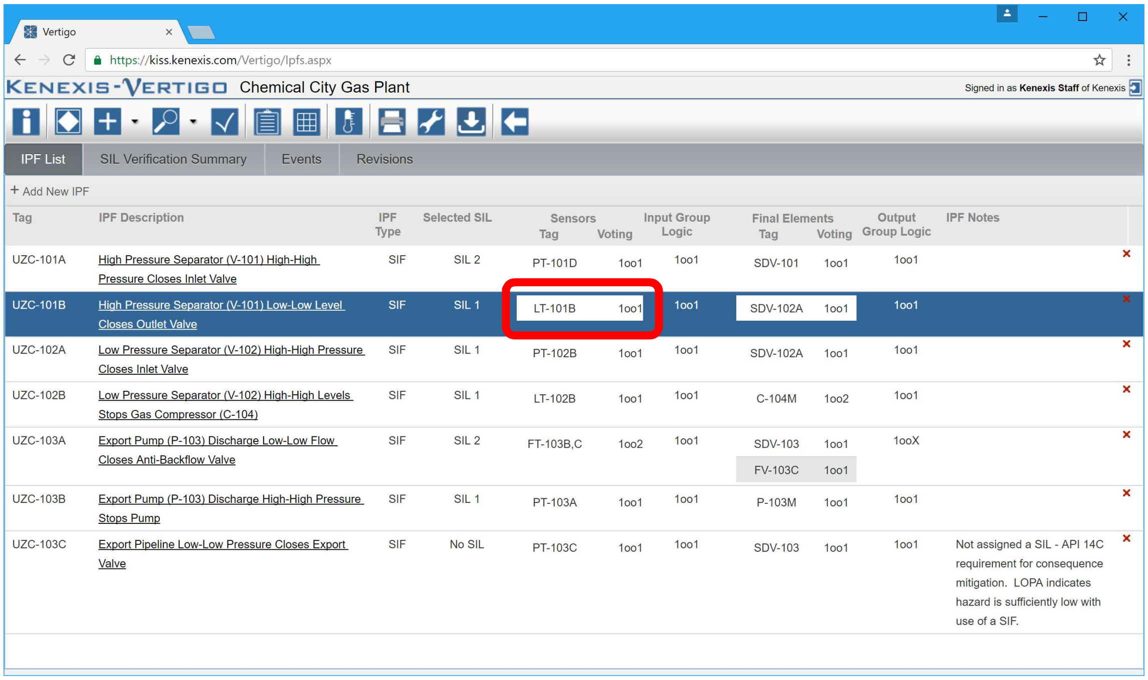
In Vertigo, the primary interface for performing SIL Verification is the “IPF List” page which can be accessed by clicking the IPF button on the main action ribbon.



Tag	IPF Description	IPF Type	Selected SIL	Sensors Tag	Sensors Voting	Input Group Logic	Final Elements Tag	Final Elements Voting	Output Group Logic	IPF Notes
UZC-101A	High Pressure Separator (V-101) High-High Pressure Closes Inlet Valve	SIF	SIL 2	PT-101D	1oo1	1oo1	SDV-101	1oo1	1oo1	
UZC-101B	High Pressure Separator (V-101) Low-Low Level Closes Outlet Valve	SIF	SIL 1	LT-101B	1oo1	1oo1	SDV-102A	1oo1	1oo1	
UZC-102A	Low Pressure Separator (V-102) High-High Pressure Closes Inlet Valve	SIF	SIL 1	PT-102B	1oo1	1oo1	SDV-102A	1oo1	1oo1	
UZC-102B	Low Pressure Separator (V-102) High-High Levels Stops Gas Compressor (C-104)	SIF	SIL 1	LT-102B	1oo1	1oo1	C-104M	1oo2	1oo1	
UZC-103A	Export Pump (P-103) Discharge Low-Low Flow Closes Anti-Backflow Valve	SIF	SIL 2	FT-103B,C	1oo2	1oo1	SDV-103 FV-103C	1oo1 1oo1	1ooX	
UZC-103B	Export Pump (P-103) Discharge High-High Pressure Stops Pump	SIF	SIL 1	PT-103A	1oo1	1oo1	P-103M	1oo1	1oo1	
UZC-103C	Export Pipeline Low-Low Pressure Closes Export Valve	SIF	No SIL	PT-103C	1oo1	1oo1	SDV-103	1oo1	1oo1	Not assigned a SIL - API 14C requirement for consequence mitigation. LOPA indicates hazard is sufficiently low with use of a SIF.

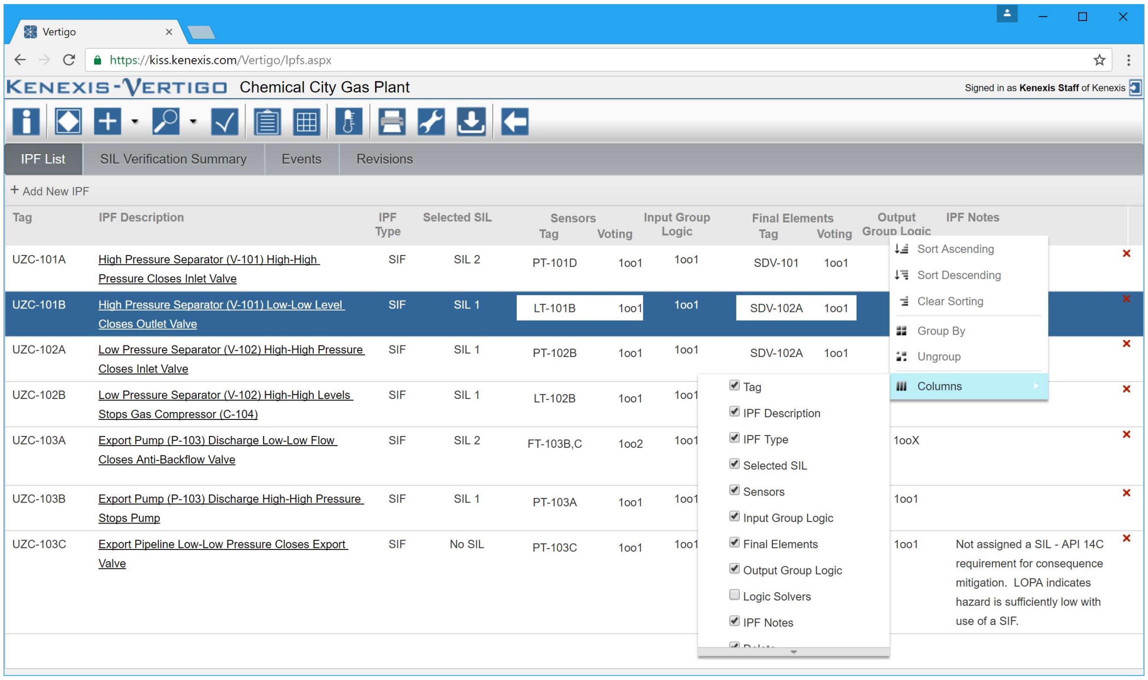
The IPF List provides a list of all Instrumented Protective Functions (IPF’s) defined in a Vertigo study along with the Selected SIL and associated Sensors and Final Elements for that IPF. Details Forms IPF’s, Sensors or Final Elements can be accessed directly from the IPF list. For IPF’s the details form can be accessed using the methods described in Section 2. For Sensors or Final Elements, the details form can be accessed via a double-click on the element tag. For example, clicking in the white space around LT-101B in the figure below will access the details form for LT-101B).

Section 3 – SIL Verification


Vertigo
https://kiss.kenexis.com/Vertigo/Ipfs.aspx
KENEXIS-VERTIGO Chemical City Gas Plant
Signed in as Kenexis Staff of Kenexis
IPF List
SIL Verification Summary
Events
Revisions
+ Add New IPF

Tag	IPF Description	IPF Type	Selected SIL	Sensors Tag	Sensors Voting	Input Group Logic	Final Elements Tag	Final Elements Voting	Output Group Logic	IPF Notes
UZC-101A	High Pressure Separator (V-101) High-High Pressure Closes Inlet Valve	SIF	SIL 2	PT-101D	1oo1	1oo1	SDV-101	1oo1	1oo1	
UZC-101B	High Pressure Separator (V-101) Low-Low Level Closes Outlet Valve	SIF	SIL 1	LT-101B	1oo1	1oo1	SDV-102A	1oo1	1oo1	
UZC-102A	Low Pressure Separator (V-102) High-High Pressure Closes Inlet Valve	SIF	SIL 1	PT-102B	1oo1	1oo1	SDV-102A	1oo1	1oo1	
UZC-102B	Low Pressure Separator (V-102) High-High Levels Stops Gas Compressor (C-104)	SIF	SIL 1	LT-102B	1oo1	1oo1	C-104M	1oo2	1oo1	
UZC-103A	Export Pump (P-103) Discharge Low-Low Flow Closes Anti-Backflow Valve	SIF	SIL 2	FT-103B,C	1oo2	1oo1	SDV-103 FV-103C	1oo1 1oo1	1ooX	
UZC-103B	Export Pump (P-103) Discharge High-High Pressure Stops Pump	SIF	SIL 1	PT-103A	1oo1	1oo1	P-103M	1oo1	1oo1	
UZC-103C	Export Pipeline Low-Low Pressure Closes Export Valve	SIF	No SIL	PT-103C	1oo1	1oo1	SDV-103	1oo1	1oo1	Not assigned a SIL - API 14C requirement for consequence mitigation. LOPA indicates hazard is sufficiently low with use of a SIF.

In addition, logic solvers associated with an IPF can be shown on the IPF list by utilizing the “columns” dropdown in the grid header context menu (described in Section 2).

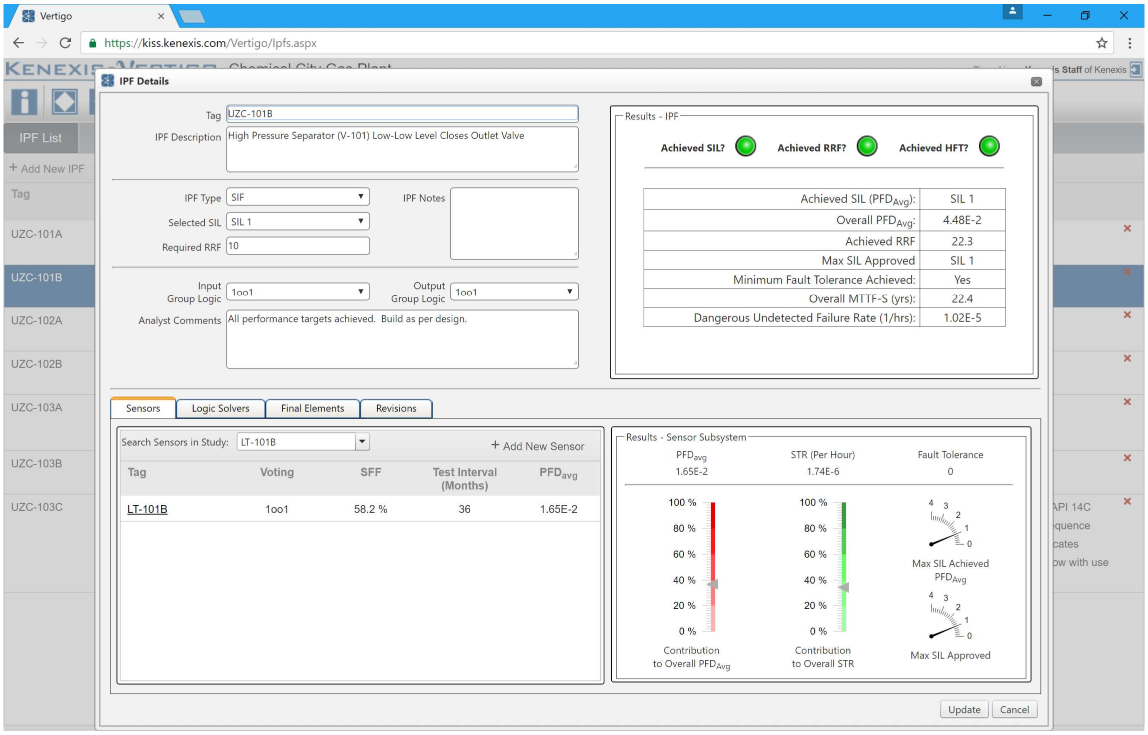


Tag	IPF Description	IPF Type	Selected SIL	Sensors Tag	Sensors Voting	Input Group Logic	Final Elements Tag	Final Elements Voting	Output Group Logic	IPF Notes
UZC-101A	High Pressure Separator (V-101) High-High Pressure Closes Inlet Valve	SIF	SIL 2	PT-101D	1oo1	1oo1	SDV-101	1oo1		
UZC-101B	High Pressure Separator (V-101) Low-Low Level Closes Outlet Valve	SIF	SIL 1	LT-101B	1oo1	1oo1	SDV-102A	1oo1		
UZC-102A	Low Pressure Separator (V-102) High-High Pressure Closes Inlet Valve	SIF	SIL 1	PT-102B	1oo1	1oo1	SDV-102A	1oo1		
UZC-102B	Low Pressure Separator (V-102) High-High Levels Stops Gas Compressor (C-104)	SIF	SIL 1	LT-102B	1oo1	1oo1				
UZC-103A	Export Pump (P-103) Discharge Low-Low Flow Closes Anti-Backflow Valve	SIF	SIL 2	FT-103B,C	1oo2	1oo1			1ooX	
UZC-103B	Export Pump (P-103) Discharge High-High Pressure Stops Pump	SIF	SIL 1	PT-103A	1oo1	1oo1			1oo1	
UZC-103C	Export Pipeline Low-Low Pressure Closes Export Valve	SIF	No SIL	PT-103C	1oo1	1oo1			1oo1	Not assigned a SIL - API 14C requirement for consequence mitigation. LOPA indicates hazard is sufficiently low with use of a SIF.

Section 3 – SIL Verification

3.3 The IPF Details Form

The IPF details form is used to perform a SIL Verification calculation on a single IPF. This form allows you to specify the Selected SIL and RRF target and all associated I/O with their respective voting configurations. The IPF details form is one of the most versatile forms in Vertigo and allows data to be entered and manipulated in many ways. For more specifics on the functionality and features available on the IPF details form, see the tutorials section of the manual for the “Performing a SIL Verification Calculation” tutorial.



Tag: UZC-101B

IPF Description: High Pressure Separator (V-101) Low-Low Level Closes Outlet Valve

IPF Type: SIF

Selected SIL: SIL 1

Required RRF: 10

IPF Notes:

Input Group Logic: 1oo1

Output Group Logic: 1oo1

Analyst Comments: All performance targets achieved. Build as per design.

Results - IPF

Achieved SIL? ● Achieved RRF? ● Achieved HFT? ●

Achieved SIL (PFD_{Avg}):	SIL 1
Overall PFD_{Avg}:	4.48E-2
Achieved RRF	22.3
Max SIL Approved	SIL 1
Minimum Fault Tolerance Achieved:	Yes
Overall MTTF-S (yrs):	22.4
Dangerous Undetected Failure Rate (1/hrs):	1.02E-5

Search Sensors in Study: LT-101B

Tag	Voting	SFF	Test Interval (Months)	PFD_{avg}
LT-101B	1oo1	58.2 %	36	1.65E-2

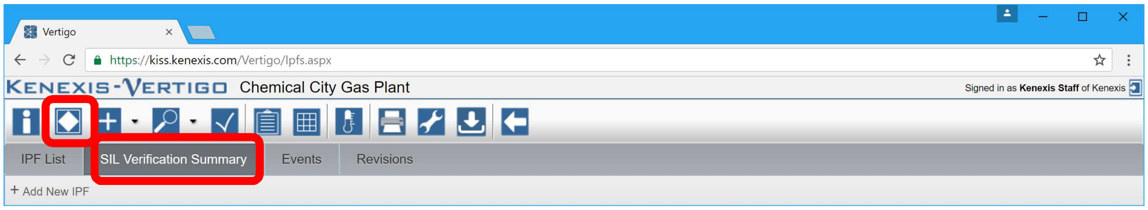
Results - Sensor Subsystem

PFD_{avg}	STR (Per Hour)	Fault Tolerance
1.65E-2	1.74E-6	0

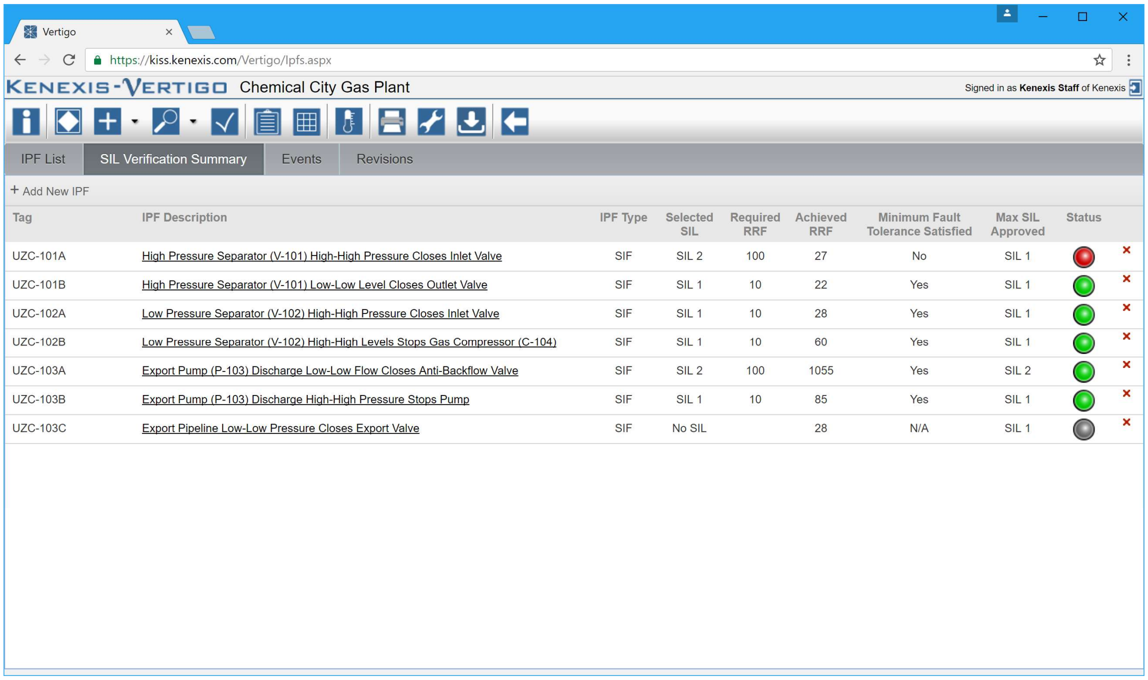
3.4 The SIL Verification Summary

The SIL Verification summary grid provides the results of SIL Verification calculations for all IPF’s in a Vertigo study in a single grid. The SIL Verification Summary is access by clicking the IPF button in the main action ribbon, then clicking the SIL Verification Summary tab.

Section 3 – SIL Verification



This grid does not detail all the calculation results however; it provides a dashboard for confirming that all Safety Instrumented Functions are achieving the Selected SIL targets in accordance with ISA 84.00.01 and IEC 61511. The status of each SIL Verification Calculation is provided on the far-right side of the grid with a light denoting the state of the calculation. If the light is green, but the Selected SIL target and RRG target are being achieved. If the light red, one or more targets are not being achieved. A grey light indicates that no targets have been specified for the associated IPF. The SIL Verification Summary grid is shown below.

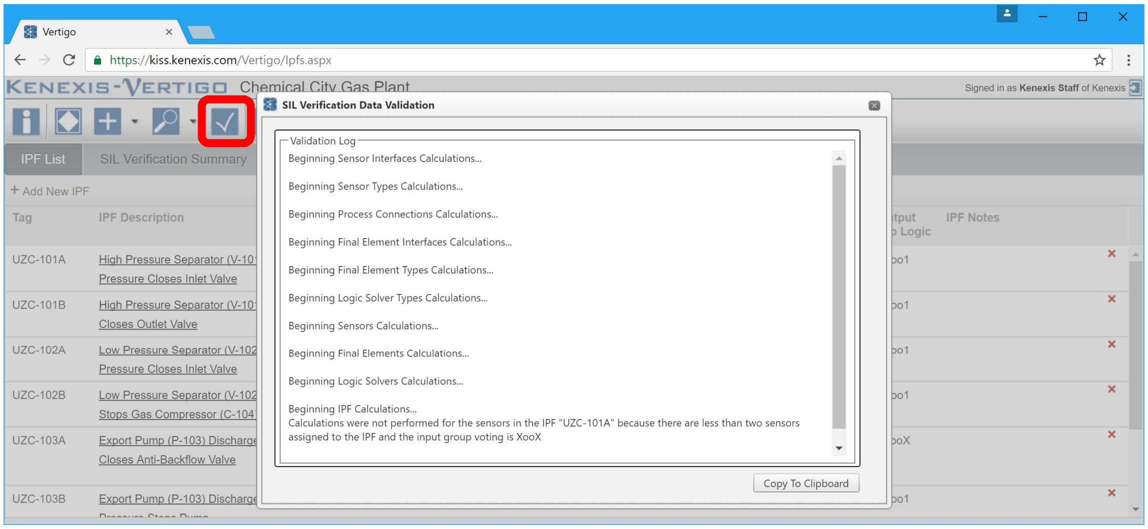


Tag	IPF Description	IPF Type	Selected SIL	Required RRF	Achieved RRF	Minimum Fault Tolerance Satisfied	Max SIL Approved	Status	
UZC-101A	High Pressure Separator (V-101) High-High Pressure Closes Inlet Valve	SIF	SIL 2	100	27	No	SIL 1	🔴	×
UZC-101B	High Pressure Separator (V-101) Low-Low Level Closes Outlet Valve	SIF	SIL 1	10	22	Yes	SIL 1	🟢	×
UZC-102A	Low Pressure Separator (V-102) High-High Pressure Closes Inlet Valve	SIF	SIL 1	10	28	Yes	SIL 1	🟢	×
UZC-102B	Low Pressure Separator (V-102) High-High Levels Stops Gas Compressor (C-104)	SIF	SIL 1	10	60	Yes	SIL 1	🟢	×
UZC-103A	Export Pump (P-103) Discharge Low-Low Flow Closes Anti-Backflow Valve	SIF	SIL 2	100	1055	Yes	SIL 2	🟢	×
UZC-103B	Export Pump (P-103) Discharge High-High Pressure Stops Pump	SIF	SIL 1	10	85	Yes	SIL 1	🟢	×
UZC-103C	Export Pipeline Low-Low Pressure Closes Export Valve	SIF	No SIL		28	N/A	SIL 1	⚪	×

3.5 The SIL Verification Validation Log

The SIL Verification Validation Log provides a check against the data input into Vertigo which is used in SIL Verification Calculations. Normally, SIL Verification Calculations in Vertigo are performed transparently, when data is entered or changes, all necessary calculations are performed without an explicit request from the user. If data is missing or invalid, calculations will not be performed until valid data is provided. While this methodology is very efficient for a productivity standpoint, it can sometimes be challenging to locate the reason a calculation is not being performed.

The SIL Verification Log provided method for you to request that all calculations be performed and that feedback be provided on the validity of the data used in the calculations. The SIL Verification Log is access through the validate button on the main action ribbon. Below is a sample SIL Verification Validation Log.


Vertigo
https://kiss.kenexis.com/Vertigo/Ipfs.aspx
KENEXIS-VERTIGO
Chemical City Gas Plant
Signed in as Kenexis Staff of Kenexis
IPF List
SIL Verification Summary
+ Add New IPF
Tag
IPF Description
tput
Logic
IPF Notes
UZC-101A
High Pressure Separator (V-101
Pressure Closes Inlet Valve
UZC-101B
High Pressure Separator (V-101
Closes Outlet Valve
UZC-102A
Low Pressure Separator (V-102
Pressure Closes Inlet Valve
UZC-102B
Low Pressure Separator (V-102
Stops Gas Compressor (C-104)
UZC-103A
Export Pump (P-103) Discharge
Closes Anti-Backflow Valve
UZC-103B
Export Pump (P-103) Discharge
SIL Verification Data Validation
Validation Log
Copy To Clipboard

```
Beginning Sensor Interfaces Calculations...

Beginning Sensor Types Calculations...

Beginning Process Connections Calculations...

Beginning Final Element Interfaces Calculations...

Beginning Final Element Types Calculations...

Beginning Logic Solver Types Calculations...

Beginning Sensors Calculations...

Beginning Final Elements Calculations...

Beginning Logic Solvers Calculations...

Beginning IPF Calculations...
Calculations were not performed for the sensors in the IPF "UZC-101A" because there are less than two sensors
assigned to the IPF and the input group voting is XooX
```

NOTE: The SIL Verification Data Validation Log is **NOT** a validation of your SIL Verification Calculations as defined by ISA 84.00.01 and IEC 61511 SIS Lifecycle. The validation log provides a means to verify that calculations completed successfully and that all data entering is within appropriate ranges. Confirmation that calculations completed successfully from the data validation log does not ensure the accuracy of your calculations in any way. It is the responsibility of the user to ensure that appropriate failure rate data is being applied and the SIL Verification Calculations are modeling the system correctly.

3.6 Working with Failure Rate Data

Definition of failure rate data is necessary to accomplish SIL Verification. In Vertigo, failure rates are applied to the following items.

- Process Connections
- Sensor Types
- Sensor Interfaces
- Logic Solver Types

- Final Element Interfaces
- Final Element Types

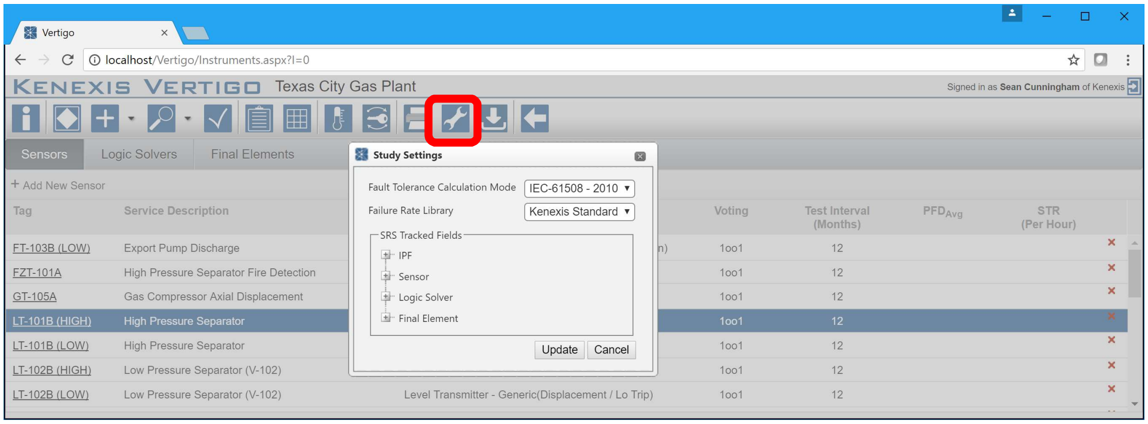
Each of the items listed above represent a placeholder for theoretical failure rate data associated with a specific device type. This theoretical failure rate data is then applied to one or more devices (sensors, logic solvers or final elements).

For example, suppose a pressure transmitter of the same make and model is used throughout a facility. Let's call it an ACME P1 pressure transmitter. A single "sensor type" can be defined for the ACME P1 transmitter where the failure rate data for the ACME P1 resides. Then this failure rate data can be applied to one or more "sensors", which are real-world tagged devices. This methodology reduces the duplication of failure rate data for each sensor, logic solver or final element.

Failure rate data can either be obtains from a library which is accessible from any Vertigo study. Or can be created within a single study. By default, all Vertigo Studies have access to a library entitled "Kenexis Standard". The Kenexis Standard library contains failure rate data for many common devices and is made available to all Vertigo users as part of the Vertigo license agreement. You do not have the ability to modify the Kenexis Standard Library however, it is regularly maintained by Kenexis Engineers and updated frequently with current industry data.

In addition to the Kenexis Standard Library you also have the capability to create your own custom library, which can be accessed from Vertigo.

The library used by a Vertigo study can changed in the Study Settings Form shown below.



Texas City Gas Plant

Study Settings

Fault Tolerance Calculation Mode: IEC-61508 - 2010

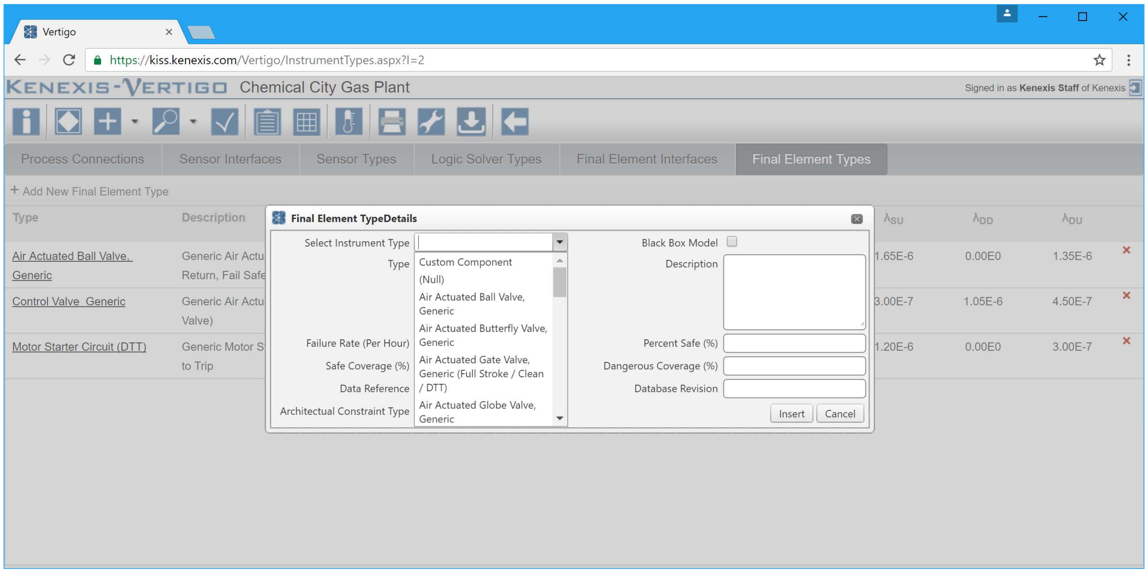
Failure Rate Library: Kenexis Standard

SRS Tracked Fields
- IPF
- Sensor
- Logic Solver
- Final Element

Tag	Service Description		Voting	Test Interval (Months)	PFD_{Avg}	STR (Per Hour)
FT-103B (LOW)	Export Pump Discharge	n)	1oo1	12		
FZT-101A	High Pressure Separator Fire Detection		1oo1	12		
GT-105A	Gas Compressor Axial Displacement		1oo1	12		
LT-101B (HIGH)	High Pressure Separator		1oo1	12		
LT-101B (LOW)	High Pressure Separator		1oo1	12		
LT-102B (HIGH)	Low Pressure Separator (V-102)		1oo1	12		
LT-102B (LOW)	Low Pressure Separator (V-102)	Level Transmitter - Generic(Displacement / Lo Trip)	1oo1	12		

Section 3 – SIL Verification

To apply a failure rate from a library, open the details form for a process connection, sensor type, sensor interface, logic solver, final element interface or final element. These forms can be opened using any of the methods described in Section 2 for opening a details form. In these forms, the first input field labeled “Select Instrument Type” is provided with a dropdown menu which will display all library items available for selection. This list can be filtered by typing into the Select Instrument Type textbox.



Vertigo
https://kiss.kenexis.com/Vertigo/InstrumentTypes.aspx?I=2
KENEXIS-VERTIGO
Signed in as Kenexis Staff of Kenexis
Process Connections
Sensor Interfaces
Sensor Types
Logic Solver Types
Final Element Interfaces
Final Element Types
+ Add New Final Element Type
Final Element TypeDetails
Insert
Cancel

Chemical City Gas Plant

Type	Description	λ_{SU}	λ_{DD}	λ_{DU}
Air Actuated Ball Valve, Generic	Generic Air Actu Return, Fail Safe	1.65E-6	0.00E0	1.35E-6
Control Valve Generic	Generic Air Actu Valve)	3.00E-7	1.05E-6	4.50E-7
Motor Starter Circuit (DTT)	Generic Motor S to Trip	1.20E-6	0.00E0	3.00E-7

Select Instrument Type

Type

- Custom Component
- (Null)
- Air Actuated Ball Valve, Generic
- Air Actuated Butterfly Valve, Generic
- Air Actuated Gate Valve, Generic (Full Stroke / Clean / DTT)
- Air Actuated Globe Valve, Generic

Failure Rate (Per Hour)

Safe Coverage (%)

Data Reference

Architectual Constraint Type

Black Box Model □

Description

Percent Safe (%)

Dangerous Coverage (%)

Database Revision

Selecting an item from the dropdown menu will automatically populate the form with the appropriate data from the library. For library items, this data is not editable.

To create a custom failure rate, specific to your Vertigo study, select “Custom Component” from the Select Instrument Type dropdown. This will populate a blank form which can be edited with the failure rate data you choose.

Additionally, an option is provided on these forms to create a “Black Box Model”, which is used to represent complex systems not easily characterized using the simplified SIL verification equations defined by ISA-TR84.00.02 and used by the Vertigo calculation engine.

3.7 Applying Instrument Types

Instrument types, as described in *Section 3.6* are applied to instruments. Instruments include:

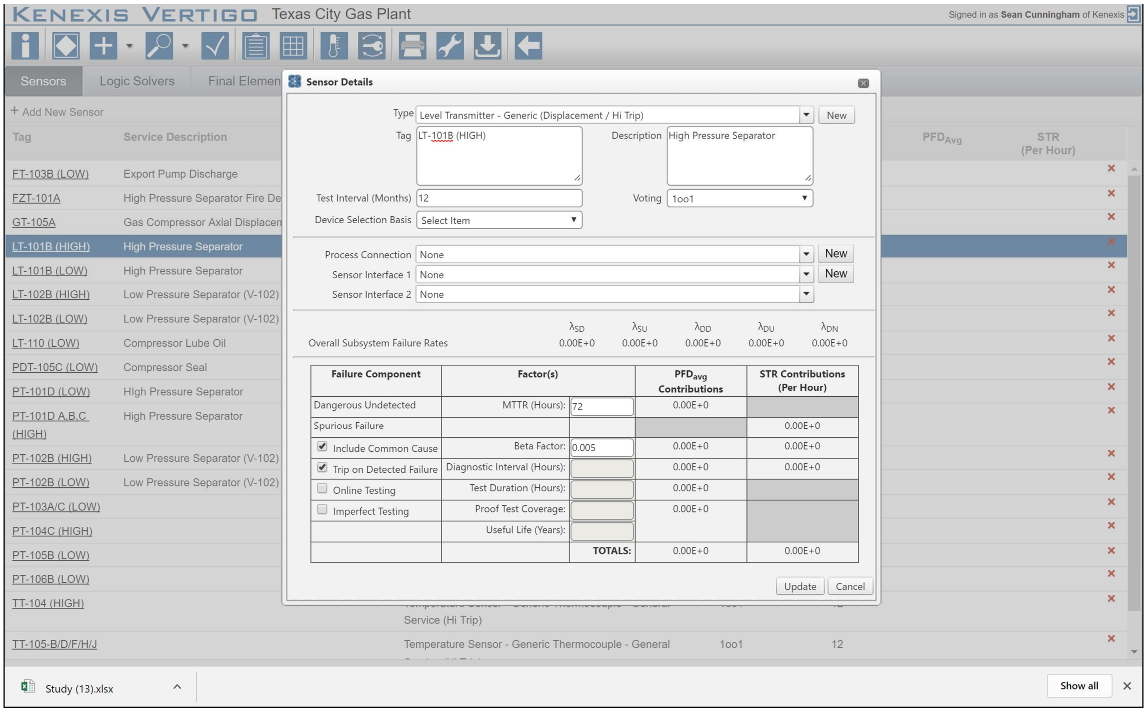
- Sensors

Section 3 – SIL Verification

- Logic Solvers
- Final Elements

The instrument type(s) applied to an instrument will impact the Average Probability of Failure on Demand (PFD$_{avg}$) for that instrument and subsequently the achieved SIL for any SIF's with which that instrument is associated.

Applying an instrument type to an instrument is done through the Sensor, Logic Solver or Final Element details form. These details forms can be accessed by any of the methods described in Section 2, for accessing details forms. The Sensor details form is shown below.



Tag	Service Description
FT-103B (LOW)	Export Pump Discharge
FZT-101A	High Pressure Separator Fire De
GT-105A	Gas Compressor Axial Displacen
LT-101B (HIGH)	High Pressure Separator
LT-101B (LOW)	High Pressure Separator
LT-102B (HIGH)	Low Pressure Separator (V-102)
LT-102B (LOW)	Low Pressure Separator (V-102)
LT-110 (LOW)	Compressor Lube Oil
PDT-105C (LOW)	Compressor Seal
PT-101D (LOW)	HIgh Pressure Separator
PT-101D A,B,C (HIGH)	High Pressure Separator
PT-102B (HIGH)	Low Pressure Separator (V-102)
PT-102B (LOW)	Low Pressure Separator (V-102)
PT-103A/C (LOW)	
PT-104C (HIGH)	
PT-105B (LOW)	
PT-106B (LOW)	
TT-104 (HIGH)	Service (Hi Trip)
TT-105-B/D/F/H/J	Temperature Sensor - Generic Thermocouple - General 1oo1 12

Sensor Details

Type: Level Transmitter - Generic (Displacement / Hi Trip) [New]
Tag: LT-101B (HIGH)
Description: High Pressure Separator
Test Interval (Months): 12
Voting: 1oo1
Device Selection Basis: Select Item

Process Connection: None [New]
Sensor Interface 1: None [New]
Sensor Interface 2: None

	λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	λ_{DN}
Overall Subsystem Failure Rates	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0

Failure Component	Factor(s)		PFD$_{avg}$ Contributions	STR Contributions (Per Hour)
Dangerous Undetected	MTTR (Hours):	72	0.00E+0	
Spurious Failure				0.00E+0
☑ Include Common Cause	Beta Factor:	0.005	0.00E+0	0.00E+0
☑ Trip on Detected Failure	Diagnostic Interval (Hours):		0.00E+0	0.00E+0
☐ Online Testing	Test Duration (Hours):		0.00E+0	
☐ Imperfect Testing	Proof Test Coverage:		0.00E+0	
	Useful Life (Years):			
		TOTALS:	0.00E+0	0.00E+0

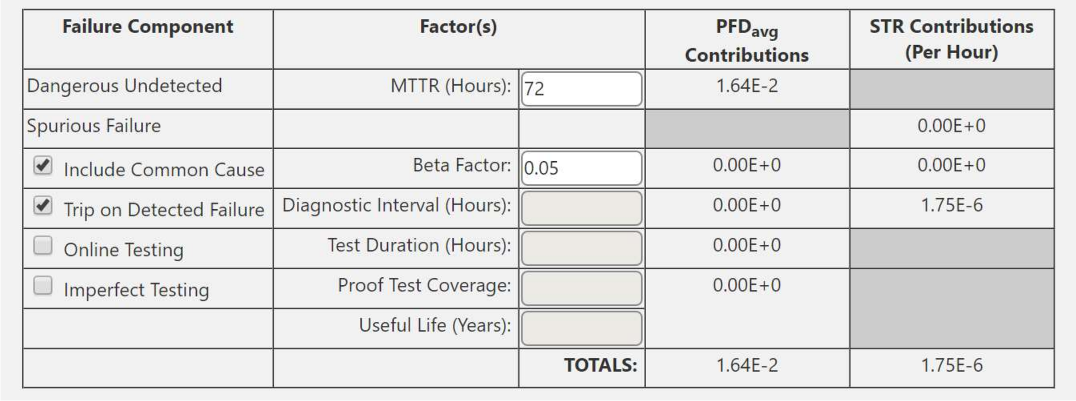
[Update] [Cancel]

To apply an instrument type to an instrument select it from the dropdown list. When a new instrument type is selected the calculations on the form will be automatically updated to display new results utilizing the failure rate data for the instrument type which was selected.

The options in the instrument types dropdown menu's will be limited to instrument types already defined within your Vertigo Study. New instrument types can be defined from the instrument form by clicking the "new" buttons located to the right of all instrument type dropdown menus. This will open a new details form of the instrument type, nested within the instrument details form. Once the new instrument type is added, it will automatically be applied to the instrument after the instrument type form is closed.

3.8 Instrument PFD Contributions

The calculated PFD_{avg} for an instrument depends largely on the instrument type applied to it as well as the testing interval. In addition, there are several functional testing and Logic Solver configuration options which can also effect the PFD_{avg}. Vertigo calculates these contributions separately based on user inputs and displays them in the PFD_{avg} contributions table on the Sensor, Logic Solver and Final Element details forms. The PFD_{avg} contributions table is shown below.



Failure Component	Factor(s)		PFD_{avg} Contributions	STR Contributions (Per Hour)
Dangerous Undetected	MTTR (Hours):	72	1.64E-2	
Spurious Failure				0.00E+0
☑ Include Common Cause	Beta Factor:	0.05	0.00E+0	0.00E+0
☑ Trip on Detected Failure	Diagnostic Interval (Hours):		0.00E+0	1.75E-6
☐ Online Testing	Test Duration (Hours):		0.00E+0	
☐ Imperfect Testing	Proof Test Coverage:		0.00E+0	
	Useful Life (Years):			
		TOTALS:	1.64E-2	1.75E-6

By default, Vertigo will configure the user selected settings to the most commonly used configurations in SIL verification. These configurations are shown in the table above. When a user selected setting is changes the PFD_{avg} and STR contributions will be calculated based on the data you've provided. An overview of each user selected setting follows.

3.8.1 Common Cause Contribution

For non-simplex subsystems (subsystems contains 2 or more elements), common cause contributions can be calculated by checking the "Include Common Cause" checkbox. If a simplex system is defined (i.e. 1oo1 voting is selected), the include common cause checkbox will be disabled.

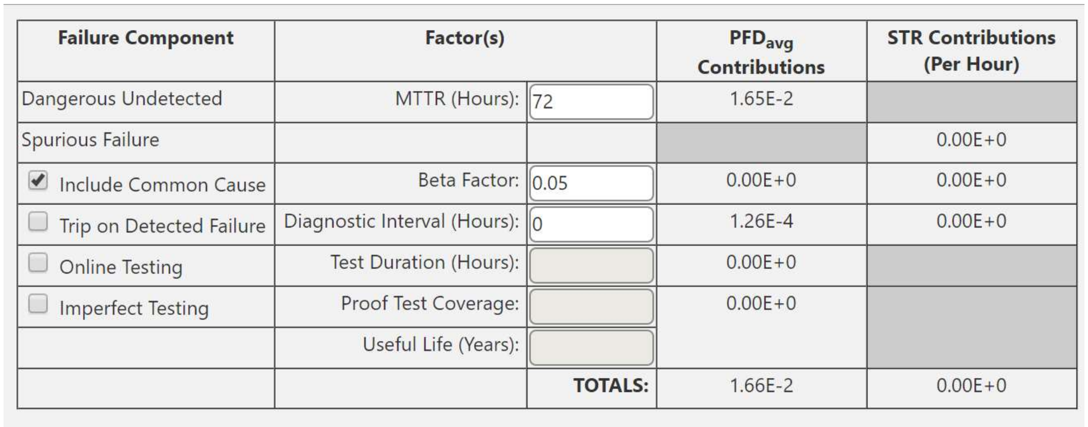
The only required user input for calculating common cause is the Beta Factor, which is defined by *ISA TR84.00.02*. Typical values for the Beta Factor range from 5% to 10%

(0.05 to 0.10). Guidance for application specific selection of the Beta Factor are provided in *ISA TR84.00.02*

3.8.2 Contribution for Actions Taken on Detect Failure

By default, Vertigo assumes that any detected failure of a device will result in a vote to trip. These failure modes include λ_{DD}, and λ_{SD} failures. When the "Trip on Detected Failure" checkbox is checked, failures associated with these failure modes will contribute the STR as shown in the table above in *Section 3.8*. When the Trip on Detected Failure checkbox is unchecked, these failure modes will contribute to the PFD_{avg}.

In order to calculate the PFD_{avg} contribution associated with these failure modes you must specify the diagnostic interval. The diagnostic interval is the time between diagnostic tests. For modern smart transmitters and programmable logic solvers, this interval is typically extremely small and can usually be assumed as zero (0.0) hours. However, for final elements this assumption is not typically valid and an appropriate interval must be specified. The table below shows a transmitter which is properly modeled if a diagnosed failure does not result in a vote to trip.

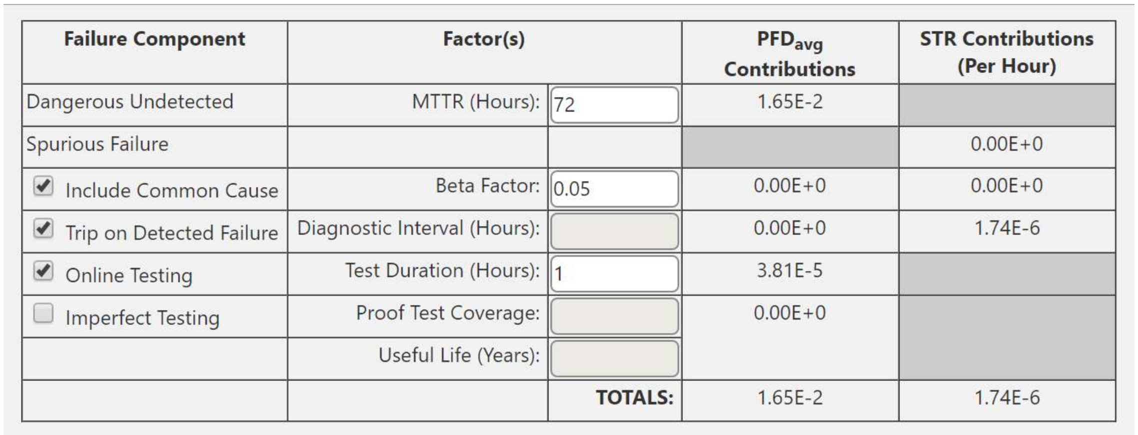


Failure Component	Factor(s)		PFD_{avg} Contributions	STR Contributions (Per Hour)
Dangerous Undetected	MTTR (Hours):	72	1.65E-2	
Spurious Failure				0.00E+0
☑ Include Common Cause	Beta Factor:	0.05	0.00E+0	0.00E+0
☐ Trip on Detected Failure	Diagnostic Interval (Hours):	0	1.26E-4	0.00E+0
☐ Online Testing	Test Duration (Hours):		0.00E+0	
☐ Imperfect Testing	Proof Test Coverage:		0.00E+0	
	Useful Life (Years):			
		TOTALS:	1.66E-2	0.00E+0

3.8.3 Online Testing Contribution

For systems where online testing is performed, it should be accounted for in the SIL verification calculations. Note that online testing is not same as diagnostic testing while the system is operational. Checking the "Online Testing" checkbox will indicate that the device is never tested off-line, all testing is performed during operation. Testing such as partial stroke testing or solenoid test packages are not considered online tests (as it is defined by Vertigo). These types of tests are considered diagnostics as should be accounted for in the Safe Coverage and Dangerous Coverage factors defined for an instrument type.

If an instrument is subject to online testing the “Online Testing” checkbox should be checked. Checking this checkbox will enable the “Test Duration” textbox and will require you to enter a valid period of time in order to calculate the PFD_{avg} contribution. The follow table shows the correct method to model online testing of a dropout valve which lasts for one hour. An assumption is made in the calculations that the valve is unavailable during the test period as online testing of a valve typically requires that a maintenance bypass around the valve be used.



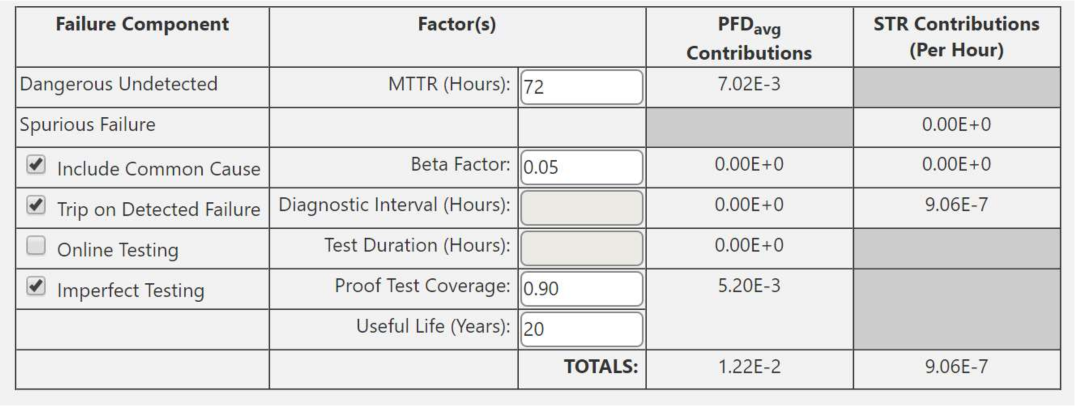
Failure Component	Factor(s)		PFD_{avg} Contributions	STR Contributions (Per Hour)
Dangerous Undetected	MTTR (Hours):	72	1.65E-2	
Spurious Failure				0.00E+0
☑ Include Common Cause	Beta Factor:	0.05	0.00E+0	0.00E+0
☑ Trip on Detected Failure	Diagnostic Interval (Hours):		0.00E+0	1.74E-6
☑ Online Testing	Test Duration (Hours):	1	3.81E-5	
☐ Imperfect Testing	Proof Test Coverage:		0.00E+0	
	Useful Life (Years):			
		TOTALS:	1.65E-2	1.74E-6

3.8.4 Imperfect Testing Contribution

Many instruments used in industrial automation can’t practically be tested in a way that will reveal 100% of the known failure modes. When this is the case the “Imperfect Testing” checkbox should be checked.

When imperfect testing is used and new failure rate term is introduced into the calculations referred to as Dangerous Never Detected (λ_{DN}). The failure rate associated with λ_{DN} represents those failure modes which can never be detected due to imperfect testing.

In order to calculate the PFD_{avg} contribution from λ_{DN} failure modes, two user inputs are required; Proof Test Coverage (0 to 1) and Useful Life (The duration of time the instrument is expected to be in service). The table below shows an instrument with imperfect testing modeled correctly if the proof test coverage is 90% and the useful life is 20 years.



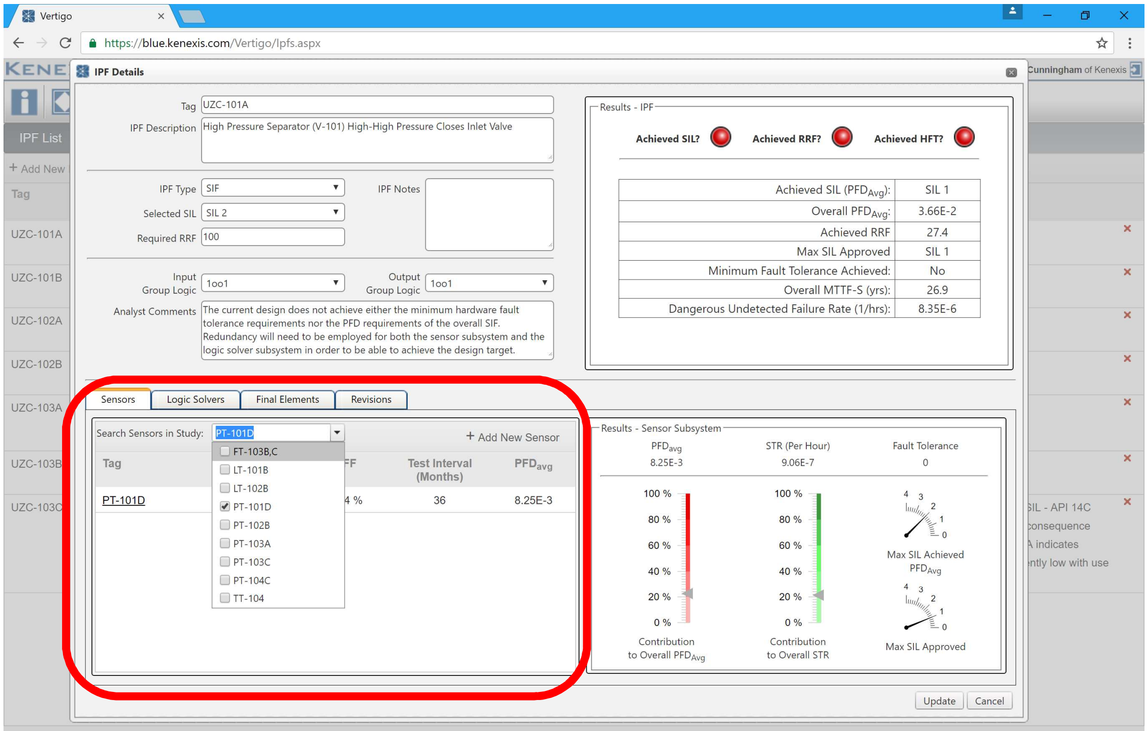
Failure Component	Factor(s)		PFD_{avg} Contributions	STR Contributions (Per Hour)
Dangerous Undetected	MTTR (Hours):	72	7.02E-3	
Spurious Failure				0.00E+0
☑ Include Common Cause	Beta Factor:	0.05	0.00E+0	0.00E+0
☑ Trip on Detected Failure	Diagnostic Interval (Hours):		0.00E+0	9.06E-7
☐ Online Testing	Test Duration (Hours):		0.00E+0	
☑ Imperfect Testing	Proof Test Coverage:	0.90	5.20E-3	
	Useful Life (Years):	20		
		TOTALS:	1.22E-2	9.06E-7

If you are unsure whether imperfect testing is required for an instrument, it is best to check with the vendor. Many vendors have begun to report proof test coverage and even proof teste procedures and part of the safety manual for SIL certified equipment.

3.9 Applying Instruments to an IPF

Each IPF is comprised of one or more Instruments (Sensors, Logic Solvers and Final Elements). Instruments can be assigned to an IPF through the IPF details form (described in *Section 3.3*).

Instruments are assigned to an IPF through the grid in the lower left corner of the IPF details form. Any instruments already assigned to the IPF will be visible in the grid under the Sensors, Logic Solvers or Final Elements tab respectively. To assign an instrument, select it from the dropdown menu labeled “Search [instrument] in Study”. With the dropdown menu expanded, typing into the search textbox will filter the dropdown results. Checking the checkbox next to an instrument will assign it to the IPF.



https://blue.kenexis.com/Vertigo/Ipfs.aspx

IPF Details

Tag	UZC-101A
IPF Description	High Pressure Separator (V-101) High-High Pressure Closes Inlet Valve
IPF Type	SIF
Selected SIL	SIL 2
Required RRF	100
IPF Notes	
Input Group Logic	1oo1
Output Group Logic	1oo1
Analyst Comments	The current design does not achieve either the minimum hardware fault tolerance requirements nor the PFD requirements of the overall SIF. Redundancy will need to be employed for both the sensor subsystem and the logic solver subsystem in order to be able to achieve the design target.

Results - IPF

Achieved SIL? ● Achieved RRF? ● Achieved HFT? ●

Achieved SIL (PFD_{Avg}):	SIL 1
Overall PFD_{Avg}:	3.66E-2
Achieved RRF	27.4
Max SIL Approved	SIL 1
Minimum Fault Tolerance Achieved:	No
Overall MTTF-S (yrs):	26.9
Dangerous Undetected Failure Rate (1/hrs):	8.35E-6

Search Sensors in Study: PT-101D

- □ FT-103B,C
- □ LT-101B
- □ LT-102B
- ☑ PT-101D
- □ PT-102B
- □ PT-103A
- □ PT-103C
- □ PT-104C
- □ TT-104

Tag	FF	Test Interval (Months)	PFD_{avg}
PT-101D	4 %	36	8.25E-3

Results - Sensor Subsystem

PFD_{avg}	STR (Per Hour)	Fault Tolerance
8.25E-3	9.06E-7	0

3.10 Calculations Details

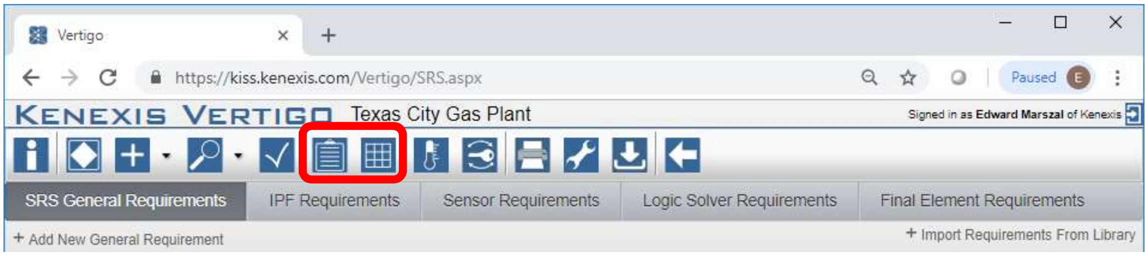
Calculations in Vertigo are performed in compliance with the recommended practice from the International Society of Automation (ISA). Details of the recommended practice for the ISA are provided in the ISA 84 Technical Report (*ISA-TR84.00.02 Safety Integrity Level (SIL) Verification of Safety Instrumented Functions*).

Section 4 - Safety Requirements Specification

4.1 Safety Requirements Specification Introduction

The Safety Requirements Specifications (SRS) are engineering design specifications for a Safety Instrumented System (SIS). The intent of the SRS is to document, in detail, all the safety functional activity performed by the SIS. SRS development is a requirement for compliance with IEC/ISA 61511. Vertigo provides a versatile interface for development and maintenance of SRS.

All SRS requirements can be maintained from the SRS page or the cause-and-effect diagram page, which is accessed by clicking the SRS button or the cause-and-effect button in the navigation bar as shown below.


Vertigo
https://kiss.kenexis.com/Vertigo/SRS.aspx
Paused
KENEXIS VERTIGO
Texas City Gas Plant
Signed in as Edward Marszal of Kenexis
SRS General Requirements
IPF Requirements
Sensor Requirements
Logic Solver Requirements
Final Element Requirements
+ Add New General Requirement
+ Import Requirements From Library

Vertigo provides versatility in SRS development and allows you to generate SRS requirements in one of two ways which are typically used in industry today.

1.) SRS General Requirements w/ Exceptions on a case-by-case basis
2.) Explicit Requirements Specification for Each IPF / Sensor / Logic Solver / Final Element

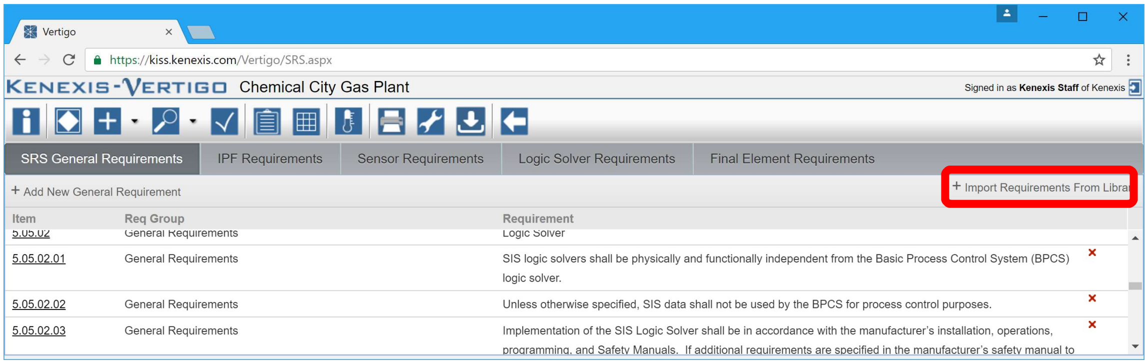
These two methods are described in the sections to come.

4.2 SRS General Requirements

Specifying SRS general requirements is done through the SRS general requirements grid on the SRS page. Specifying general requirement is a methodology made popular and favored by Kenexis as it limits the amount of repeat data which is documented. When applying this methodology of SRS documentation requirements are developed which apply to all SIF which are part of the SIS, noting any deviations from those general requirements on a case-by-case basis. These deviations are sometimes referred to as either specific requirements or specific notes, but are documented in the same grid as the general requirements, using the numbering system and grouping labels to separate specific notes from general requirements and allowing for easy reference to these notes from other sections of the SRS.

For example, most SIS are designed to operate in a deenergize-to-trip configuration. This is typically true for all Safety Instrumented Functions with few exceptions. With the general requirements method, a single requirement should be written to express a deenergize-to-trip configuration. Then for any deviations a specific note should be developed to document the deviation and the associated acceptance criteria.

Because SRS general requirement are likely to be used in more than one Vertigo study, libraries exist outside of a Vertigo study to allow SRS general requirements to be quickly developed from library templates. As part of your Vertigo license, you have access to the Kenexis Standard SRS General Requirements Template which can be imported from the Kenexis Standard library by clicking the “Import Requirements from Library” button on the SRS General Requirements tab as shown below.


Vertigo
https://kiss.kenexis.com/Vertigo/SRS.aspx
KENEXIS-VERTIGO
Chemical City Gas Plant
Signed in as Kenexis Staff of Kenexis
SRS General Requirements
IPF Requirements
Sensor Requirements
Logic Solver Requirements
Final Element Requirements
+ Add New General Requirement
+ Import Requirements From Librar

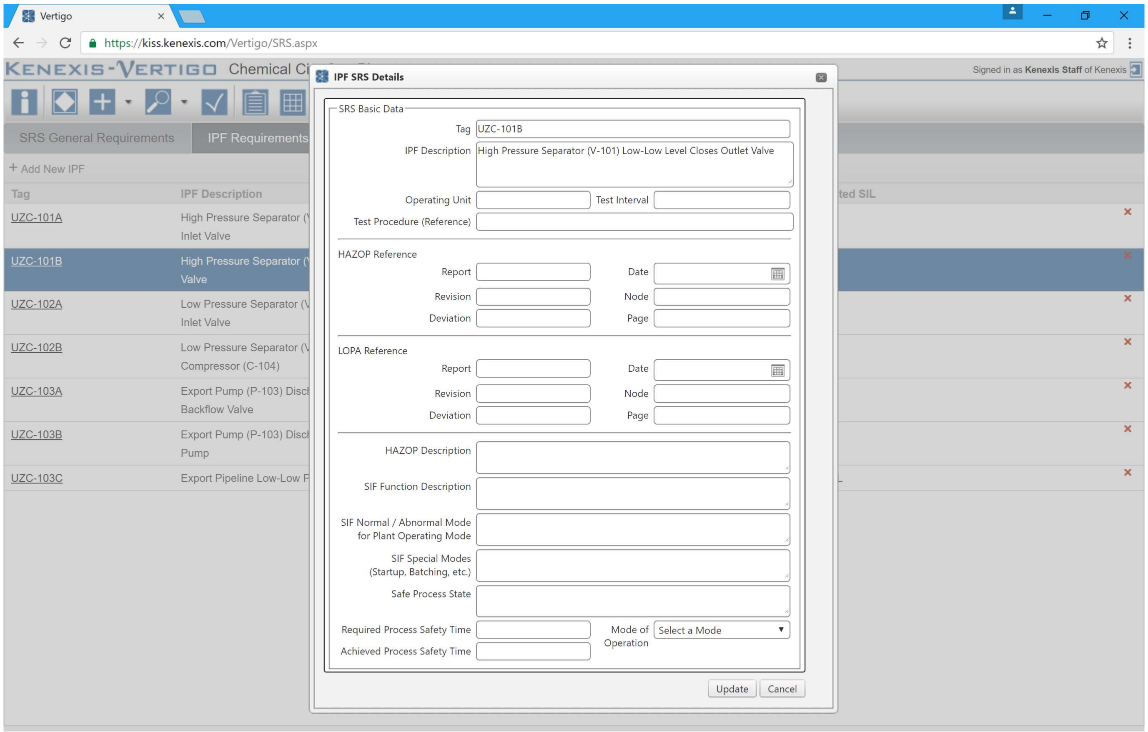
Item	Req Group	Requirement
5.05.02	General Requirements	Logic Solver
5.05.02.01	General Requirements	SIS logic solvers shall be physically and functionally independent from the Basic Process Control System (BPCS) logic solver.
5.05.02.02	General Requirements	Unless otherwise specified, SIS data shall not be used by the BPCS for process control purposes.
5.05.02.03	General Requirements	Implementation of the SIS Logic Solver shall be in accordance with the manufacturer’s installation, operations, programming, and Safety Manuals. If additional requirements are specified in the manufacturer’s safety manual to

Alternatively, new SRS General requirements can be added through the “Add New General Requirements” button to the left in the screen shot above.

4.3 SRS Datasheets

In addition to SRS General Requirements some SRS requirements must be explicitly documented for each IPF, Sensor, Logic Solver and Final Element in individual datasheets. These data sheets contain a large assortment of fields that can be completed to document specific requirements for individual items.

For each item type (IPF, Sensor, Logic Solver, Final Element) a tab is provided on the SRS page which contains a grid when requirements can be added. Requirements are added in the SRS details form for each requirement type as individual fields in a detail form. Details forms are accessed by any of the methods described in *Section 2*. The information that is shown on a datasheet can be customized to meet the requirements of every individual organization. The Vertigo database contains a superset of all the fields that one might desire to have on a datasheet. The user can then customize which fields are shown by selecting and de-selecting them on the settings form. Below is an example of the details form for SRS Requirements for an IPF.


Vertigo
https://kiss.kenexis.com/Vertigo/SRS.aspx
KENEXIS-VERTIGO Chemical Ci
Signed in as Kenexis Staff of Kenexis
SRS General Requirements
IPF Requirements
+ Add New IPF

Tag	IPF Description
UZC-101A	High Pressure Separator (\ Inlet Valve
UZC-101B	High Pressure Separator (\ Valve
UZC-102A	Low Pressure Separator (\ Inlet Valve
UZC-102B	Low Pressure Separator (\ Compressor (C-104)
UZC-103A	Export Pump (P-103) Disc Backflow Valve
UZC-103B	Export Pump (P-103) Disc Pump
UZC-103C	Export Pipeline Low-Low F

IPF SRS Details

SRS Basic Data

Tag: UZC-101B

IPF Description: High Pressure Separator (V-101) Low-Low Level Closes Outlet Valve

Operating Unit:
Test Interval:
Test Procedure (Reference):

HAZOP Reference

Report:
Date:
Revision:
Node:
Deviation:
Page:

LOPA Reference

Report:
Date:
Revision:
Node:
Deviation:
Page:

HAZOP Description:
SIF Function Description:
SIF Normal / Abnormal Mode for Plant Operating Mode:
SIF Special Modes (Startup, Batching, etc.):
Safe Process State:
Required Process Safety Time:
Mode of Operation: Select a Mode
Achieved Process Safety Time:

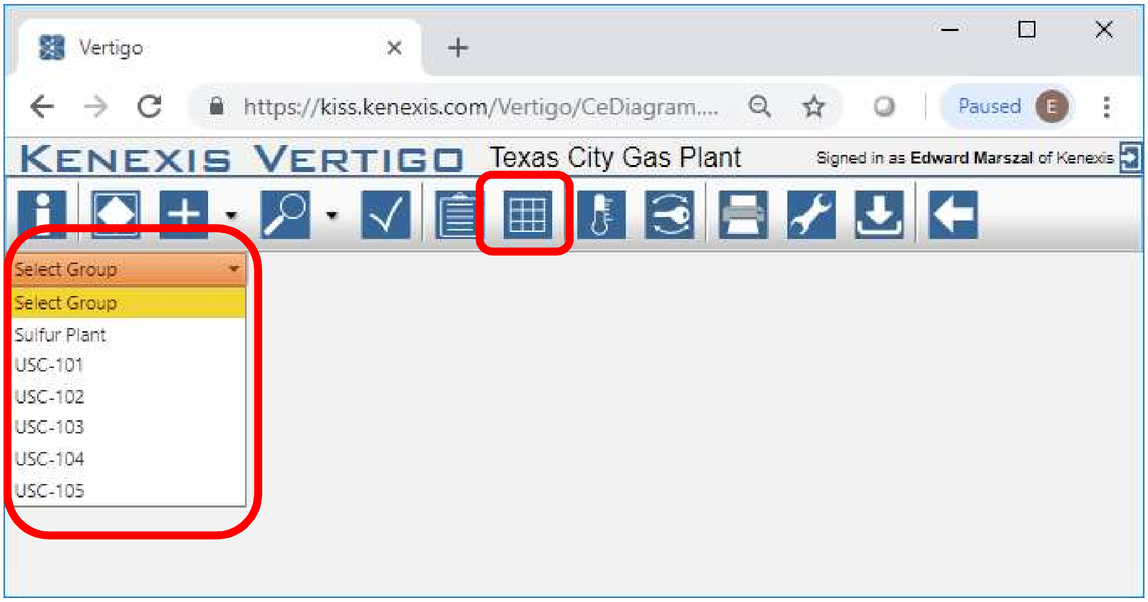
The Explicit SRS requirements for IPFs, Sensors, Logic Solvers or Final Elements can be filtered through the study settings form.

4.4 Cause-and-Effect Diagrams

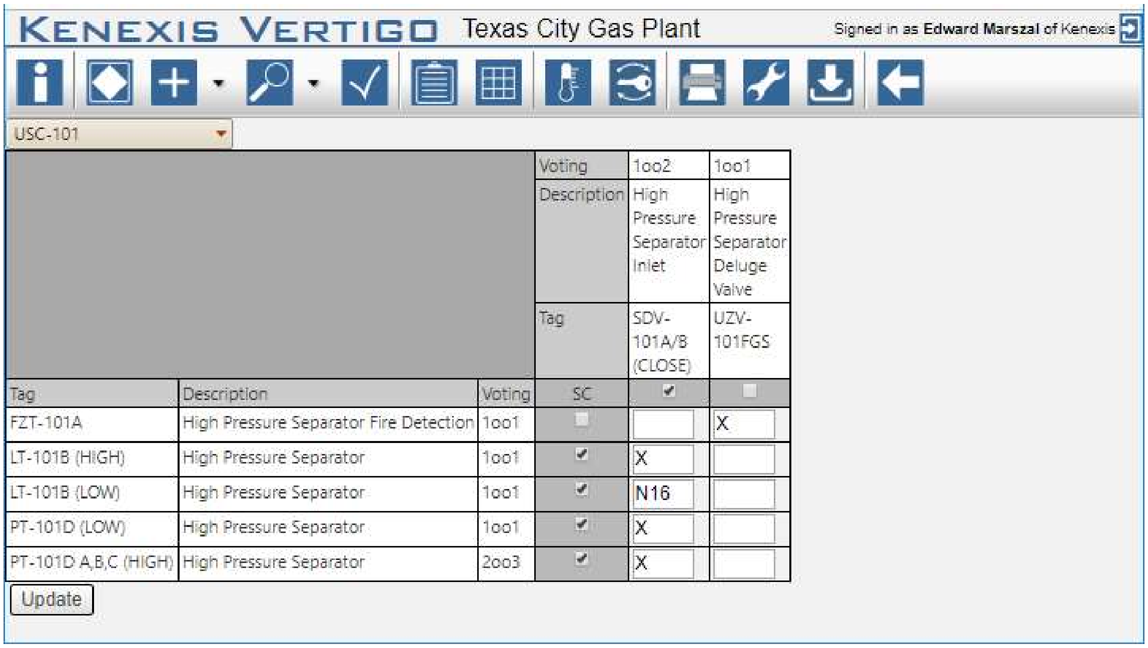
One of the most critical portions of the SRS is the logic description. While the IEC/ISA 61511 standard allows for a wide range of options for providing a logic description, such as textual narratives and binary logic diagrams, the most efficient, compact, and common approach is the use of cause-and-effect diagrams, which is what is employed in Vertigo.

Section 4 - Safety Requirements Specification

The cause-and-effects diagrams page is accessed by clicking its button in the navigation bar. When the cause-and effects page is entered, the user will see a drop-down box where an IPF group can be selected.



In Vertigo, cause-and-effect diagrams are automatically built based on each IPF group. In the SRS datasheets for each sensor and final element, the user can select an IPF group out of the list of IPF groups that have been defined.



			Voting	1oo2	1oo1
			Description	High Pressure Separator Inlet	High Pressure Separator Deluge Valve
			Tag	SDV-101A/B (CLOSE)	UZV-101FGS
Tag	Description	Voting	SC	☑	☐
FZT-101A	High Pressure Separator Fire Detection	1oo1	☐		X
LT-101B (HIGH)	High Pressure Separator	1oo1	☑	X	
LT-101B (LOW)	High Pressure Separator	1oo1	☑	N16	
PT-101D (LOW)	High Pressure Separator	1oo1	☑	X	
PT-101D A,B,C (HIGH)	High Pressure Separator	2oo3	☑	X	

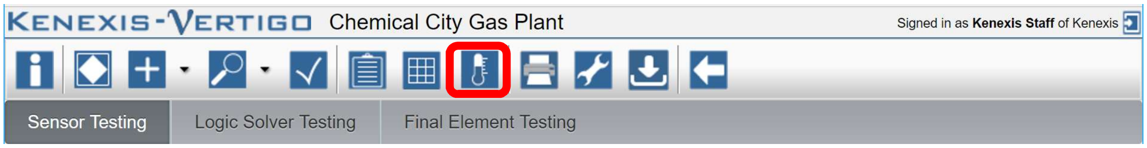
Then, on the cause-and-effect diagram page, when an IPF group is selected the application will build a grid with all the sensors in the IPF group as rows and all the final elements in the IPF Group as rows. The application will also create an intersection grid to relate each sensor to each final element. The contents of the intersection grid can be edited by the user to include any 5-character text field. Commonly, a simple “X” is used to designate that a sensor activation results in a final element activation, but this field can also include more explanatory codes such as “OPEN” or “STOP”, or event references to notes that contain more elaborate logic description, such as “N 16” that corresponds to the text of requirement 16 of the general requirements section.

Section 5 – Test Tracking

TEST TRACKING

5.1 Test Tracking Introduction

Vertigo is capable of tracking functional testing of any instrument defined within a study. The status of an instruments testing records can be viewed from in the instrument testing grids by clicking on the testing button on the main action ribbon.

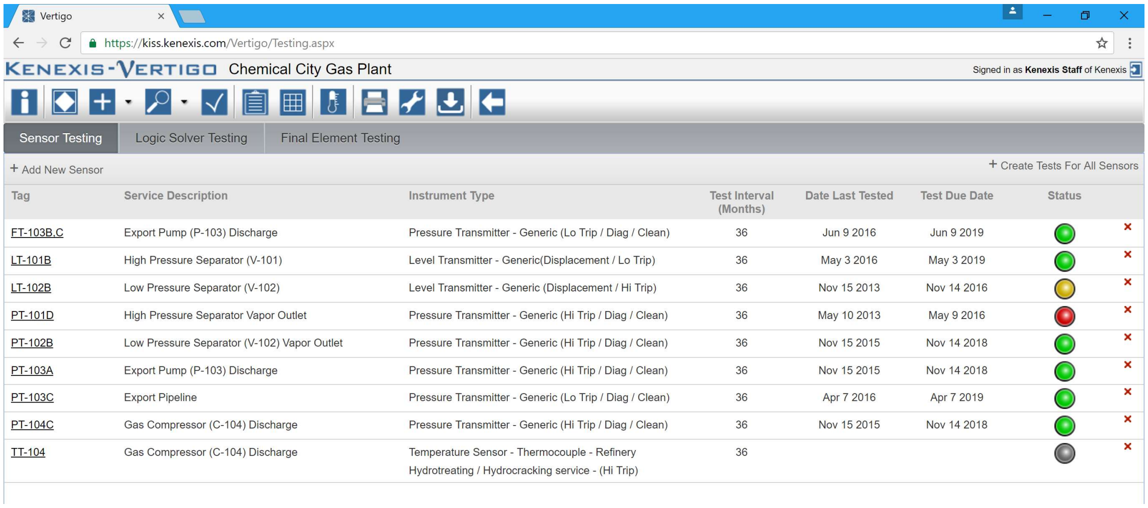


Instruments are listed in three grids, one for each instrument type (Sensors, Logic Solvers and Final Elements).

5.2 Testing Summary Grid

Each grid contains a summary of the current testing status for instruments a given type. This summary includes:

- Instrument Tag
- Service Description
- Instrument Type (Make / Model #)
- Test Interval (As Defined by the SIL Verification Calculations)
- Date Last Tested (default to commissioning date if no functional tests have been tracked)
- Test Due Date
- Status
  - Green Indicates no action is required
  - Yellow indicates an upcoming test within the next six months
  - Red indicates an instrument which is past due for testing
  - Grey indicates an instrument insufficient data to calculate a test due date. Alternately it indicates an instrument which has been decommissioned.



Vertigo

https://kiss.kenexis.com/Vertigo/Testing.aspx

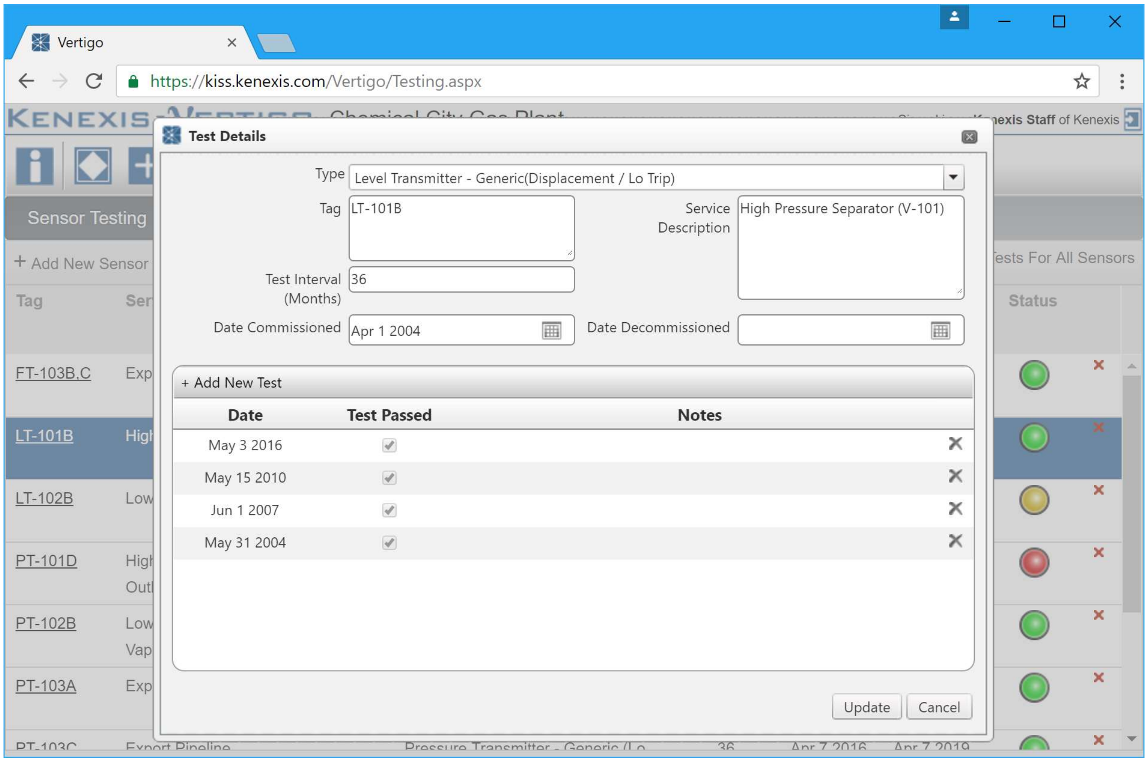
KENEXIS-VERTIGO Chemical City Gas Plant

Signed in as **Kenexis Staff** of Kenexis

Tag	Service Description	Instrument Type	Test Interval (Months)	Date Last Tested	Test Due Date	Status	
FT-103B,C	Export Pump (P-103) Discharge	Pressure Transmitter - Generic (Lo Trip / Diag / Clean)	36	Jun 9 2016	Jun 9 2019	🟢	✕
LT-101B	High Pressure Separator (V-101)	Level Transmitter - Generic(Displacement / Lo Trip)	36	May 3 2016	May 3 2019	🟢	✕
LT-102B	Low Pressure Separator (V-102)	Level Transmitter - Generic (Displacement / Hi Trip)	36	Nov 15 2013	Nov 14 2016	🟡	✕
PT-101D	High Pressure Separator Vapor Outlet	Pressure Transmitter - Generic (Hi Trip / Diag / Clean)	36	May 10 2013	May 9 2016	🔴	✕
PT-102B	Low Pressure Separator (V-102) Vapor Outlet	Pressure Transmitter - Generic (Hi Trip / Diag / Clean)	36	Nov 15 2015	Nov 14 2018	🟢	✕
PT-103A	Export Pump (P-103) Discharge	Pressure Transmitter - Generic (Hi Trip / Diag / Clean)	36	Nov 15 2015	Nov 14 2018	🟢	✕
PT-103C	Export Pipeline	Pressure Transmitter - Generic (Lo Trip / Diag / Clean)	36	Apr 7 2016	Apr 7 2019	🟢	✕
PT-104C	Gas Compressor (C-104) Discharge	Pressure Transmitter - Generic (Hi Trip / Diag / Clean)	36	Nov 15 2015	Nov 14 2018	🟢	✕
TT-104	Gas Compressor (C-104) Discharge	Temperature Sensor - Thermocouple - Refinery Hydrotreating / Hydrocracking service - (Hi Trip)	36			●	✕

5.3 Testing Details Form

The details of testing for a single instrument can be viewed in the testing details find. The testing details window can be displayed by either double clicking on a row of the grid or clicking on the underlined tag for an instrument. The testing details form is shown below.



Vertigo

https://kiss.kenexis.com/Vertigo/Testing.aspx

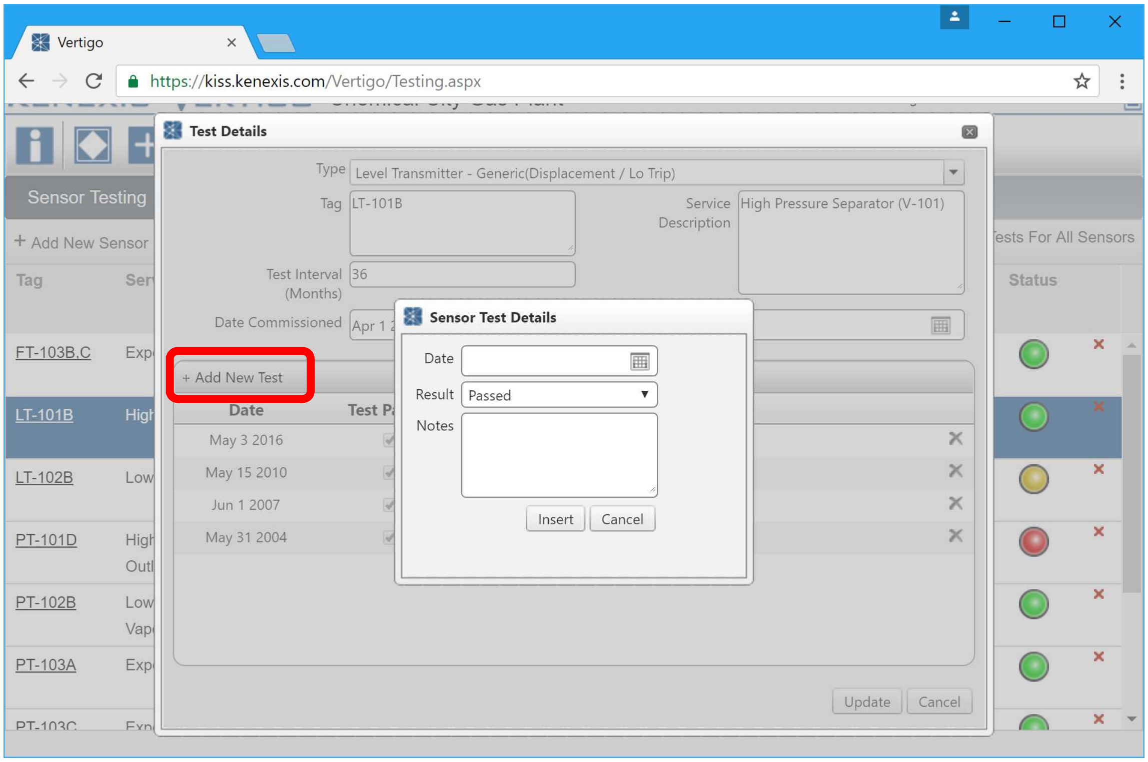
Test Details

Type	Level Transmitter - Generic(Displacement / Lo Trip)		
Tag	LT-101B	Service Description	High Pressure Separator (V-101)
Test Interval (Months)	36		
Date Commissioned	Apr 1 2004	Date Decommissioned	

Date	Test Passed	Notes	
May 3 2016	☑		✕
May 15 2010	☑		✕
Jun 1 2007	☑		✕
May 31 2004	☑		✕

Section 5 – Test Tracking

The test details form is made up of two parts. The top of the form summarizes information which is applicable to test recording, such as test interval, service description, commission date and decommission date. The bottom of the form contains a grid with a list of all recorded tests for the instrument. Tests can be added to the grid by clicking the “Add New Test” button in the grid header. This will open an interface to create a new test. See below.



https://kiss.kenexis.com/Vertigo/Testing.aspx

Test Details

Type: Level Transmitter - Generic(Displacement / Lo Trip)
Tag: LT-101B
Service Description: High Pressure Separator (V-101)
Test Interval (Months): 36
Date Commissioned: Apr 1

Date	Test P
May 3 2016	✓
May 15 2010	✓
Jun 1 2007	✓
May 31 2004	✓

Sensor Test Details

Date:
Result: Passed
Notes:

Tag	Ser	Status
FT-103B,C	Exp	●
LT-101B	High	●
LT-102B	Low	●
PT-101D	High Outl	●
PT-102B	Low Vap	●
PT-103A	Exp	●
PT-103C	Exp	●

When creating a new test, you are prompted to enter the test date, results of the test and any notes pertaining to the test. If the result if the test is set to failed an additional field can be entered to specify the failure mode of the device. By entering the failure mode, it is possible to calculate the actual failure rate of instruments and revalidate the failure rate data applied to instrument types used in SIL Verification calculations.

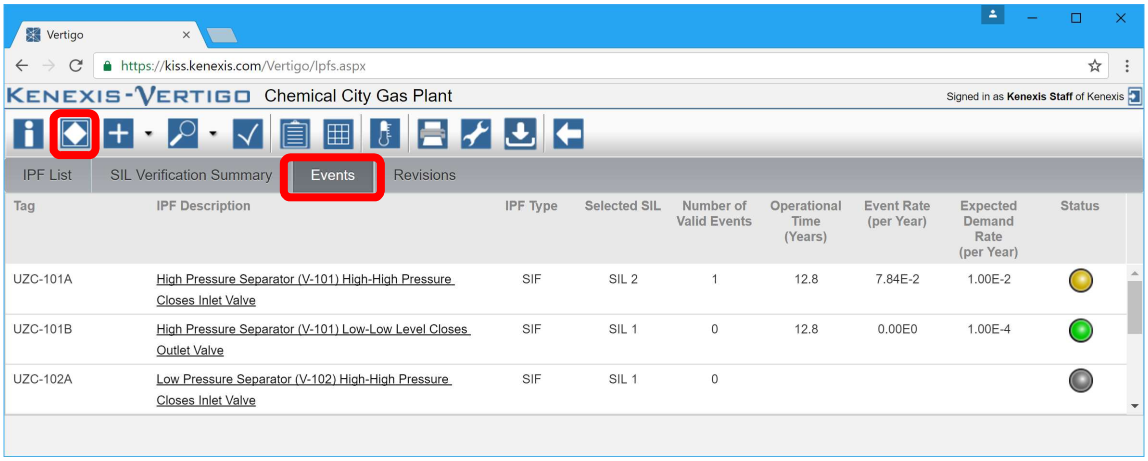
Section 6 – Event Tracking

6.1 Event Tracking Introduction

Vertigo provides a feature to track event's associated with an Instrumented Protective Function (IPF). The intent of the event tracking feature is to allow you to monitor the health of an SIS, validating assumptions about IPF demand rates and IPF spurious trip rates. Furthermore, API PR 754 – Process Safety Performance Indicators for the Refining and Petrochemical Industries – recommends tracking and report of these events all way up through senior management, and Vertigo is an excellent way to facilitate and automate this type of report. The event tracking feature can provide valuable input on the day-to-day operation of the SIS and proves useful in understanding where the SIS is not performing up to the expected level of performance or where assumptions made during the SIL Selection regarding SIS demand rates are being violated.

6.2 The Event Tracking Grid

The event tracking grid contains a summary of events on an IPF-by-IPF basis. The grid lists all IPF's contains in a Vertigo study along with a summary of events which have been tracked for each IPF. The IPF grid can be found by clicking on the "IPF List" button in the main action ribbon, then navigating to the "Events" tab. See below.


Vertigo
https://kiss.kenexis.com/Vertigo/Ipfs.aspx
KENEXIS-VERTIGO
Signed in as Kenexis Staff of Kenexis
IPF List
SIL Verification Summary
Events
Revisions

Chemical City Gas Plant

Tag	IPF Description	IPF Type	Selected SIL	Number of Valid Events	Operational Time (Years)	Event Rate (per Year)	Expected Demand Rate (per Year)	Status
UZC-101A	High Pressure Separator (V-101) High-High Pressure Closes Inlet Valve	SIF	SIL 2	1	12.8	7.84E-2	1.00E-2	🟡
UZC-101B	High Pressure Separator (V-101) Low-Low Level Closes Outlet Valve	SIF	SIL 1	0	12.8	0.00E0	1.00E-4	🟢
UZC-102A	Low Pressure Separator (V-102) High-High Pressure Closes Inlet Valve	SIF	SIL 1	0				●

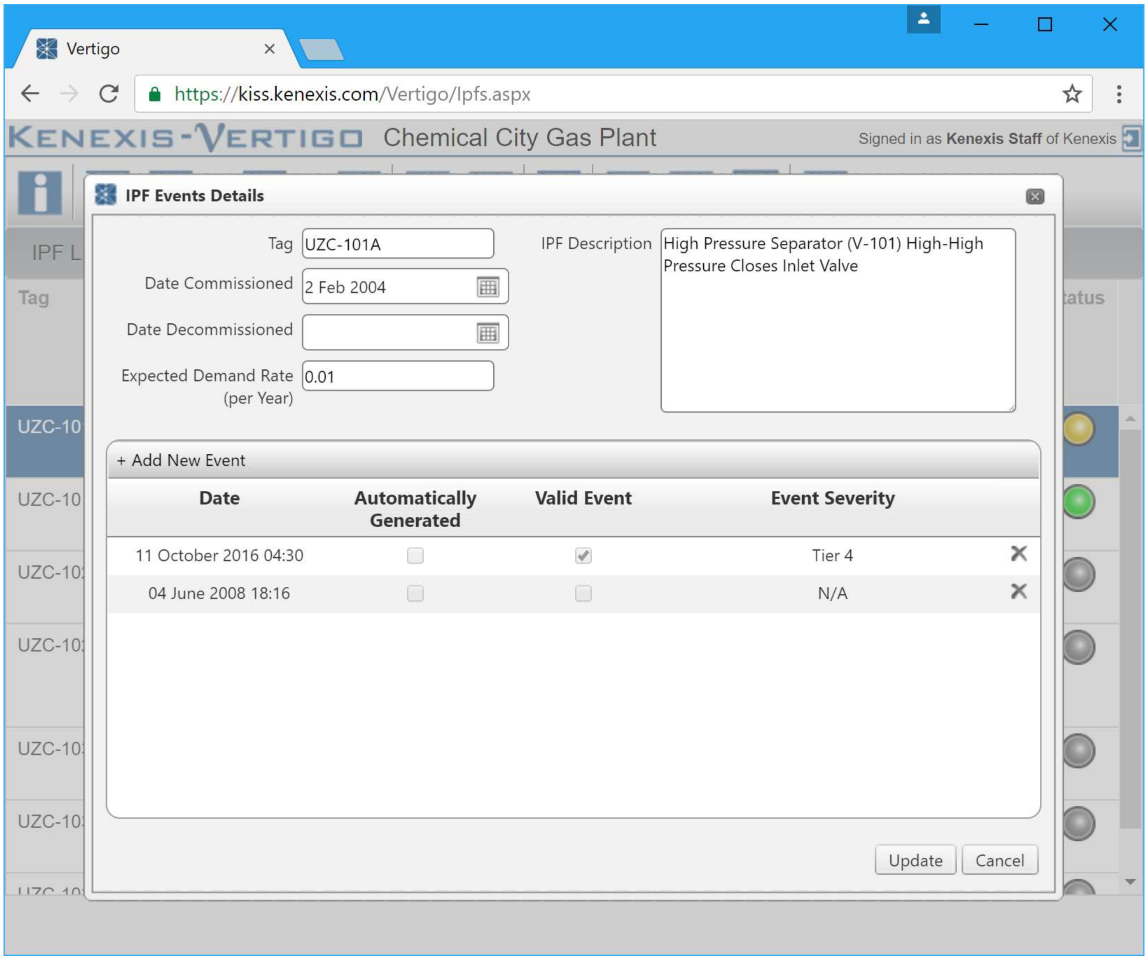
Once on the events grid page you can see a summary of events for each IPF. A status is provided for each IPF. The colors for the status are defined as follows:

- Green Indicated no action is required. The actual demand rate of the IPF is less than the demand rate assumed in the risk assessment used to select the SIL requirement for the IPF.

- Yellow indicated that the actual demand rate of the IPF exceeds the assumed demand rate from the risk assessment used to select the SIL requirement for the IPF. In this case the risk assessment should be updated to reflect the higher demand rate and the selected SIL should be adjusted accordingly, if required.
- Grey indicated that there is either insufficient data to determine if the assumed demand rate is valid, or the IPF has been decommissioned.

6.3 The IPF Event Details Form

From the event grid, an IPF event details form can be opened to view and modify the events for a single IPF. The event details form can be opened either by double-clicking on a row of the grid, or by clicking on the underlined IPF description for an IPF. The IPF event details form is shown below.



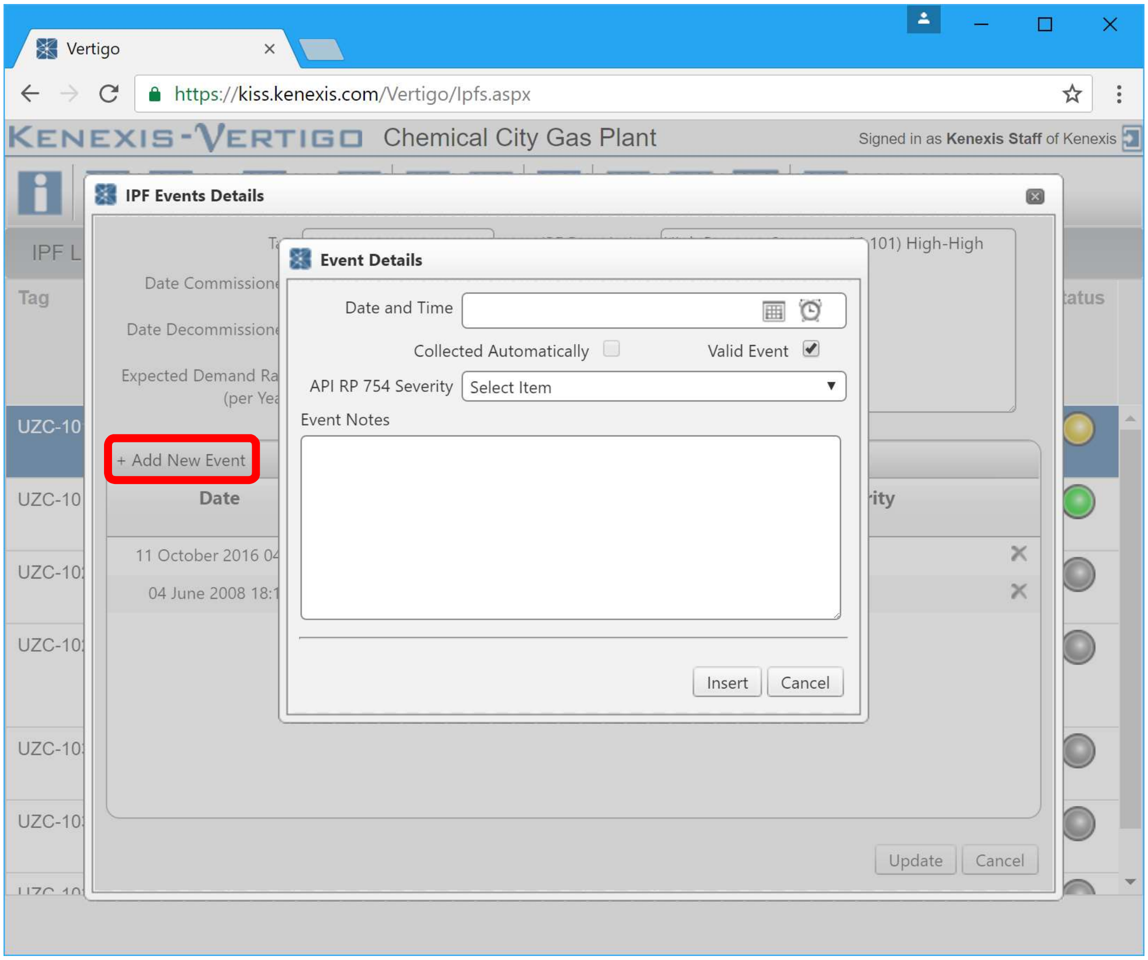
Tag	UZC-101A
Date Commissioned	2 Feb 2004
Date Decommissioned	
Expected Demand Rate (per Year)	0.01
IPF Description	High Pressure Separator (V-101) High-High Pressure Closes Inlet Valve

+ Add New Event

Date	Automatically Generated	Valid Event	Event Severity	
11 October 2016 04:30	□	☑	Tier 4	✕
04 June 2008 18:16	□	□	N/A	✕

The IPF event details form is broken into two sections. The top of the form contains fields which are relevant in tracking of IPF events. Several fields are required to generate the IPF event status shown in the event grid. Both “Date Commissioned” and “Expected Demand Rate” are required to calculate this status.

The bottom section of the form contains a grid which lists all events recorded for the IPF. The events can be added by clicking of the “Add New Event” button in the header of the grid. Clicking this button will open a new interface to create a new event, as shown below.



Event Details

Date and Time

Collected Automatically ☐ Valid Event ☑

API RP 754 Severity: Select Item

Event Notes

11 October 2016 04

04 June 2008 18:1

When creating a new event, you will be prompted to enter several values.

- Date and Time – The Date and Time at which the event occurred.
- Collected Automatically – This field is automatically populated and can’t be modified. If event data was automatically generated by query against the DCS historian this field will be set to true.

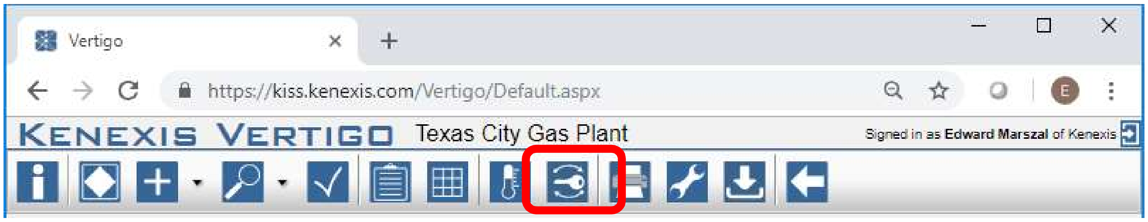
Section 6 – Event Tracking

- Valid Event – Valid event should be checked if the event was a genuine demand on the IPF (i.e. the event was caused by process values deviating outside of their safe operating limits). For spurious activations or events which do not result in a trip, the valid event field should remain unchecked.
- API RP 754 Severity – The event severity level of the event as defined by *API RP 754 Process Safety Performance Indicators for the Refining and Petrochemical Industries*
- Event Notes – Any user notes describing the event.
- Validation Notes (If Valid Event is unchecked) – Validation notes are provided to allow the user to provide a description for why an event was marked as invalid.

Section 7 – Bypass Tracking

7.1 Bypass Tracking Introduction

Tracking the bypass of critical safeguards is an important part of any process safety management program. Vertigo provides a feature to track bypassing associated with an Instrumented Protective Function (IPF). The intent of the bypass tracking feature is to allow you document and authorize bypass activations and ensure that the appropriate risk analysis and alternate means of protection are in place to allow bypasses to occur safely. Bypass information can be displayed by clicking on the Bypass button in the Navigation bar.



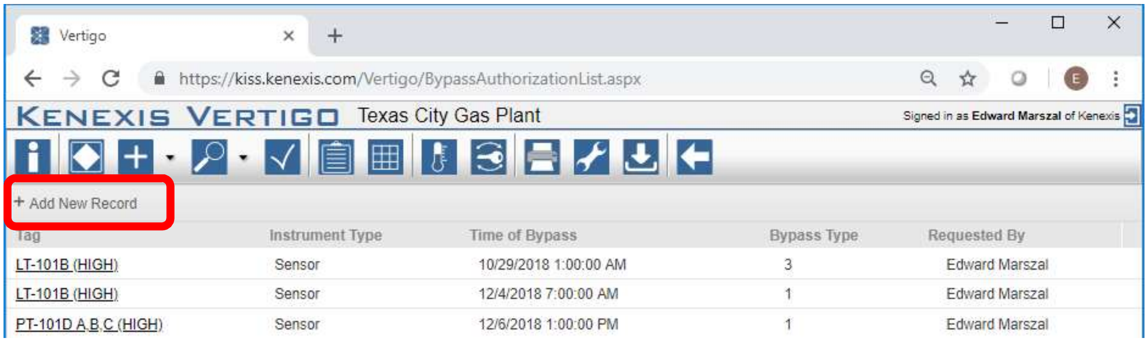
https://kiss.kenexis.com/Vertigo/Default.aspx

Texas City Gas Plant

Signed in as Edward Marszal of Kenexis

7.2 Bypass Authorization Grid

A summary of information related to bypass authorizations can be found in the bypass authorization grid. Each bypass authorization entry for the plant will be included on this list, which can be filtered, sorted, and grouped as discussed earlier in this user's manual. New bypass authorization records can be created by clicking on the "+ Add New Record" button.



https://kiss.kenexis.com/Vertigo/BypassAuthorizationList.aspx

Texas City Gas Plant

Signed in as Edward Marszal of Kenexis

Tag	Instrument Type	Time of Bypass	Bypass Type	Requested By
LT-101B (HIGH)	Sensor	10/29/2018 1:00:00 AM	3	Edward Marszal
LT-101B (HIGH)	Sensor	12/4/2018 7:00:00 AM	1	Edward Marszal
PT-101D A,B,C (HIGH)	Sensor	12/6/2018 1:00:00 PM	1	Edward Marszal

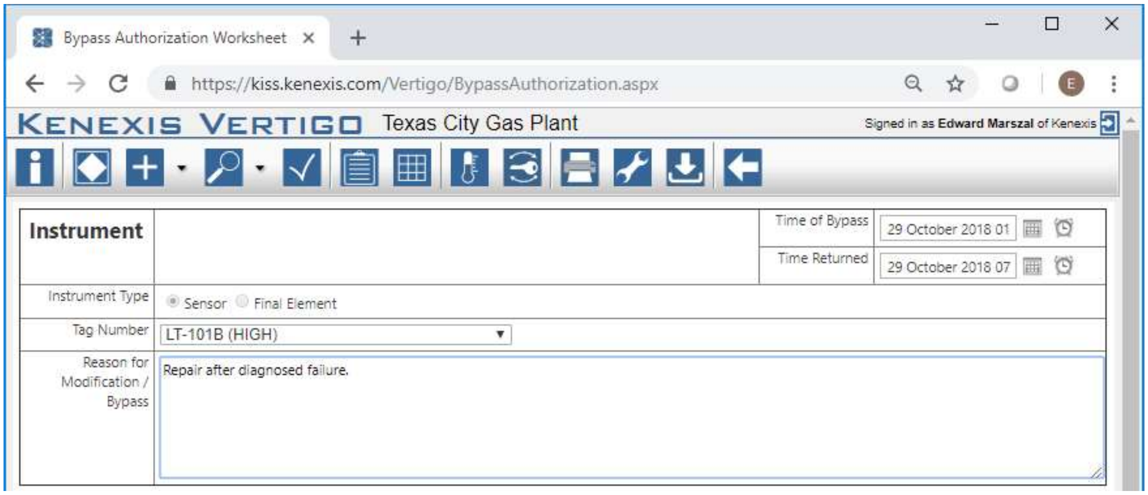
The bypass authorization grid includes the tag and instrument type of the device that is being bypassed. In addition, the time of the bypass activation is listed, along with the bypass type, and the person requesting the bypass. More information on the bypass type is included in the next section.

Section 7 – Bypass Tracking

7.3 Bypass Authorization Form

The bypass authorization form is shown either when a new bypass authorization is added, or an existing bypass authorization is opened by clicking on its hyperlink in the bypass authorization grid. The bypass authorization form has five sections:

- Bypass Identification
- Bypass Type Selection
- Alternate Protection Plan
- Bypass Risk Analysis
- Approvals


Bypass Authorization Worksheet
https://kiss.kenexis.com/Vertigo/BypassAuthorization.aspx
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Signed in as Edward Marszal of Kenexis

Texas City Gas Plant

Instrument		Time of Bypass	29 October 2018 01
		Time Returned	29 October 2018 07
Instrument Type	● Sensor ○ Final Element		
Tag Number	LT-101B (HIGH)		
Reason for Modification / Bypass	Repair after diagnosed failure.		

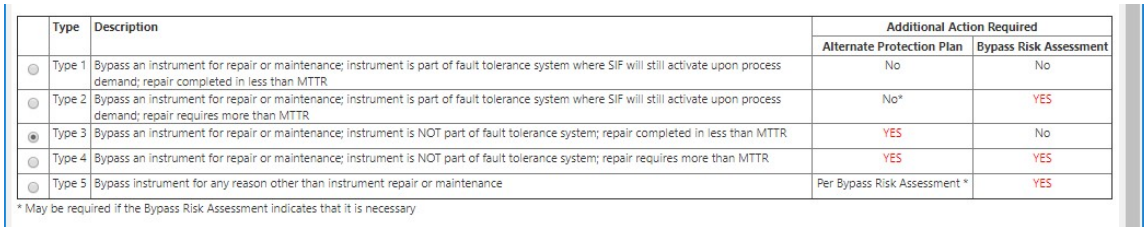
The bypass identification section includes information that will define the instrument and the bypass event. This section includes selection of the date and time of the bypass event. The instrument being bypassed is selected by first clicking on the radio button which selects that it is either a sensor or a final element. Once the instrument type is selected, the specific instrument can be selected from the drop-down list from all the instruments that have been defined in the Vertigo study. Finally, the reason for the bypass can be entered in the associated text box.

The next section is the bypass type selection. Vertigo allows the user to select from 5 different types of bypasses, each of which will result in different analysis and documentation requirements. The factors that impact which type of bypass will be selected include the following:

- Redundancy of subsystem

Section 7 – Bypass Tracking

- Repair Completion Duration
- Reason for Bypass



	Type	Description	Additional Action Required	
			Alternate Protection Plan	Bypass Risk Assessment
○	Type 1	Bypass an instrument for repair or maintenance; instrument is part of fault tolerance system where SIF will still activate upon process demand; repair completed in less than MTTR	No	No
○	Type 2	Bypass an instrument for repair or maintenance; instrument is part of fault tolerance system where SIF will still activate upon process demand; repair requires more than MTTR	No*	YES
●	Type 3	Bypass an instrument for repair or maintenance; instrument is NOT part of fault tolerance system; repair completed in less than MTTR	YES	No
○	Type 4	Bypass an instrument for repair or maintenance; instrument is NOT part of fault tolerance system; repair requires more than MTTR	YES	YES
○	Type 5	Bypass instrument for any reason other than instrument repair or maintenance	Per Bypass Risk Assessment *	YES

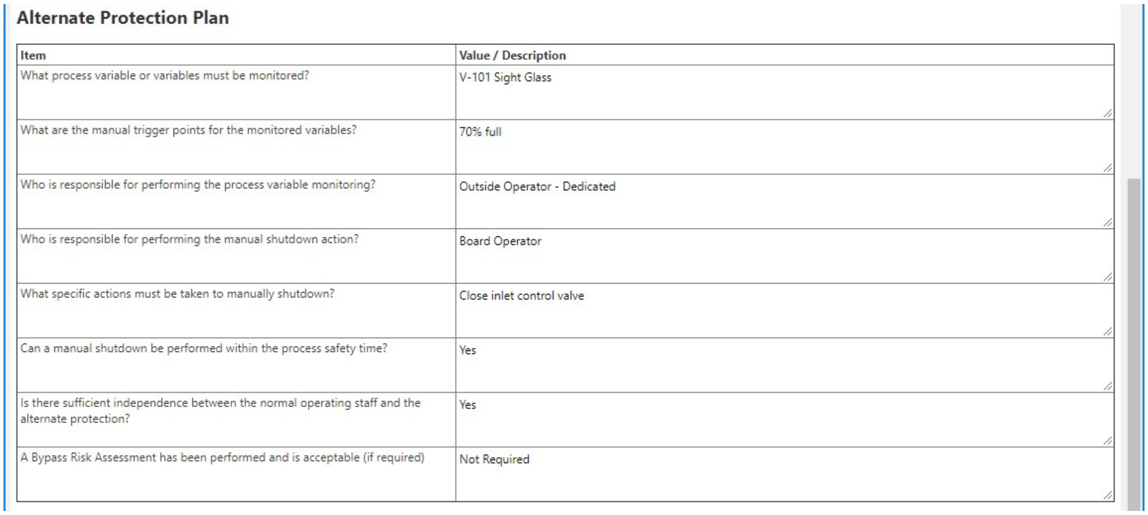
* May be required if the Bypass Risk Assessment indicates that it is necessary

If the reason for bypass is anything other than instrument repair, maintenance, or testing, then the bypass is considered to be an abnormal situation which requires additional analysis. This is a Type 5 bypass. This additional analysis will be documented in a bypass risk analysis. Also, Type 5 bypasses require that an alternate protection plan be put in place to protect the facility while the device is in the bypass state. By selecting a Type 5 bypass, the form will automatically display the sections required to be filled in for Bypass Risk Assessment and Alternate Protection Plan.

A standard bypass assumes that the device will be out of service for less than the Mean Time to Repair (MTTR) assumed in the SIL verification calculations. If more time is required, the situation is abnormal and requires Bypass Risk Assessment. As such, when either Type 2 or Type 4 are selected because the bypass duration will exceed the MTTR, the bypass risk assessment form will be shown for completion.

The amount of redundancy related to the device that is being bypassed is important in determining whether alternate protection measures are required. If a bypassed device is part of a redundant system where other devices are available to perform the function of the bypassed device, then an alternate protection plan is not required. If there is no redundancy, then in accordance with IEC/ISA 61511 a written alternate protection plan must be put in place. As such, for Type 2 and Type 4 bypasses, where there is no redundancy, the alternate protection plan form is shown.

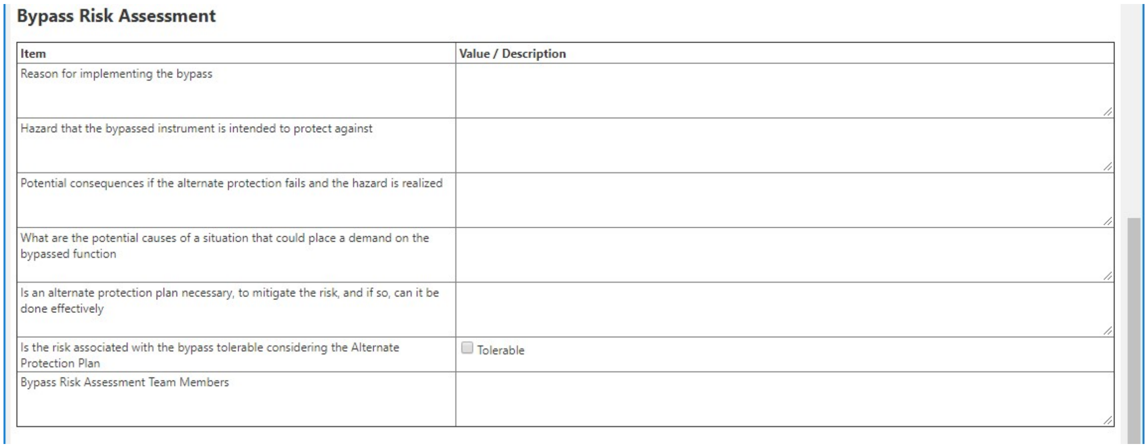
When an alternate protection plan form is created, the user is expected to enter the associated information. This information describes what actions are to be taken, when, and by whom, when a bypass is in effect so that the functionality of the bypassed device can still be achieved by other means.



Alternate Protection Plan

Item	Value / Description
What process variable or variables must be monitored?	V-101 Sight Glass
What are the manual trigger points for the monitored variables?	70% full
Who is responsible for performing the process variable monitoring?	Outside Operator - Dedicated
Who is responsible for performing the manual shutdown action?	Board Operator
What specific actions must be taken to manually shutdown?	Close inlet control valve
Can a manual shutdown be performed within the process safety time?	Yes
Is there sufficient independence between the normal operating staff and the alternate protection?	Yes
A Bypass Risk Assessment has been performed and is acceptable (if required)	Not Required

The alternate protection plan form contains fields for the required indicators in lieu of the bypassed function, action points, personnel performing the action, and as assessment of whether the alternate protection plan will be sufficiently effective.



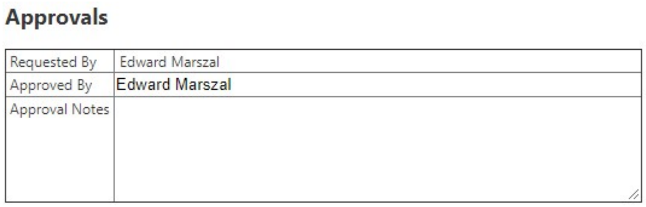
Bypass Risk Assessment

Item	Value / Description
Reason for implementing the bypass	
Hazard that the bypassed instrument is intended to protect against	
Potential consequences if the alternate protection fails and the hazard is realized	
What are the potential causes of a situation that could place a demand on the bypassed function	
Is an alternate protection plan necessary, to mitigate the risk, and if so, can it be done effectively	
Is the risk associated with the bypass tolerable considering the Alternate Protection Plan	☐ Tolerable
Bypass Risk Assessment Team Members	

The bypass risk assessment section contains an abbreviated checklist style risk assessment for guiding discussion and documenting the hazards associated with bypassing and instrument along with an assessment of whether the risk of the bypass is tolerable.

Section 7 – Bypass Tracking

The form ends with an authorization section with associated notes.

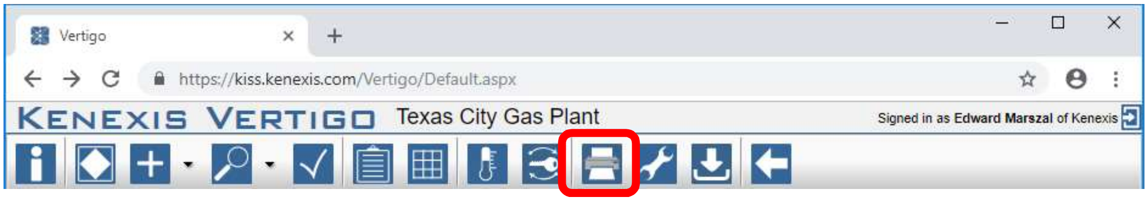


Approvals

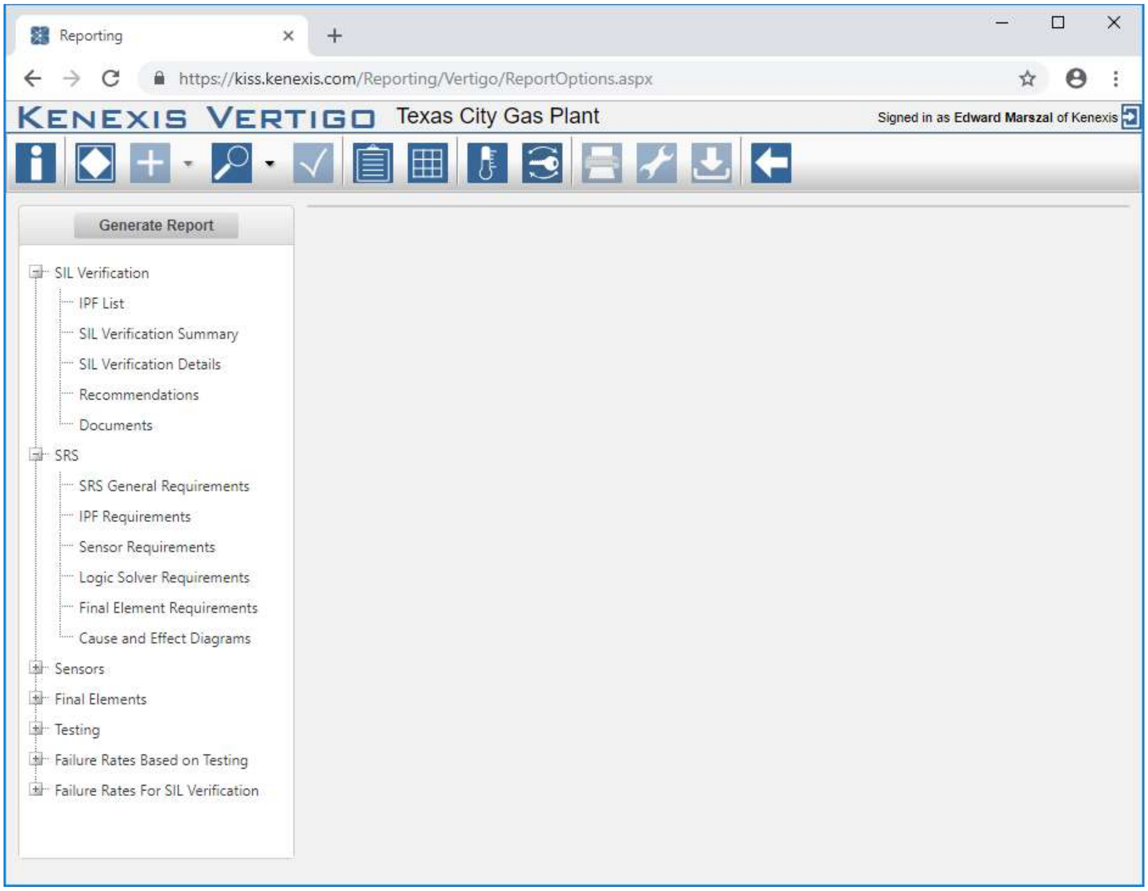
Requested By	Edward Marszal
Approved By	Edward Marszal
Approval Notes	

Section 8 - Reporting

Vertigo can generate a variety of reports to summarize and/or detail the data stored within, and calculations performed by Vertigo. All reports are generated from the same location. Reporting can be accessed by clicking on the reporting button in the main action ribbon.


Vertigo
https://kiss.kenexis.com/Vertigo/Default.aspx
KENEXIS VERTIGO Texas City Gas Plant
Signed in as Edward Marszal of Kenexis

From the reporting page, you are presented with a tree view on left side of the interface which lists all available report types, sub-divided into categories. Below is a semi-expanded list of all available reports. A full list of reports for each reporting category can be accessed by clicking on the "+" button next to the reporting category.


Reporting
https://kiss.kenexis.com/Reporting/Vertigo/ReportOptions.aspx
KENEXIS VERTIGO Texas City Gas Plant
Signed in as Edward Marszal of Kenexis
Generate Report

- SIL Verification
  - IPF List
  - SIL Verification Summary
  - SIL Verification Details
  - Recommendations
  - Documents
- SRS
  - SRS General Requirements
  - IPF Requirements
  - Sensor Requirements
  - Logic Solver Requirements
  - Final Element Requirements
  - Cause and Effect Diagrams
- Sensors
- Final Elements
- Testing
- Failure Rates Based on Testing
- Failure Rates For SIL Verification

The table on the following page describes the variety of report types that are available in Vertigo. Each of these types can be customized in terms of content.

Category	Report Name	Description
SIL Verification	IPF List	A list of all IPF's in table format including inputs and outputs associated with each IPF. This report is equivalent to the IPF List grid view.
	SIL Verification Summary	A summarizing table for the selected and achieved SIL for each IPF. This report is equivalent to the SIL Verification Summary grid.
	SIL Verification Details	Complete details of the SIL Verification calculations for each IPF including, IPF overview, sensor details, logic solver details and final element details. Appendix level of detail.
	Recommendations	A list of all documents defined in a study
	Documents	A list of all documents defined in a study.
SRS	SRS General Requirements	A list of all the SRS general requirements defined in a study.
	IPF Requirements	Details the IPF SRS requirements datasheets on an IPF-by-IPF basis. A page is generated for each IPF which contains the same data as the IPF SRS details form as filtered in the Settings Page.
	Sensor Requirements	Details the Sensor requirements datasheets on a sensor-by-sensor basis.
	Logic Solver Requirements	Details the Logic Solver requirements datasheets on a logic solver-by-logic solver basis.

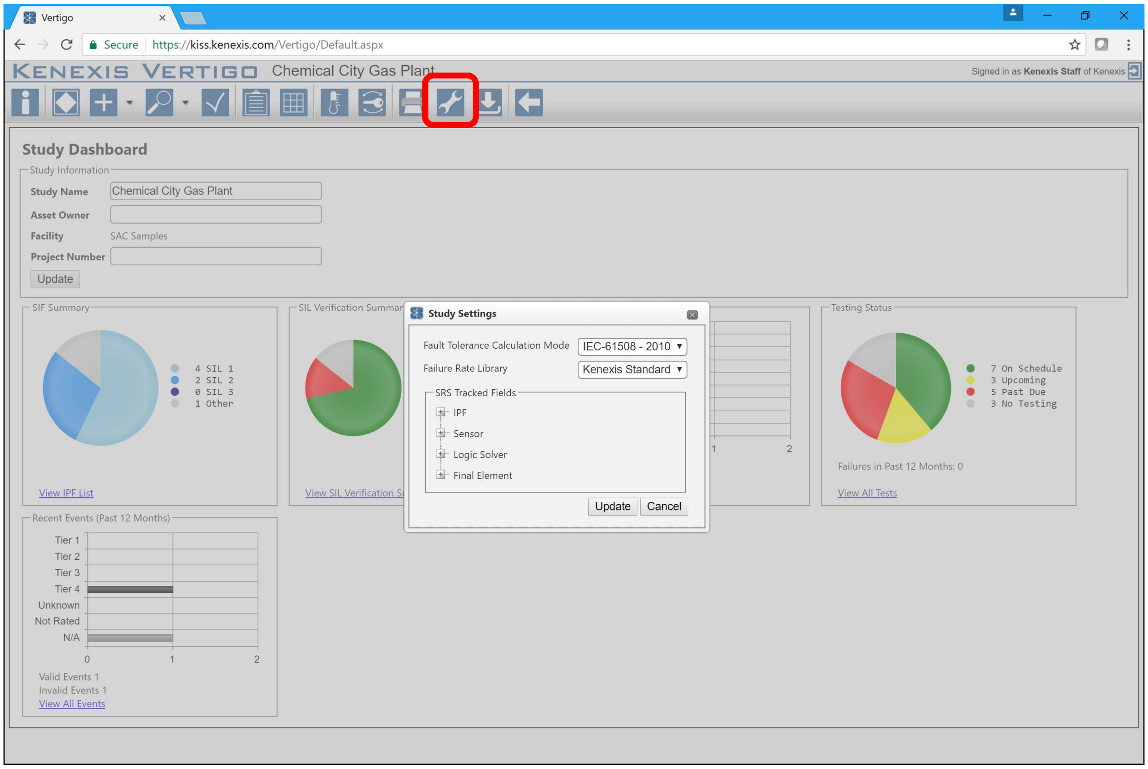
	Final Element Requirements	Details the Finale Element requirements datasheets on a final element-by-final element basis.
	Cause and Effect Diagrams	Cause and Effect diagrams for each IPF group. The Cause and Effect Diagram defines the functionality of IPF's in a sample grid format.
Sensors	Setpoint List	Details the units, range, and setpoint settings for each instrument.
Final Elements	Activation Time List	Details the action and allowable response time for all final elements.
Testing	Sensor	Provides a list of all the sensors and their current status regarding testing.
	Logic Solver	Provides a list of all the logic solvers and their current status regarding testing.
	Final Element	Provides a list of all the final elements and their current status regarding testing.
	Sensor History	Provides a list of all the tests for each individual sensor that is selected.
	Logic Solver History	Provides a list of all the tests for each individual logic solver that is selected.
	Final Element History	Provides a list of all the tests for each individual final element that is selected.
Failure Rates Based on Testing	Process Connection	Provides summary failure statistics for each type of process connection, including inventory, operational time, number of failures in each mode, failure rate in each mode

	Sensor Interfaces	Provides summary failure statistics for each type of sensor interface
	Sensor Types	Provides summary failure statistics for each type of sensor type
	Logic Solver Types	Provides summary failure statistics for each type of logic solver type
	Final Element Interfaces	Provides summary failure statistics for each type of final element interface
	Final Element Types	Provides summary failure statistics for each type of final element type
Failure Rates for SIL Verification	Process Connection	Provides a listing of the failure rate data used for SIL verifications for all process connections including failure rates, safe failure percentages, and diagnostic coverages
	Sensor Interfaces	Provides a listing of the failure rate data used for SIL verifications for all sensor interfaces
	Sensor Types	Provides a listing of the failure rate data used for SIL verifications for all sensor types
	Logic Solver Types	Provides a listing of the failure rate data used for SIL verifications for all logic solver types
	Final Element Interfaces	Provides a listing of the failure rate data used for SIL verifications for all final element interfaces

	Final Element Types	Provides a listing of the failure rate data used for SIL verifications for all final element types

Section 9 – Study Settings

Settings for a Vertigo study can be accessed through the Study Settings form. This form is accessed through the main Vertigo navigation bar as show below.



https://kiss.kenexis.com/Vertigo/Default.aspx

Study Dashboard

Study Information

Study Name: Chemical City Gas Plant
Asset Owner:
Facility: SAC Samples
Project Number:

Study Settings

Fault Tolerance Calculation Mode: IEC-61508 - 2010
Failure Rate Library: Kenexis Standard

SRS Tracked Fields
- IPF
- Sensor
- Logic Solver
- Final Element

There are three settings options which are described in detail in the following sections.

- Fault Tolerance Calculation Mode: Used to adjust the minimum fault tolerance requirements for SIF's in SIL Verification calculations
- Failure Rate Library: Change the selected failure rate library used to populate instrument type dropdown menus when inserting instrument types
- SRS Tracked Fields: Adjust the fields to be displayed on SRS details forms for IPF's, Sensor's, Logic Solver's and Final Element's

8.1 Fault Tolerance Calculation Mode

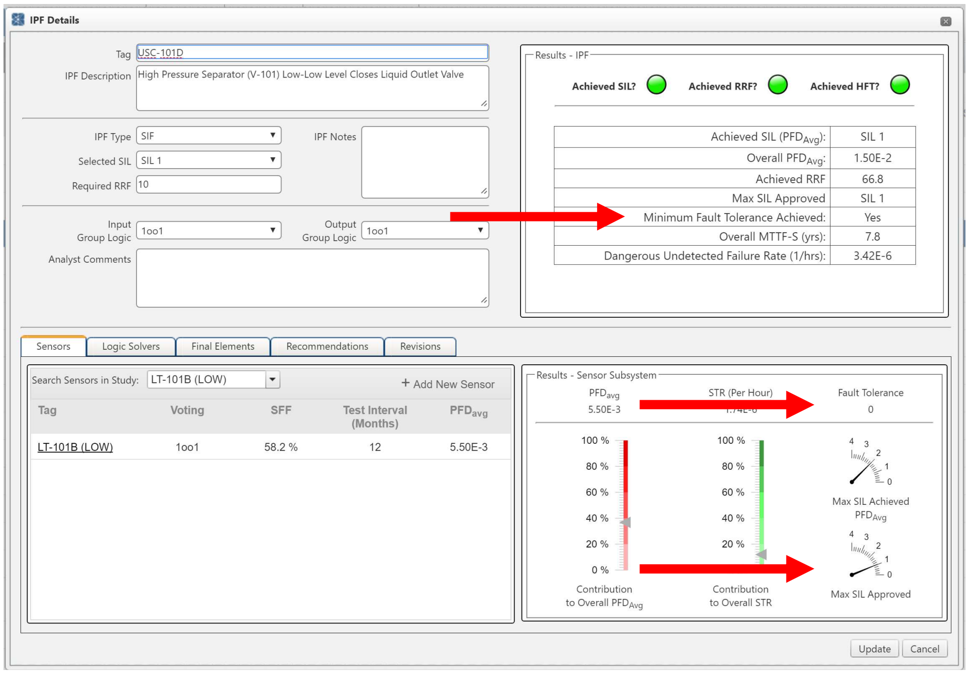
The fault tolerance calculation mode setting adjusts how hardware fault tolerance calculations are performed in SIL verification. There are three available options for the fault tolerance calculation mode.

- IEC-61511 – 2003
- IEC-61511 – 2016

Section 9 – Study Settings

By default, the fault tolerance calculation mode is set to IEC-61511 – 2003, which is the calculation method used by all Vertigo studies prior to the introduction of the fault tolerance calculation mode setting.

The IEC 61511 standard provides requirements for minimum hardware fault tolerance based on the Selected SIL for each SIF. Hardware fault tolerance can be defined as the number of hardware failures that the system can sustain and continue to operate without failure of the system as a whole. Higher SIL requirements lead to requirements for higher degrees of fault tolerance. When performing SIL Verification calculations, Vertigo will calculate the hardware fault tolerance for each subsystem (Sensors, Logic Solvers, and Final Elements) for a SIF and compare that fault tolerance against the minimum fault tolerance requirements for the selected SIL. The results of these calculations can be viewed on the IPF details form at both the subsystem and at the IPF levels as highlighted in the screenshot below.



IPF Details

Tag: USC-101D
IPF Description: High Pressure Separator (V-101) Low-Low Level Closes Liquid Outlet Valve
IPF Type: SIF
Selected SIL: SIL 1
Required RRF: 10
IPF Notes:
Input Group Logic: 1oo1
Output Group Logic: 1oo1
Analyst Comments:

Results - IPF

Achieved SIL? ● Achieved RRF? ● Achieved HFT? ●

Achieved SIL (PFD_{Avg}):	SIL 1
Overall PFD_{Avg}:	1.50E-2
Achieved RRF	66.8
Max SIL Approved	SIL 1
Minimum Fault Tolerance Achieved:	Yes
Overall MTTF-S (yrs):	7.8
Dangerous Undetected Failure Rate (1/hrs):	3.42E-6

Search Sensors in Study: LT-101B (LOW)

Tag	Voting	SFF	Test Interval (Months)	PFD_{avg}
LT-101B (LOW)	1oo1	58.2 %	12	5.50E-3

Results - Sensor Subsystem

PFD_{avg}	STR (Per Hour)	Fault Tolerance
5.50E-3	1.74E-6	0

The release of the IEC 61511 2nd Edition in 2016 came with a change to the minimum hardware fault tolerance requirements. The Fault Tolerance Calculation Mode setting allows you to select which version of the minimum hardware fault tolerance requirements Vertigo will used when performing SIL Verification calculations.

Section 9 – Study Settings

Selecting IEC 61511 – 2003 will cause Vertigo to apply the minimum hardware fault tolerance requirements from Table 5 and Table 6 of the 2003 version of IEC 61511 Part 1. These requirements are summarized below.

IEC 61511 Part 1 – 2003 Table 5: Minimum Hardware Fault Tolerance of PE Logic Solvers

SIL	Minimum hardware fault tolerance		
	SFF < 60%	SFF 60% to 90%	SFF > 90%
1	1	0	0
2	2	1	0
3	3	2	1
4	Special requirements apply (See IEC 61508)		

IEC 61511 Part 1 – 2003 Table 6: Minimum Hardware Fault Tolerance of Sensors and Final Elements and Non-PE Logic Solvers

SIL	Minimum hardware fault tolerance
1	0
2	1
3	2
4	Special requirements apply (See IEC 61508)

Selecting IEC 61511 – 2016 will cause Vertigo to apply the minimum hardware fault tolerance requirements from Table 6 of the 2016 version of IEC 61511 Part 1. These requirements are summarized below.

Section 9 – Study Settings

IEC 61511 Part 1 – 2016 Table 6: minimum Hardware Fault Tolerance Requirements According to SIL

SIL	Minimum hardware fault tolerance
1 (any mode)	0
2 (low demand mode)	0
2 (high demand or continuous mode)	1
3 (any mode)	1
4 (any mode)	2

In both the 1st and 2nd Editions of IEC 61511 Part 1, the option is provided for the user to comply with the architectural constraint requirements of IEC 61508 Part 2 2010 in place of the fault tolerance requirements defined by IEC 61511. Vertigo will always calculate the architectural constraint requirements for Table 2 and Table 3 of IEC 61508 Part 1 2010 and use the more optimistic between the 61511 standard and the 61508 standard. These requirements are shown in the following tables.

IEC 61508 Part 2 – 2010 Table 2: Hardware Safety Integrity: Architectural Constraints on Type A Safety-Related Subsystems

Safe Failure Fraction	Hardware Fault Tolerance		
	0	1	2
< 60%	SIL 1	SIL 2	SIL 3
60% - < 90%	SIL 2	SIL 3	SIL 4
90% - < 99%	SIL 3	SIL 4	SIL 4
>= 99%	SIL 3	SIL 4	SIL 4

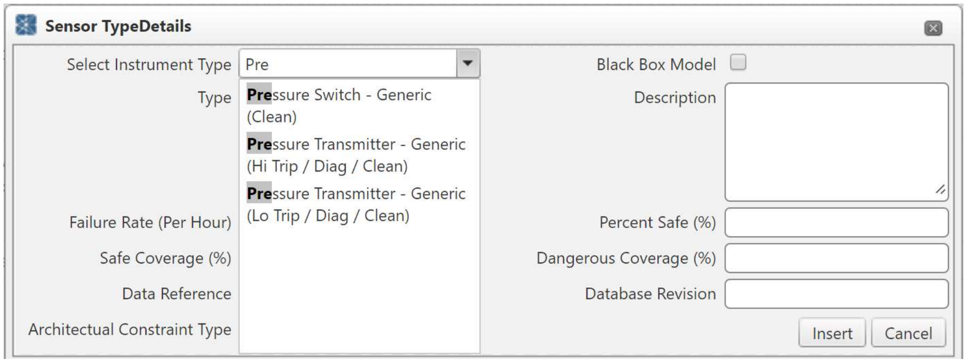
Table 8.5 IEC 61508 Part 2 – 2010 Table 3: Hardware Safety Integrity: Architectural Constraints on Type B Safety-Related Subsystems

Safe Failure Fraction	Hardware Fault Tolerance		
	0	1	2
< 60%	Not allowed	SIL 1	SIL 2
60% - < 90%	SIL 1	SIL 2	SIL 3
90% - < 99%	SIL 2	SIL 3	SIL 4
>= 99%	SIL 3	SIL 4	SIL 4

When selecting a Fault Tolerance Calculation Mode for your studies you should be aware of the legal requirements for the country in which the Safety Instrumented System will operate. Currently, not all countries are required to comply with the 2016 Edition of IEC 61511, and the 2003 Edition might be a more appropriate choice.

8.2 Failure Rate Library

The failure rate library dropdown list on the study settings form allows you to link your Vertigo study with pre-built or custom libraries containing failure rate data for instrument types. By default, when a study is created, it will be linked with the Kenexis Standard Library which is a pre-built library contained "generic" failure rate data for a wide variety of instruments used in Safety Instrumented System applications. Making a change to the failure rate library setting will affect the population of the list of instrument types you have to choose from when inserting a process connection, sensor interface, sensor type, logic solver type, final element type or final element interface through the instrument type details form. An expansion of this list is shown below.



Sensor TypeDetails

Select Instrument Type: Pre

Type:
- Pressure Switch - Generic (Clean)
- Pressure Transmitter - Generic (Hi Trip / Diag / Clean)
- Pressure Transmitter - Generic (Lo Trip / Diag / Clean)

Failure Rate (Per Hour)

Safe Coverage (%)

Data Reference

Architectual Constraint Type

Black Box Model □

Description

Percent Safe (%)

Dangerous Coverage (%)

Database Revision

In addition to the pre-build failure rate libraries, you have the option to create your own libraries, which can be accessed from any of your Vertigo studies. Building custom libraries is a great way to enforce standardization of failure rate data throughout your organization and reduce project execution times be leveraging reuse of data, reducing data entry times. To learn more about building custom libraries see the KISS Project Manager User's Manual.

8.3 Tracked SRS Fields

The tracked SRS fields setting section allows the user to determine which fields should be displayed on data sheet forms and reports for IPF, Sensors, Logic Solvers, and Final Elements. For each type of detail form, the list can be expanded to show a complete list of available fields in the "super set" of fields that are grouped into sections. The fields that the user desires to display on forms and reports by simply clicking on the check box next to the field name.