

Using Vertigo[™]

Workbook and Study Guide

V 1



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Introduction

This workbook and study guide is an integral part of the Using Vertigo[™] training module. The Using Vertigo[™] training module provides a detailed discussion of the use of the Vertigo[™] software for the lifecycle management of the Safety Instrumented Systems (SIS). The training course presents a discussion how Vertigo[™] can be used to perform analysis, design, and documentation of all phases of the SIS safety lifecycle including SIL verification calculations, safety requirements specifications, managing and



documenting SIS testing, managing and documenting bypasses, and managing, documenting, and reporting activation of the SIS.

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 – Scope and Roadmap

Safety instrumented systems (SIS) are one of the most flexible and common safeguards used in the process industries to reduce risk to a tolerable level. Design and implementation of SIS occurs using a lifecycle process that includes numerous analysis and documentation steps. Vertigo[™] is the best-in-class software tool that is utilized to facilitate this process. This training course will provide detailed instruction for how to utilize the Vertigo[™] software tool to perform SIS lifecycle activities.

Course Objectives

The overall objective of this training course is to explain how to use the Vertigo[™] software application to perform SIS lifecycle activities.

- Logging in to the Kenexis Integrated Safety Suite (KISS), creating, and managing studies
- Understand the overall interface employed by Vertigo including the navigation ribbon that allows switching between sections of the application and interacting with grids
- Interacting with the IPF list page
- Working with the SIL Verification Details Form
- Understanding how to use failure rate data in different formats and from different locations, including failure rate databases
- Learn to apply the different terms of the probability of failure on demand calculations
- Understand the structure of SIL verification data, including instrument types, instruments, and complete IPF
- View the range of calculations results for SIL verification
- Understand the structure of SRS data, including general requirements, instrument worksheets, and cause-and effect diagrams
- Learn how to track and document SIS testing, including statistical review of testing results
- Understand how to implement event tracking and monitoring
- Learn to track and document and track the authorization of bypasses
- Learn to work with the full range of reports that are available in Vertigo™
- Understand the available study settings and their impact on calculation and reporting



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ROADMAF

Section 0 – Scope and Roadmap Course Roadmap

The training course is divided into the following sections:

- Section 0 Scope and Roadmap
- Section 1 Getting Started
- Section 2 Interface
- Section 3 SIL Verification
- Section 4 Safety Requirements Specifications
- Section 5 Test Tracking
- Section 6 Event Tracking
- Section 7 Bypass Tracking
- Section 8 Reporting
- Section 9 Study Settings

Course Limitations and Prerequisites

This training course only provides instruction on how to implement SIS safety lifecycle tasks, it does not provide background on the theory behind how safety lifecycle tasks are performed, including the details of risk analysis, reliability engineering for SIL verification, and statistics related to development of failure rates and confidence intervals for failure rates. For the student to develop an understanding of the theory behind SIL verification and the rationale for the SIS safety lifecycle the authors recommend that prior to taking this training course the student should first attend the following Kenexis Training Courses.

- 1. Safety Instrumented Systems Overview and Awareness
- 2. Safety Integrity Level Verification

Also, this course assumes that the user understands how to navigate around the Kenexis Integrated Safety Suite (KISS) Project Manager section. More information on the KISS Project Manager can be found in the following Kenexis Training Course.

1. Using Kenexis Integrated Safety Suite (KISS) Project Manager

Section 1 – Getting Started

This section will provide information on logging into the Kenexis Integrated Safety Suite (KISS) of applications and how to navigate the Project Manager portion of the suite in enough detail to allow Vertigo studies to be opened and created. More detailed instruction on use of the KISS Project Manager is contained in the Using KISS Project Manager training course.

<section-header>

KISS is accessed through a web browser connected to the internet. The user should direct the browser to <u>https://kiss.kenexis.com</u> for the public instance of KISS. Users that are to access a private instance of KISS will need to receive the URL from their software administrator. The login page provides access to the suite of software after entering your username and password. If login information is lost, either username or password, this information can be retried by clicking on the "Forgot Password?" hyperlink. Also, additional assistance can also be obtained from Kenexis support via e-

mail at support@kenexis.com.

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After logging in you will be directed the Study Manager Page where clicking on your name in the title bar will bring up your account settings. In the account settings page you will be able to change your password and check the status of your licenses.

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Create New Facility and Study 1.2

New Facilities and studies are created in the Project Manager portion of KISS. A new facility can be created by clicking on the "+" icon at the top of the facilities list.

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KENEXIS INSTRUMENTED SAFEGUARD SUITE	Signed in As Kenedin	Staff of Ker	nexis 🗖
Facility List			
ITraining Instructor			

This brings up a dialog box requesting a Facility Name as shown below.



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After entering the facility name the Study Manager will show a blank Study List for the new facility. A new study is created by clicking on the "Add Study" Button and selecting Vertigo.

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Arbor Effigy Open PHA SIS SRS Vertigo	C - RU
196 - Atlantic LNG	

The new study is created and a study information page, requesting a study name and project number, is shown prior to launching into the Vertigo application with the new study.

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Once the new study is created the Vertigo application is launched and the user is moved to the Study Dashboard page of the application where the Asset Owner can also be added to the study information.



1.3 Exercise #1 – Create a Facility and Study

For exercise #1, you are required to create a new facility and a new study that will be used throughout the rest of the course. *Appendix 1* of this Workbook and Study guide contains information regarding a sample process that will be the basis for this training course. You should read through *Appendix 1* to familiarize yourself with the sample plant and the log into Vertigo and create a facility and study.

Facility Name – General Oil and Gas Operating Company – Texas City

Study Name – Gas Production Facility

Project Number – P-2004

Section 2 – Interface

This section will provide a detailed explanation of the interface employed by Vertigo including a discussion of the navigation bar for switching between application sections and the grid controls that are prevalent throughout the application.

2.1 Navigation Toolbar



The navigation toolbar is the primary means for navigating between application sections and tools.

2.2 Working with Grids – Add, Edit, Delete

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LT-1018	High Pressure Separator (V-101)	Level Transmitter - Generit(Displacement / Lo Trp)	fimit	36	1.685-0	1.74E-0	*
LT-1025	Los Pressen Separator (V 107)	Level Transmitter - Generic (Dischemment / H Trip)	toot.	36	1.646-2	1.758-0	
PT-101D	High Pressure Separator Vepor Dutiel	Pressure Transmitter - Generic (H Trip / Dieg / Clean)	1mu1	36	8,256-3	5.06E-7	×
PT-1028	Los Pressure Separator (V-102) Veper Outlet	Pressure Transmitter - General (H Trip / Diag / Clean)	1001	.30	7.81E-3	9,06E-7	
PT-1036	Esport Party (P-193) Discharge	Pressure Transmitter - Generic (H Trip / Diag / Clean)	test	36	7.818-3	9.068-7	к
PT-102C	Export Pipeline	Pression Transmitter - Generic (Lo Trip / Dieg / Clean)	tanti	36	7.896-3	0.008-7	*
PT-104C	Geo Compressor (C-104) Discharge	Pressure Transmitter - Generic (H Tilp / Dieg / Clean)	1007	36	7.81E-3	0.06E-7	*
TT-104	Gee Compressor (C-104) Discharge	Temperature Sensor - Thermocoupie - Rethnery Hydrotrealing / Hydrocraeking sensore - (Hi Trip)	1001	36	4.61E-4	1.16E-6	×

Grids are the primary tool that are used in Vertigo to interact with project data. There are data grids associated with SIS equipment items, SIS equipment types, safety requirements specifications requirements, tests, bypasses, and a variety of other items. New records can be added by clicking on the "+ Add" button that is shown for all grids. When a grid is displayed, each record in the grid can be opened for editing or deleted.



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LT:1929	Low Pressum Separator (V-102)	Level Transmitter - Generic (Displacement / H	1001	1941	1,645.2	1,756-4		1
PT.t01D	High Pressure Separator Vapor Outlet	Pleasure Transmitter - Generic (Hi Trip / Diag.) Chean)	Copy Outer	56	8.25E-3	6.09E-7	×	



INTERFACE

2.3 Working with Grids – Sorting

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Pressure Transmitter - Generic (Hi Trip / Deg.)

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Low Pressure Separator (V-102) Voper Outle

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PT-1028

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PT-MAC

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PT-103C	Export Pipeline	Pressure Transmitter - Generic (Lo Trip / Dieg.) Cloan)	tent	38	7,888-3	5.00E-7	*
FT-1038.C	Export Pung (P-10% Dautharge	Pressure Transmitter - Seneric (Le Trip / Deg / Clean)	1002	56	4.77E-4	1,80E-6	*

Grids can be sorted, grouped, and have their column display customized. Clicking on a column heading will change the sort from alphabetical, to reverse-alphabetical, to unsorted. Right-clicking on a column header will display the context menu that will allow you to select the desired sorting and group and allow the displayed columns to be changed.

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PT-1030.C	Export Pwmp (P-100) Discharge	Press Citizet # Group By	pi/ Dieg	1002	28	4.778-4	1.808-0	*	
ET-1034	Export Pump (P-103) Discharge	Press Chart III Colorite	o / Dieg	1001	19	7,816-3	DOVE-7		
PT-104C	Gas Compressor (C-104) Discharge	Descent Transmitter, Genetic IIII Cleanty	Ten II of	Toot	36	7.416-3	9.05E-7	×	
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2.4 Working with Grids – Context Menus

Many of the grids have context menus that allow you to perform specific actions to individual selected records or a group of selected records. The context menu is always accessed by right-clicking on the mouse after a selection of a record or records is made. All the context menus are different depending on the grid being displayed but copy and delete are common choices regardless of which grid is being displayed.

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ET-108LG	Export Pump (/1-100) Electrarge	Pressure Transmitter - Generic (La Trip / Dieg / Closer)	1962	36	4.778-4	1.825-0		1
PT-103A	Export Pursp (P. 103) Disphalige	Pressure Transmitter - Clarionis (Hi Trip / Dieg / Claver)	1001	36	7/81E-3	9.96E-7	*	1
PT-1946	Gas Congress (C-104) Discharge	Pressan Transmitter - Generic (Hi Traj / Ding / Chart)	topi		7.410-3	B.OEE-T		1
11-105	Can Congressen (C-104) Discharge	Temperature Sensor - Thermooning & Midney Hydrotrating / Hydrocracking service Copy	tiest	. An	4.81E-4	1.186.4		
LT-1018	High Pressure Separator (V-101)	Level Travarabler - GenericsDisplace Delete	test	30	1.686.2	1.74E-6		Г
ET 101D	High Pressure Separator Vapor Curter.	Pressure Transmitter - Generic (Hi Trip / Diag) Cleant	1001	36	8.25E-3	9.06E-7	×	

2.5 The Document List

Vertigo contains a document list that can include all the documents that a SIS design is based on. This can include the piping and instrumentation diagrams, process flow diagrams, specification sheets, safety manuals, risk analysis reports, and other various documents and specifications. The list includes information about the document and a hyper-link to allow easy access to the document from its storage location.

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Add New Document					
	Revision	Document Type	Description	Link	
0254.901	1	PID	Process Flow Diagram - Gas Production Facility	https://onedtive.live.com/redir? resid=307CB78ABBBF4372/193345auth	×
D254.002-01	1	PID	Legend Bheet - Gas Production Facility	https://onedrive.live.com/redir2 resid=307CB78ABBBF4372/19330&autr Zw&thint=11e%2codf	×
D254.002-02	3	PID	High Pressure Separator - Gas Production Facility	https://onedrive.live.com/tedir? resid=307CE78AEBBF4372/19333&auth	×
0254.002-03	1	PID	Low Pressure Separator - Gas Production Facility	https://onednive.live.com/tedir2 /esid=3D7CB78ABBBF4372r193318auft	*
0254.002-04	3	PID	Pipeline Pump - Gas Production Facility	https://onedrive.live.com/redir? resid=307CB76AB88F4372/193355auth	×

Individual documents are entered and edited in the Document Dialog Box.

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

2.6 IPF Group List

SIS instrumentation are often grouped into larger collections than just a single SIF in order to facilitate documentation, maintenance, and testing. Often equipment is grouped by plant area or major pieces of equipment. In Vertigo these groupings are referred to as "IPF Groups". IPF groups are created and edited on the IPF Groups page.

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KENEXI	S VERTIGO Texas City Gas Plant	Signed in so Edward Manazal of Feneric
HOH		
+ Add New IPF Group		
Teg	Description	
USC-101	High Pressure Separator	
USC-102	Low Pressure Separator	3
USC-193	Expert Pump	
USC-104	Export Compressor	(a)
180,105	Lunid Fund Pineine	

IPF groups are edited using the IPF Group Details dialog box.

IPF Group Details	×
Tag	USC-101
Description	High Pressure Separator
	Update Cancel

2.7 Recommendations List

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1	Add two new transmitters in the same services as PT-101 (renamine transmitters to be PT-101A B C) and conference the transmitters for a 2xx3 vote. This modification is resourced to achieve the resource (PTCARR) and meet architecture constraints. resumments of this SH, 2 function, in addition, this modification will decrease, studies, this and address the device to achieve the PFCARR) tareats at the desired increased last interval of 3 votes - site motifications.	10	High	Instrumentation and Cantrol	Penting			*
2	increase the test interval of the sensor subuvitien PT-101A B C to the desired three veen blue air month contributors / 42 month, mac),	1	High	Instrumentation and Control	Note			×
3	increase the test interval of the final element subovitien SOV-101A.8 to the desired, three years blut do month contineerby (42 month mar).	15	High	Instrumentation and Control	Note			*
								-

There are several places in Vertigo where recommendations can be generated and entered. The recommendations list provides a unified set of recommendations in one location. Recommendations can be edited using the recommendations details dialog box.

Recommendation	on Details
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 V
Responsible Party	Instrumentation and Control
Status	None 🔻
Comment	
	Update Cancel

2.7 Overview – Dashboard

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Study Name	Texas City Gas Plant		
Asset Owner	General Oil and Gas Company	()]	
Facility	General Oil and Gas Operatin	a Company	
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2.7 Exercise #2

Create a document list and an IPF list for the General Oil and Gas Operating Company Chemical City Gas Plant. *Appendix A* contains a complete list of all the piping and instrumentation diagrams for the facility. The drawings include all the information that you need to complete to document details form other than a hyperlink to a document management system, which you can ignore for this exercise. *Appendix A* also includes a list of major equipment items in the process description section. Create an IPF Group for each equipment item and tag them sequentially starting with USC-101. There is no need to create a group for the support facilities.



Section 3 – SIL Verification

This section will provide a detailed explanation of the portions of the Vertigo application that are used to perform, view, and edit SIL verification calculations. SIL verification is a core activity of the SIS safety lifecycle. It is the task where reliability engineering, probability, and statistics are combined to confirm that a proposed design can achieve its SIL target.

3.1 The IPF List

Letern/Vertigis/brits ease Chemical City Gas I Chemical City Gas I Company Events Name	Plant B more	20	0		_	_		_	Signal in an Revents Malf of P	Az I
Chemical City Gas I	Plant	2 D	8		-	-		_	Signal In on Kenneth NetT of P	
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dar (V-1913) High-High. Viden	SAF	53, 2	PT-1010	tool	toot	SEN-101	fact	1001		9
tor (V-101) Low-Low Level	SIF	51.1	17-101B	1061	Soot	80V-102A	1001	too1		
lar (V. 102) High-High Preesure.	SIF	SIC 1	PT-1025	ton	toot	50% 102A	1001	1001		2
tar (V-102) High-Miah Levelu. or (C-104)	Δ.F	55.1	LT-902B	loci	toot	G-104M	1002	tan t		1
Discharge Low-Low Flow	SIF	84.2	FT-1038,C	1065	1007	SDV-103	1001	1008		
(aba						FV-1510	toot			
Discharge High-High Pressure.	54F	54. 1	PT-103A	1001	toot	P-103M	1001	foot		0
ow Pressure Gores Export.	SIF	No SIL	PT-103G	1001	too!	SDV-163	too1	1001	Not assigned a StL - API 14 requirement for consequence mitigation. LOPA indicates framed is sufficiently low with use of a SIF.	
	ar (V-103) Ham-Hut-Lawels, er (G-109) Sacharos Low-Law Flow, dibe Sacharos Hot-Hot-Paraison, av Pressure Giores Export.	er (V-1921) High-Hudh Lewels. 114 er (G-1945) Xechanos Low-Low From. Str Alban Zischanos High-High Pressure. Str Av Pressure Closes Export. Str	er (V-1021) Han-Hadri Levela. III ^{II} SL. 1 er (G-109) Alstranne Love-Love Flore SIF SL. 2 Alstranne Hah-Hadri Pressure, SIF SL. 1 Zechanne Hah-Hadri Pressure, SIF SL. 1 In Pressure Glores Excort. SIF No SIL	ar (V-1021) Ham-Hudri Lawela, IIIP 54, 1 LT-5028 c1G-109) Sacharosa Love-Law Flow, SHF 94, 2 FT-1038, C doba Sacharosa Hude-Hude Pengelani, SHF 54, 1 PT-103A Sacharosa Hude-Hude Pengelani, SHF 54, 1 PT-103A SAC Pressure Globers Export, SHF No. 54, PT-103C	ar (V-1021) Han-Huh Lawela, nor hit, t (7-1028) toet c1G-1090 Sacharos Low-Low Flow, SiF Bill, 2 FT-1038, C 1000 Alber Sacharos Hah-Huh Perspane, SiF Bill, 1 PT-103,4 1001 Sacharos Hah-Huh Perspane, SiF No SiL PT-103,4 1001	ar (V-1021) Ham-Huar Lawela, 307 58, 7 LF-9028 tool clG-109 Alexandroa Low-Law Flow, SF 98, 8 FT-1038, C 1062 1001 Alexandroa Hah-Huar Paranaza, SF SL 1 PT-1038, 1001 1001 Sectorea Hah-Huar Paranaza, SF SL 1 PT-1038, 1001 1001 av Pressure Gloces Export, SF No SR PT-1030, 1001 1001	ar (V-CO2) Ham-Hut-Lawella, IIIP 51, 1 LT-3028 toet teol C-104M c)C-1090 Altransa Low-Law Flow, SIF 81, 2 FT-1038, C 1062 teol SCM-403 Altransa Hut-Hut-Paranam, SIF 81, 1 PT-103A tool tool P-103M av Pressure Cixces Export, SIF No 51, PT-103C teol tool SCM-103	ALVEGISE Ball, 1 LE-SO2B Tool C-TONN Tool2 ELG-1091 Secharoa Low-Law Flow SIF SL 2 FT-1038, C Tool2 SIOT SECA-102 Tool2 abbar FT-1038, C Tool2 Tool2 SIF SL 1 FT-1038, C Tool2 FULCE Tool2 abbar FULCE SIF SL 1 FT-1038, Tool2 Tool1 FULCE Tool2 Secharoa Hot-High Paralace SIF SL 1 FT-1038, Tool1 Tool1 FL00110 Tool1 Secharoa Hot-High Paralace SIF SIL 1 FT-1038, Tool1 Tool1 FL0011, Tool2 Secharoa Hot-High Paralace SIF No.SIL FT-1030, Tool1 Tool1 SCW-103 Tool1	ar (V-1021) Ham-Huar Lawaka, Bir SiL 1 (17-1028) toot tool (2-1044) tool tool c)(2-109) Sechara Low-Law Flow, SiF SiL 2 FT-1038, C tool 1001 FV-1036 tool (000) Sechara Hah-Huar Pressure SiF SiL 1 PT-1034 tool 1001 P1-1034 tool (1001) Sechara Hah-Huar Pressure SiF SiL 1 PT-1034 tool 1001 P1-1034 tool (1001) Sechara Hah-Huar Pressure SiF SiL 1 PT-1034 tool 1001 P1-1034 tool (1001) Sechara Hah-Huar Pressure SiF No SiL PT-1036 teol (1001) Schu-103 tool (1001)	ar. (V-1021) Ham-Huar Lawses. IIIF SL. 1 LT. 1028 tool C-104M 1oo2 Tool cl.C.1030 SECHADE Low-Law Fiber. SIF SL. 2 FT-1038, C 1oo2 Tool Tool dobs FE-1018 SIF SL. 1 PT-1038, C 1oo1 SECHADE 1001 Tool Tool Abbra SIF SL. 1 PT-1038, T tool 1oo1 Tool Tool Abbra SIF SL. 1 PT-1038, T tool 1oo1 Tool Tool Abbra SIF SL. 1 PT-1038, T tool 1oo1 1oo1 Tool Abbra SIF SL. 1 PT-1038, T tool 1oo1 1oo1 Tool Abbra SIF No. SIL PT-1030, Tool 1oo1 1oo1 Noc assigned a SIL - API 141 Abbra SIF No. SIL PT-1030, Tool 1oo1 1oo1 Noc assigned a SIL - API 141 Abbra SIF No. SIL PT-1030, Tool 1oo1 1oo1 Noc assigned a SIL - API 141 requinterter for consequanter requinement for consequanter for consequ

The IPF list is the primary interface for interacting with the SIF that are included in any study. This SIF list contains information on each SIF including, tagging description, inputs, outputs, group voting and notes.

3.2 The IPF Details Form

The IPF details form provides identification information for the SIF, a summary of the IPF calculation results, access to details on the equipment that comprises the SIF, and calculation results for individual subsystems of the SIF.

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3.3 Working with Instrument Types and Failure Rate Data

SIL Verification Calculations begin with data regarding the failure rate characteristics of the equipment that comprises the SIF. Since many instruments are of the same type, Vertigo begins the process by defining "types" of instruments that are included in a study. These equipment types fall into the following categories:

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

Sensor types are defined on a project level and can be defined in four ways:

- Pulled from a library
- Custom defined for a project
- Black Box Model Direct Input
- Black Box Model from Arbor Fault Tree

3.3.1 Selecting a Failure Rate Library

The most common way to assign failure characteristics to equipment types is to obtain those rates from a library. Kenexis Vertigo allow the user to select from the Kenexis standard library or custom libraries that are built by users or user organizations.

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109C-101A	High Pressure. Securitized (V-1011	- 54	Pallure Rate Library	Kenevis Standard *	IDV-MIA9 ICLOSES	1002	1401	- 80	PLC			
	Han Han		(d) 177	Gustom	20							
	Energy States		e Sensor	Eds Custom	2							
UBC-1018	High Flessure Segurator (V-101)	OF	al Logic Solver	Renexa contractory	BATOL/VOL	1002	1001	2010	村(0)			×
	LowLow.			Update Cancel	1.00000							
	miet Vatve			Constraint, Constraint,								
USO-1010	High Pressure Secendar (V-101) High-High Lavel	SF.	No Sit. LT-101 UNCH	B 1001 1001 0	SOV-IDIAB (CLOSE)	1002	1001	5949	FLC			

3.3.3 Create a Custom Instrument Type

Custom instrument types are employed when a user desires to enter failure rate data for components in directly, and then have the Vertigo calculation engine calculate the PFD and STR of subsystems.

Add New Denser, To	on service traditions. I service types	rolin zowi Jbei	THE DECENTION		Carried	
	Sensor Type Details	Variante Sent Same	10 (1990) (1990) (1990) 10 (1990)	0.266610	With With Liney	
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amiliar	Failure Bate (Der Heury 10.00F.4	Dercard Safe Hill	61/01/16	1.2.02.0		
e Delector De	Safe Coverage (%) 0:00 %	Dangerous Covenage (%)	55.00 %	1 15E-7	0	×
ics X3301 / K336	Data Reference (Plant Records	Database Revision	0	111415-0	-	
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sd)	Time Triget in Some Triget Scher while English					
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ne Detector - enc - MV/IR	Flame Detector - Generic - 1 8.00E-8 UV/IR Detectori	30.0 % 0.0 % 95.0	% 0.00E0 1.80E-6 2.73E	-6 1.47E-6	0	×

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VERIFICATION

3.3.2 Create an Instrument Type from a Failure Rate Library

The most common way to create an instrument type is to pull the data from the library that has been selected in the settings dialog. Selecting the item from the drop down list will cause its information to be copied to the project. The "Current with Library" light tells the user whether the data in the project is consistent with the library and allows you to update.

KEN	IEXIS VE	RTIGO Texas City	/ Gas Plant	(and the Parameter)			24	rail II as Er	Anard Marso	Lat. of high	
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1	Connection S	enes minifares Serve	r Turres - Lorne Sel	Care Terrere Care Foreign						PC.	
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0.680-				Pestion	101	54.)	0.00E0	0.00€0	0	ж.	
N Bog B	Failure Rate (Per Hour)	3.005-6	Fercent Safe (%)	40.00 %			Grandelle		0	5. H	
Action of the second of the se	Sele Coverage (%) Data Reference	0.00 % 8.001	Dangerous Coverage (%) Database Revision	0.00 N	12	-0	0.0066	1.006-6			
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Gal and	(Sibrid)	Hanlant, in gel talang									
Clustom Fi	cal Element Custom	9		N. N.					0	H.	

3.3.4 Create a Block Box Model Instrument Type

If a system is very complex, instead of entering in failure data and having Vertigo calculate PFD and STR for the subsystem, it can be entered directly. Simply check "Black Box Model" and enter the PFD and STR directly.

NENE/	XIS VERTI	G Texas City G	las Plant			299	al 11 pa Bahna	ed Marsdal	d Harana
Process Con					rinertac		anal Elect	and Type	
+ All North	🚺 Logic Solver Type Details								
Type			flack des Moder	8		600	April .		
	Type	Logic Solver from Vendor X - Black Box Model	Description	Logic Solver Vendor X Supplied Data for the				Library	
General F cot				Complete Subsystem Including all cards and Interfaces	7	005-6	1.00E-6	0	×
Generic 8 . 1	PFDarp	316.5	STR (Par Hour)	2.56-9	7	935-7	1.008-8	0	*
PLC	Link PFD to Fault Tree		Link STR to Fault Tree						
Lpos.Son r.E	Hardware Fault Tolerance	1 •}	Mar Sil, Approvet:	51.3 *				0	18
	Data Reference	Vendor X Datasheet	Ostatase Revision	0					
	Architectual Constraint Type	8 *		insert Cancel		/			



3.3.4 Create a Block Box Model from Arbor Fault Tree

A common way to generate the PFD and STR for complex systems is by using a fault tree analysis. Vertigo allows you to directly connect a Vertigo study's instrument type data to an Arbor fault tree analysis study.

KENEX	IS VERTIGO Texas City Gas Pla	ant	9	grad III as Edward Marsdal of Variana 🖥
Process Conne	ctum Sense mierfaces Sense Vacs	Logic Solver Types Titual General Interfa		Fanal Element Types
+ Abit Firme Constant	Tipe			
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	Type Eutom Configuration from Pault Tree for PT Compensated Flow	Description Configuration from Fault Tree for PT Compensated From		
Anter Clisiciacament Service - Generic			30E.0	2 505-7
Custom Confourat from Fault Trave for Compensated Flow	Seact Arbor Study (FT Compensated Flow *)	Link STR to Asult Tires		0 *
Guttern Etessure. Transmitter	Architectual Constraint Type A	Update Cancel	- 06-8	1,205-5
Flame Detector - D Tromca X3301 / X3	ed. Flame Detector - Manufacturer <u>0</u> 2.925 202, Det Tranice - Modell XXX01 /	14 12.3 % 0.0 % 95.5 % 0.00E0 3.586-7	2.455-8	1.156-7 🔘 *

3.4 Working with SIF Components

SIF are generally made up of a sensor subsystem, logic solver subsystem, and final elements subsystem. Each subsystem can be comprised of multiple instrument groups, but each instrument group is created individually on its component details page. The components that can be defined include.

- Sensor
- Logic Solver
- Final Element

3.4.1 Component Details – Sensors

Sensors are created, defined, and edited on the sensor details page.

KENE	XIS V	ERTIGO Tex	as City Gas Plant			59	nt in as Ed	heard Marsaal (P	lamoth
HO	E3 · M			20	C				
ALS BAS		an array heat too			0.30				
Servers	Louis Selva	ers Final Elements							
+ Anti Merie Tar		Sensor Details							
145	Service De	Type Pr	essure Transmitter - Generic (),	o Trip / Diag / Ci	seri)	• New	1	STR.	
ET-1028.	Export Pun	76g FT	-1038 (JOW)	Descriptio	e Export Pump Orac	harge	2	9.00E-7	*
EZT-101A	isign Press	The state of the state of the			- [200]		-2	4.53E-6	
QT-1058	Ges Comp	Device Selection Basia	C 61508 Complant]	9 [1001.		3	2.50E-7	×
LT-1016	High Press	Process Connection	one ore			• New	3	1.75E-6	×
LT-101R	High Press	Sensor Interface 2 N	orw.			•			ж
LT-1028	Low Press	Overall Subsystem Failure	Rates 7	λ ₅₀ λ ₁ .50E-7 0.00	μ λ ₀₀ E+0 1.50E-7	λ ₀₀ λ _{0N} 6,00E-7 0.00E+0	æ	0.00E0	
LT-1028	Low Please	Failure Component	Factor(s)	1	PFD _{ang} Contributions	STR Contributions (Per Hour)] 3	1.74E-6	×
T-110 (LOW)	Compressie	Dangerous Undetected Spurious Pailura	MTR (Hours)	72	2.108-Z	0.00E+0	1	1.74E-II	8
PD7-1950	Compresse	Include Common Cause No Trip on Detected Failure	Beta Factor: 🚺 Diagnostic interval (Hours)		0.00E+0 0.00E+0	0.00E+0 9.00E-7	3	R 00E-7	×
ET-092	Low Press	Online Testing Imperfect Testing	Text Duration (Hours) Proof Test Coverage		0,00E+0			3.00E-7	*
FT-101D	High Press		Useful Life (Wears)	TOTALS:	2.106-2	9.00€-7	2	0.006.0	×
ET-101D	High Press					Update Cancel].,	1.10E-9	×
ABC/HOH	regarment L		Diag (Cwan)					1.106-9	

3.4.2 Component Details – Calculation Components

The component details page allows modification and shows results for the various items that contribute to the overall PFD and STR of a component, sub-system, and SIF.

Failure Component	Factor(s)		PFD _{avg} Contributions	STR Contributions (Per Hour)
Dangerous Undetected	MTTR (Hours):	72	1.79E-3	
Spurious Failure				9.72E-12
Include Common Cause	Beta Factor: 🔚	0.005	1.13E-4	7.50E-10
Trip on Detected Failure	Diagnostic Interval (Hours):		0.00E+0	3.45E-10
Online Testing	Test Duration (Hours):	16 🗘	5.22E-4	
Imperfect Testing	Proof Test Coverage:	0.99	9.32E-6	
	Useful Life (Years):	25		
		TOTALS:	2.43E-3	1.10E-9







3.4.3 Component Details – Logic Solvers

Logic solver information is entered on the logic solver details page.

ogic Solver Details				
Type Gen	eric SIL 3 Certified PLC			▼ New
Tag SIS P	LC	Descripti	on Safety PLC Logic	Solver
Test Interval (Months) 84		Voti	ing 1001	T
		λ _{SD} 2	λ _{SU} λ _{DD}	λ _{DU} λ _{DN}
Overall Subsystem Failure R	ates	8.10E-6 9.0	0E-7 9.90E-7	1.00E-8 0.00E+0
Failure Component	Factor(s)		PFD _{avg} Contributions	STR Contributions (Per Hour)
Dangerous Undetected	MTTR (Hours):	72	3.07E-4	
Dangerous Undetected Spurious Failure	MTTR (Hours):	72	3.07E-4	9.00E-7
Dangerous Undetected Spurious Failure Include Common Cause	MTTR (Hours): Beta Factor:	72	3.07E-4 0.00E+0	9.00E-7 0.00E+0
Dangerous Undetected Spurious Failure Include Common Cause Trip on Detected Failure	MTTR (Hours): Beta Factor:	72	3.07E-4 0.00E+0 0.00E+0	9.00E-7 0.00E+0 9.09E-6
Dangerous Undetected Spurious Failure Include Common Cause Trip on Detected Failure Online Testing	MTTR (Hours): Beta Factor: Diagnostic Interval (Hours): Test Duration (Hours):	72	3.07E-4 0.00E+0 0.00E+0 0.00E+0	9.00E-7 0.00E+0 9.09E-6
Dangerous Undetected Spurious Failure Include Common Cause Trip on Detected Failure Online Testing Imperfect Testing	MTTR (Hours): Beta Factor: Diagnostic Interval (Hours): Test Duration (Hours): Proof Test Coverage:	72	3.07E-4 0.00E+0 0.00E+0 0.00E+0 0.00E+0 0.00E+0	9.00E-7 0.00E+0 9.09E-6
Dangerous Undetected Spurious Failure Include Common Cause Trip on Detected Failure Online Testing Imperfect Testing	MTTR (Hours): Beta Factor: III Diagnostic Interval (Hours): Test Duration (Hours): Proof Test Coverage: Useful Life (Years):	72	3.07E-4 0.00E+0 0.00E+0 0.00E+0 0.00E+0 0.00E+0	9.00E-7 0.00E+0 9.09E-6

3.4.4 Component Details – Final Elements

Final elements information is entered on the final elements details page.

Final Element Details							
Type A	Actualed Ball Valve, Generic					+ Nec	
10	V-101A/8 (CLOSE)	Descrip	tor Hø	Pressure Sep	re Separator Iniet		
Test Interval (Months) 75			Ting Too	2			
Device Selection Basis Se	ed ten						
Inal Exercic Interface 1 Ge	neric 3-way SOV (017)					+ New	
Inal Bernert Interface 2 No.	re.					•	
Final Demont Ty Final Demont Int	pe. artica 1	3 ₁₀ 0.02E+0 0.02E+0	3 ₅₀ 1458-8 1255-4	300 0.002-3 0.005+0	1,355-8 8,006-7	April 0.008-0 0.008-0	
Overall Subsystem Failure	Rates	0.00(+8	2.858-6	0.006+0	2.156-6	0.005+0	
Failure Component	Factorité		Coe	PFD _{avg} tributions	STR Cor	tributions Hour)	
Dangerous Undelacted	MTTR (Hours):	72	1	5.228-3			
Spurious Relium					5.5	125-6	
Incude Common Caul	e Beta Factori 🚺	0.005		104E-4	-61	KE+0	
18 Top on Detected field	e Diagnostic Interval (Hours)		1.0	1.00E+0		20E+0	
12 Online Testing	Test Duration (Hours)		1	5.005+3			
17 Imperfect Testing	Proof Test Coverage			1.00E+0			
	Useful Life (Years)		1				
		TOTALS	1	5.310-3	5.1	706-6	

3.5 SIL Verification Data Validation Log

Vertigo provides a utility that allows the user to check the calculation status of all the components, subsystems, and SIF in a study. The utility will check each calculation to ensure that all the data required to perform the calculation is present. The data can also be copied and exported to other applications.

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St	SIL Verification Data Validation			×	ן ר
	Validation Log				
S	Beginning Sensor Interfaces Calculations			<u> </u>	
₽ F	Beginning Sensor Types Calculations Lamda's for sensor sensor type could not be calculated due to incomplete failure rate	e data			
F	Beginning Process Connections Calculations				
	Beginning Final Element Interfaces Calculations				
	Beginning Final Element Types Calculations				
	Beginning Logic Solver Types Calculations				
	Beginning Sensors Calculations				
	PFD dangerous diagnosed contribution could not be calculated for the sensor PT-002 option is set to false and there is missing data for the diagnostic interval	because the vote to	o trip		
	PFD and STR could not be calculated for the sensor LT-101B (LOW) because a sensor t	ype has not been a	ssigned		
	Beginning Final Elements Calculations				
	Beginning Logic Solvers Calculations			-	
		Copy To	o Clipboa	ard	
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3.6 The SIL Verification Summary

The SIL Verification Summary page provides an overview of the results of all the SIF in study, but not the details of the calculations. This page is useful for determining, which, if any, SIF in a study have not achieved their targets.

+ AAL New IFE	PF Description	#F 346	Selected	Required	Achieved	Minimum Fault	Max 55.	Shifed	
		000000	36.	RRF	Rittle	Tolerance Slatisfied	Approved	-	
UZC-101A	High Pressure Separation (V.101) High High Printage Closes Intel Value	8#	84.2	100-	187.1	140	SL1		0
U20-11118	that Presses Separator 19:1011 Love-Low Lonet Occess Outlet Value	58	54.1	10	20	Yes	381. 1	0	
11212-1112A	Low Pressure Separator IV-1021 High-High Pressure Closes Intel Value	240	51, 1	16	58	Yes	541. 5	0	-
UZC-1025	Low Pressure Separator (V-102) High High Levels Stops Gas Concreasor (C-104)	8#	BIL 1	10	80	Yes	OL 1	0	*
U2C-1034	Expert Pixerp (P-100) Discharge Low-Low Pixer Closes Arth-Backflow Weine	5#P	86.2	100	1065	Yes.	54.2	0	*
020-038	Excert Party JP-1021 Discherum High High High Pennare Stops Party	147	56.1	10	85		346.1	0	*
u20-1090	Export Pipetine Low Pressure Green Export Wiles	8#F	No DL		28	76/8	84.1	0	*

SIL VERIFICATION

3.7 SIL Verification Revisions Page

This page allows the user to view the revision level and approval status of all SIF in one location.

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IPF List	SIL Verification Summary Events Revision	ons					
Tag	IPF Description	IPF Type	Revision	Date	Checked	Approved	
USC-101A	<u>High Pressure Separator (V-101) High-High</u> Pressure Closes Inlet Valve	SIF	1	Oct 10 2017	ø	¢.	^
USC-101B	High Pressure Separator (V-101) Low-Low Pressure Closes Inlet Valve	SIF	0	Nov 26 2018			
USC-101C	High Pressure Separator (V-101) High-High Level Closes Inlet Valve	SIF	0	Nov 26 2018			
USC-101D	High Pressure Separator (V-101) Low-Low Level Closes Liquid Outlet Valve	SIF	0	Nov 26 2018			
USC-102A	Low Pressure Separator (V-102) High-High Pressure Closes Inlet Valve	SIF					
USC-102B	Low Pressure Separator (V-102) Low-Low Pressure Closes Inlet Valve	SIF					
USC-102C	Low Pressure Separator (V-102) High-High Level Closes Inlet Valve	SIF					
USC-102D	Low Pressure Separator (V-102) Low-Low Level	SIF					•

3.8 Exercise #3

Create a SIF definition and perform SIL Verification Calculations for the High-Pressure Separator SIF of the General Oil and Gas Operating Company Chemical City Gas Plant. *Appendix A* contains a complete list of all the piping and instrumentation diagrams for the facility. The High-Pressure Separator is shown on Drawing D-254-002 Sheet 2 of 6.

There are two SIF associated with this vessel, both operating in low demand mode:

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

• SIL 2 Target with Minimum Risk Reduction Factor of 150

USC-101B – High-Pressure Separator (V-101) High-High Level Closes Inlet Valve

• SIL 1 Target with Minimum Risk Reduction Factor of 35

The inputs and outputs to these functions can be seen on the drawing and are connected to the USC-101 function. Assume that the inlet shutoff valve type is a "Air Actuated Ball Valve, Generic", all level transmitters are "Level Transmitter – Generic (Displacement)", and all pressure transmitters are "Pressure Transmitter – Generic". For the inputs, assume that the process connection for the pressure transmitter is "typical" in clean service and that for the level transmitter the connection is "large" and in clean service. Also assume that there are no interface devices between the logic solver and the sensors. There is a single interface device for the shutoff valve which is a "Generic 3-way SOV (DTT)". The logic solver in this case is a "Generic SIL 3 certified PLC". The "Generic SIL 3 Certified PLC" data entry is an Equivalent 1001 type, so the voting should be 1001 regardless of the actual configuration. While the logic solver has been third party certified to be compliant with IEC 61508, the field devices have been selected based on prior use experience.

The major turnaround interval for this plant is 3 years, so assume a 36-month test interval, and also assume a Mean Time To Repair (MTTR) of 72 hours for all components. For the first pass of calculations, assume common cause is ignored, detected failures of all components result in a vote to trip (i.e., cause a shutdown), no online testing is performed, and manual proof testing is 100% effective.

1. Based on the above, determine Achieved SIL, Achieved RRF, and Overall MTTF-S for both SIF.

- Change the voting arrangement of the sensor subsystem for pressure measurement to 2003 voting with a common cause failure beta factor of 5%. For the high-pressure SIF – determine Achieved SIL, Achieved RRF, and Overall MTTF-S.
- Change the response to detected failures for the pressure measurement subsystem to NOT trip on detected failures and include a diagnostic interval of one PLC scan (effectively 0). For the high-pressure SIF – determine Achieved SIL, Achieved RRF, and Overall MTTF-S.
- Change the testing to "imperfect" for the pressure measurement subsystem and include a proof test coverage of 95% and a useful life of 25 years – determine Achieved SIL, Achieved RRF, and Overall MTTF-S.
- Change the testing to include online testing for the pressure measurement subsystem and include two annual tests (after year 1 and after year 2), each having a duration of 2 hours (4 hours total over the mission) – determine Achieved SIL, Achieved RRF, and Overall MTTF-S.





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Section 4 – Safety Requirements Specifications (SRS)

This section will provide a detailed explanation of the portions of the Vertigo application that are used to perform, view, and edit SIL verification calculations. SIL verification is a core activity of the SIS safety lifecycle. It is the task where reliability engineering, probability, and statistics are combined to confirm that a proposed design can achieve its SIL target.

4.1 SRS Overview

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SRS General Requirements	IPIF Requirements Sensor Requirements Logic Solver	Requirements	Final B	Element	Requi	ements	
+ Add New General Requirement			+1	mport Re	quireme	inta From I	Library

SRS data can be accessed from the Safety Requirements Specifications and Cause-and-Effect Diagrams pages. There are three types of SRS data:

- General Requirements (and Specific Requirement Notes)
- Datasheets
- Logic Description (Cause-and-Effect Diagrams)

General requirements and datasheets for IPF, Sensors, Logic Solvers, and Final Elements are all accessed from the Safety Requirements Specification pages by using the tab strip at the top of the page. The set of cause-and-effect diagrams is available on the Cause-and-Effect diagram page by selecting which IPF Group's cause-and-effect diagram is to be displayed.

4.2 SRS General Requirements

General requirements are a listing of textual specifications that apply to all instruments and IPF of a SIS. The general requirements are listed in a grid. Specific requirements or specific notes are also incorporated into the general requirements grid. Each requirement record contains a number, grouping labels (for sorting and classification purposes), and the text of the requirement itself. A large group of standardized general requirements can be imported from a library of individual requirements can be entered.

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H K	1 + · P ·									
SRS Ge	neral Requirements	IPF Requirements Se	nsor Requirements Logic Solver Requirements	Final Element Requirements						
+ Add New	General Requirement			+ Import Requiriments	From L	ibraity.				
Item	Reg Group		Requirement							
11	Purpose		This document specifies the safety requireme (IPF) associated with the Gas Plant at the Ter the Safety Instrumented System (SIS). This is of the functional activity performed by the SIS ortical. This specification describes both the requirements of each IPF.	This document specifies the safety requirements of Instrumented Protective Functions (IPF) associated with the Gas Plant at the Texas City Facility. All IPF together represent the Safety Instrumented System (SIS). This document also specifies requirements for all of the functional activity performed by the SIS regardless whether or not it is safety critical. This specification describes both the functional requirements of each IPF.						
12	Purpose		Where applicable, this specification is design 84 01-2004 Application of Bafety Instrumente IEC 61511 Functional Safety – Safety Instrum	Where applicable, this specification is designed to be in compliance with ANSI/ISA 84 01-2004 Application of Bafety instrumented Systems for the Process Industries and IEC 61511 Functional Safety – Safety Instrumented Systems for the Process Sector						
14	Field Devices	Use blue paint on solenoids.								
21	Scope		This SRS applies to the SIS of the Gas Plant. Plant Safety instrumented System (SIS) designated actions.	This SRS applies to the SIS of the Gas Plant, including the IPF identified in the Gas Plant Safety instrumented System (SIS) design basis report and other additional non- safety ortical actions.						
22	Score		This SRS specifies requirements for functional Plant Unit SRS decign as per industry consens applicable) and Client engineering practices I functional usfaty. This SRS provides goosnal details that are specification of the system's a	I safety and safety integrity of the Gas sus standards from ISA and IEC (where half guide users of automation in activering functional requirements of the SIS and i safety. This document docs not provide defailed design. The selection of specific						

4.3 SRS Datasheets

Detailed information that is applicable to individual portions of an SRS are documented in datasheets. The content of the datasheet, in terms of available fields, is customizable from the Settings tab, allowing the user to only select the portion of the field superset that is appropriate for their organization.

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	Cotgrasso (04)	Report	[]	Date	商		
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1002-1108	Parts Parts (P-520 Dad	HADOF Description	[1
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		UF Special Master (Startup, Satching, etc.)					
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		Required Process Labory Time	(î	Made of Second	a 1464a 🔹 🔹		
		Achieved Possess Safety Time	()	Operation			
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Datasheets are available for:

- IPF
- Sensors
- Logic Solvers
- Final Elements

4.4 Cause-and-Effect Diagrams

Vertigo documents SIS logic using cause and effect diagrams. The cause and effect diagram of each IPF Group can be viewed and edited by selecting the cause-and-effect diagram button from the navigation bar and then selecting the appropriate IPF Group from the IPF Group down box.

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USC-101		▦		3	/	Ł	Ŧ			
			Voting	1002	1001					
			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	1001			Х					
LT-101B (HIGH)	High Pressure Separator	1001	~	Х						
LT-101B (LOW)	High Pressure Separator	1001	2	N16						
PT-101D (LOW)	High Pressure Separator	1001	1	X						
PT-101D A,B,C (HIGH)	High Pressure Separator	2003	*	Х						
Update										

4.5 Exercise #4

Create some of the SRS information for the High-Pressure Separator SIF of the General Oil and Gas Operating Company Chemical City Gas Plant. Refer to *Appendix A* the



required plant information. The SRS information that should be incorporated for this exercise include the following.

- Insert the set of general requirements from the Kenexis Standard Library
- Insert a new general requirement
 - o Item Number 16
 - o Group: Specific Notes
 - Requirement: Incorporate a 20 second time delay on closure of the high-pressure separator inlet vessel upon detection of a high level in the separator vessel.
- For the IPF tagged USC-101A add the following information:
 - IPF Group = USC-101
 - Equipment Number = V-101
- For the IPF tagged USC-101B add the following information:
 - IPF Group = USC-101
 - Equipment Number = V-101
- For the sensor tagged LT-101B
 - IPF Group = USC-101
 - Trip Type = HH
 - Data Reference = Sheet 2 of 6
 - Safety Critical = Checked
- For the sensor tagged PT-101D
 - IPF Group = USC-101
 - Trip Type = HH
 - Data Reference = Sheet 2 of 6
 - Safety Critical = Checked
- For the final element tagged SDV-101 (Close)
 - IPF Group = USC-101
 - SIF Action =Close
 - Data Reference = Sheet 2 of 6
 - Safety Critical = Checked
- Build out the cause-and-effect diagram intersections showing a reference to note 17 for the intersection with LT-101B



Section 5 – Test Tracking

Section 5 – Test Tracking

This section will provide a detailed explanation of the portions of the Vertigo application that are used to track and document the testing of SIS components.

5.1 Test Tracking Overview



The test tracking and documentation section of Vertigo is accessed by selecting the Testing button on the navigation bar. This will bring you to the testing page which displays grids for all of the components of each type. There are grids for sensor, logic solvers, and final element.

5.2 Testing Summary Grid

The testing grid for each SIS subsystem that lists the individual components of that type. The grid lists the current status of test for each component including test interval, date last tested, test due date, and a status light. From this form the user can view the historical test results for any component by clicking on its hyperlink. Also, the user can create a test record for all of the components into the database at one time by clicking on the link "+Create Tests for All Sensors", or logic solver, or final element.

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Sensor Testing	Logic Bolver Testing Final Element Te	staro.					
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tau	Service Description	induariant Type	Text Interval (Workfrai)	Date Last Tested	Text Das Date	Status.	
ET.1038.C	Export Pure (P. 103) Dechorpe	Pressure Transmitter - Generic (La Trip / Diop / Clean)	36	Jun 9 2016	Jun 9-2019	0	×
LT-1018	High Pressure Separator (V-101)	Level Transmitter - Generic/Displacement / J.o. Trip)	30	May 3 2010	May 3 2019	•	
LT-1078	Low Prepare Separator (V-102)	Lavel Transmitter - Deneric (Displacement (PR Trp)		Nov 15 2013	Nov 14 2018	0	
E5-1010	High Processe Separator Vayor Outlet	Pressure Transcritter - Genetic (H Trip / Dieg / Cleen)	30	May 10 2013	Wey 9 2016	0	*
PT-1029	Low Pressure Separator (V-102) 'Hapor Dutlet	Pressure Transmitter - General (H. Trip) Ding / Gent)	36	Nov 15 2015	Nov 14 2018	0	ж
PT-103A	Equati Pure (P-100) Decharge	Pressze Traventar - Genetic (Hi Trip / Dag / Case)	26	Nov 15 2018	New 14 2018	0	
PE-103C	Export Pipeline	Pressure Transmitter - Generic (Le Trip / Dieg / Gean)	- 38	Apr 7 2018	Apr 7 2019	0	*
EE:1040	Gas Compressor (C-104) Discharge	Pressure Transmitter - Generic (Hi Trip / Diog / Gean)	34	Nov 15 2015	Nov 54 2018	0	ж
11-10 4	Gas Compressor (C-104) Discharge	Temperature Sensor - Thermoscupia - Referry Hydrometing / Hydromacking service - 0.4 Tep	30			0	
Section 5 – Test Tracking

5.3 Testing Details

For each component, there is a testing details form that includes testing attributes of the component along with a list of all the tests that have historically been performed for that component. Each individual test can be viewed and edited by clicking on the individual test's hyperlink.

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ests For All Sense							Derigter	Add New S
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O *							Low	T-1028
							Auto	
							Exp	T-103A

5.4 Exercise 5

Create some test tracking information for the High-Pressure Separator SIF of the General Oil and Gas Operating Company Chemical City Gas Plant. Refer to *Appendix A* the required plant information. The test tracking information that should be incorporated for this exercise include the following.

- For all four instruments that were created, insert a commissioning date of two years in the past
- For the LT, logic solver, and valve, insert a passed test with today's date
- For the PT insert a failed test (today's date) with a failure mode of Dangerous Detected, a description of Failed to Function, and failed component of "Sensor Type"

Section 6 – Event Tracking

Section 6 – Event Tracking

This section will provide a detailed explanation of the portions of the Vertigo application that are used to track and document activation events of SIF or other protective functions managed using Vertigo.

6.1 Event Tracking Overview

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IPF	List SIL V	verification Summary	Events Revisions					

The event tracking and documentation section of Vertigo is accessed by selecting the IPF List button on the navigation bar and then selecting "Events" from the . This will bring you to the testing page which displays grids for all of the components of each type. There are grids for sensor, logic solvers, and final element.

6.2 The Event Tracking Grid

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Tag	IPF Description	IPF Type	Selected SIL	Number of Valid Events	Operational Tune (Years)	Event Rate (per Ynat)	Expected Demand Rate (per Year)	State	15	
USC-101A	High Pressure Separator (V-101) High-High. Pressure Closes Intel Valve	SF	SIL 2	0	2.62	0.00E0	1.00E-2	C)	i
USC-101B	High Pressure Separator (V-101) Low-Low Pressure Closes inlet Valve	SIF	SIL 1	1	2	4.99E-1	1.00E-1	C)	
USC-101C	High Pressure Segarator (V-101) High High Laval Closes Inlet Valve	SIF	No SIL	0	2	0.00E0	1.00E-1	0)	
USC-101D	High Pressure Separator (V-101) Low-Low Level Closes Liquid Outlet Velve	SIF	SIL 1	0	<u>.</u>	0.00E0	1.00E-1	0)	
USC-102A	Low Pressure Separator (V-102) High-High Pressure Occes Inlet Valve	SF	SIL1	•	2	0.00E0	1,00E-1	0		
USC-102B	Low Pressure Secarator (V-102) Low-Low Pressure Closes Inlet Valve	SIF	SIL 1	0	2	0.00E0	1.00E-1	0)	
USC-102C	Low Pressure Secarator (V-102) High-High Level Globes Init! Valve	SIF	SIL 1	0	2	0.00E0	1.00E-1	0)	
USC-102D	Low Pressure Secarator (V-102) Low-Low Level.	SIF	No SIL	0	1.99	0.00E0		G)	

The event tracking grid displays each IPF's events, event rate, and status.

Section 6 – Event Tracking



6.3 The IPF Event Details Forms

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742	USC-1018	If Description	High Pressure Separation (V-101) Low-Later	-11		
Des Connectioner	e ber kine 👸		Pressure Cases Intel Valve			
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06 December 2018 00	65 E	1	Ter 1	×	APR RP 754 Seventy (Specificm Event Notes	
			(Lenters) (Si		-	[insert] [Ca

Each individual IPF has a details form for input of commission/decommission dates and expected demand rate along with a list of events. The event input includes date and time, means of collection, validity, API 754 severity, and notes.

6.4 Exercise 6

Create some event tracking information for the High-Pressure Separator SIF of the General Oil and Gas Operating Company Chemical City Gas Plant. Refer to *Appendix A* the required plant information. The event tracking information that should be incorporated for this exercise include the following.

- For both IPF that were created, insert a commissioning date of two years in the past and an expected demand rate of 0.1 events per year.
- For IPF USC-101A, add an event that occurred today, has an API 754 severity of 3 and a note stating, "The high pressure separator V-101 high pressure shutdown activated due to excessive inlet pressure from the incoming pipeline."

Section 7 – Bypass Tracking

This section will provide a detailed explanation of the portions of the Vertigo application that are used to track and document IPF bypasses using Vertigo.

7.1 Bypass Tracking Overview

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The bypass tracking section of the vertigo application is accessed by clicking on the Bypass button on the Navigation Bar. This will bring you to the Bypass Authorizations grid page.

7.2 Bypass Authorization Grid

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+ Add New Record								
Tag	Instrument Type	Time of Bypasa	Bypass Type		quent	nt By		
LT-1018 (HEGH)	Sensor	10/29/2018 1:00:00 AM	3		Edward	d Marsz	ai i	
LT-1018 (HIGH)	Sensor	12/4/2018 7:00:00 AM	1		Edward	t Marsz	al	
PT-101D A.B.C. (HIGH)	Senso/	12/6/2018 1:00:00 PM	1		Edward	Marsz	al	

The bypass authorization grid shows a list of all the bypass authorization records. The list contains identification information about the device that was bypassed along with bypass type, time, and requestor.

7.3 Bypass Authorization Form

The bypass authorization form is a dynamic form that includes all data that might be required to properly document that assessment and authorization of a bypass, including the following sections.

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

• Approvals

7.3.1 Bypass Authorization – Identification

📓 Bypass Autho	rization Worksheet × +			-		
← → C	https://kiss.kenexis.com/Vertigo/BypassAuthorization.aspx		Q	☆ 0	E	
	S VERTIGO Texas City Gas Plant	Si	igned in as E	Edward Marsz	al of Ken	exis
Instrument		Time of Bypass Time Returned	29 Octob	per 2018 01		_
Instrument Type Tag Number	Sensor Final Element					
Reason for Modification / Bypass	Repair after diagnosed failure.					_

The bypass authorization form identification section contains information related to what device was bypassed, when, and why.

7.3.2 Bypass Authorization – Type Selection

	type	Description	Additional Acti	on Required
			Alternate Protection Plan	Dypins Risk Assessment
0	7958 1	Bypeas an instrument for regar or reachanance, instrument is part of fault toxiconce sphere where SP will dill admate upon proposal demand; repart completed in less than 35118	bip	hių -
- 6	2,04.3	Bypeas an instrument for repair or maintenance; instrument is part of fault toerance system where SP will bit actuate upon process; demand; repair resultes more than MTM	Star	+85
	7 _{(the})	Bypass an instrument for repair or maintenance; instrument is NOT part of fault to erance system; repair completed in less than MTTR	185	teq
- 10	Type A	Eppels an instrument for reper or maintenence; instrument to NOE part at fourt boarance system; reper requires more than MTTR.	111	185
0	Type 5	Rypass instrument for any masses other than instrument repair or maintenance	Per Bypess Rice Assessment 5	182
1 3,745	200 1012-	and if the Busian Risk Assessment indicates that A is responding		

The bypass authorization type selection section allows the user to select what type of bypass is being performed, considering redundancy, ability to repair within MTTR, and reason for the bypass. This information is used to display other related sections.

7.3.3 Bypass Authorization – Alternate Protection Plan

If a bypass is to be implemented on a device where there is no redundancy to replace the device's functionality during the bypass, then an alternate protection plan must be documented using the following form.

×

BYPASS TRACKING

Alternate Protection Plan

Value / Description
V-101 Sight Dass
70% 5.4
Dutside Operator - Dedicated
Rearch Operator
Class (dat control value
Tesi
Ten .
Nucl Required

7.3.4 Bypass Authorization – Bypass Risk Assessment

If a non-standard bypass is to be performed, specifically a bypass for reasons other than maintenance and repair one a bypass that will exceed the mean time to repair (MTTR) assumed in SIL verification calculations, then a bypass risk assessment form is displayed in order to assess and document the risk of the bypass.

Bypass Risk Assessment

Barn	Value / Description
Rewarden for implementing the bypers	
Hadavid that the toppeased instrument is intended to protect epierot	
Potential consequences if the attenuits protection fails and the hazard is realized	
What are the potential opcase of a vitualizer that could place a derived un the legenned function	
Is an alternate probability plan necessary, to mitigate the risk, and if so, can it be done effectively.	
to the risk exocuted with the logistic tolerable considering the Attenuate Protection Part	10 Tolerable
Rypana Rish Assanaerard Tearr Marclans	

7.3.5 Bypass Authorization – Authorization

The authorization section includes the names of approvers of the bypass form.

Approvals

Requested By	Edward Marszal	
Approved By	Edward Marszal	
kpproval Notes		
		1

7.4 Exercise 7

Create a bypass authorization for the high-level transmitter of the High-Pressure Separator SIF of the General Oil and Gas Operating Company Chemical City Gas Plant. Refer to *Appendix A* the required plant information. The event tracking information that should be incorporated for this exercise include the following.

- Assume that the bypass will be implemented today at 6 PM and is expected to remain in bypass for 2 hours.
- Review the information in Appendix A and your best judgment to document an alternate protection plan, if required.

Section 8 – Reporting

This section will provide information on the reports that are available in Vertigo along with how to configure and customize them.

8.1 Reporting Overview

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+	→ C	https://kiss.kenexis.com/Vertigo/Default.aspx	\$	θ	ŧ
K	ENE)	KIS VERTIGO Texas City Gas Plant	Signed in as Edward Marsza	f of Ken	exis 🖸
i					

All reports are accessed from the same location, the reporting page. This page can be accessed by clicking the Reports button in the navigation bar.

8.2 SIL Verification Reports

<	reviewing reporting to			н	0 :
CENEXIS VER	TIGO Texas	City Gas Plant		Signed in as Edward Marszal	of Kenesia
1 🖸 🗄 - 🔎 -					
Generate Report	🔄 Tag	IPF Description	IPF Type	Selected SIL	
al-St. Verification	USC-TOTA	High Pressure Separator (V-101) High-High Pressure Closes Inlet Valve	SIF	SIL 2	Ì
SIL Verification Summary SIL Verification Details Recommendations	05C-1018	High Pressure Separator (V-101) Low-Low Pressure Closes Infet Valve	SIF	58L 1	
Documents al SRS	III USC-101C	High Pressure Separator (V-101) High-High Level Closes inter Valve	SIF	ND SIL	
al Final Bernents al Testing	10 USC-1010	High Pressure Separator (V-101) Low-Low Level Closes Liquid Outlet Valve	SIF	SIL 1	
al Failure Rates Based on Testing al Failure Rates For SiL Venfication	USC-102A	Low Pressure Separator (V-102) High-High Pressure Closes Inlet Valve	SIF	SIL Y	

SIL Verification reports include:

- IPF List
- SIL Verification Summary
- SIL Verification Details
- Recommendations
- Documents



8.3 Safety Requirements Specifications Reports

← → U ■ https://kiss.kene	exis.com/Reporting/Verb	igo/ReportOptions.aspx		¢ e	1
KENEXIS VERT	Texas Ci	ity Gas Plant		Signed in as Edward Marszal of Ki	erievis 🔁
1 🖸 🖽 • 🔎 •		▋▋■ℤ₿₣	1		
Generate Report	🔁 Tag	IPF Description	IPF Type	Selected SIL	
a) SIL Venification a) SRS SRS General Requirements	* 🗐 USC-101A	High Pressure Separator (V-101) High-High Pressure Closes Inlet Value	SIF	SIL 2	Î
 IPF Requirements Sensor Requirements Lonic Solver Requirements 	USC-1018	High Pressure Separator (V-101) Low-Low Pressure Closes inlet Valve	SIF	SIL 1	
Final Element Requirements Cause and Effect Diagrams	III USC-101C	High Pressure Separator (V-101) High-High Level Closes inlet Valve	SLF	No SIL	
ali Semon ali Final Bamanta ali Testing	U USC-1010	High Pressure Separator (V-101) Low-Low Level Closes Liquid Outlet Valve	SIF	50.1	
11 Failure Rates Based on Testing	USC-103A	Low Pressure Separator (V-102) High-High	SIF	SIL 1	

Safety Requirements Specifications reports include:

- SRS General Requirements
- IPF Requirements
- Sensor Requirements
- Logic Solver Requirements
- Final Element Requirements
- Cause and Effect Diagrams



8.4 Sensor Reports

Generate Report	Tag	Service Description	IPF Group	Safety Critical	
SIL Verification	E FT-1038 (LOW)	Export Pump Discharge	USC-103	90	
SAS Servora	E FZT-YOTA	High Pressure Separator Fire Detection	USC-101		
Entpoint List	E 07-105A	Gas Compressor Axial Displacement	USC-104	×	
Testing	EI LT-1018 (HIGH)	High Pressure Separator	USC-101	×	
Failure Rates Based on Testing	E LT-1018 (LOW)	High Pressure Separator	USC-101	18	
Failure Rates For SIL Verification	E LT-1028 (H00H0	Low Pressure Separator (V-102)	USC-102	×	
	III LT-1028 (LOW)	Low Pressure Separator (V-102)	USC-102	×	
	10 LT-110 (LOW)	Compressor Lube Oil	USC-104		



Sensor reports include:

• Setpoint List

8.5 Final Element Reports

KENEXIS VER	TIGO Texas City Gas	Plant		Signed in as Edward Manszal of	Nevenis
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Generate Report	🗇 Tag	Service Description	IPF Group	Safety Critical	
pl SIL Verification	C-104-M (STOP)		USC-104	90	i.
ni 545	U None	None			
el Sensors	E P-103-M (STOP)		USC-10)	×.	-
Activation Time List	E P-1048-M (START)		6/5C+104		
al Testing al Failure Rates Based on Testing	5DV-101A/8 (CLOSE)	High Pressure Separator Inlet	USC-101	ж.	
al Failure Rates For SIL Verification	ID SOV-102A (CLOSE)	Low Pressure Separator Inlet	USC-102	*	
	EDV-1028 (CLOSI)	Low Pressure Separator Outlet	USC-102		- 1
	E) SDV-108 (CLOSE)		USC-103	. 10	
	El emissión intentos		1.007+3398	- 94	

Final Element reports include:

• Activation Time List



8.6 Testing Reports

Generale Report	() Tag	Service Description	IPF Group	Safety Critical
SIL Verification	# @ #T-1038 (LOW)	Export Pump Discharge	USC-103	8
585 Semons	AIGI-TZF 🗍	High Pressure Separator Fire Detection	USC-101	
Final Elements Testing	@ 0T-105A	Gas Compressor Asial Displacement	USC-104	8
Senuce	🔲 (T-1018 (HIGH)	High Pressure Separator	VEC-101	×
Logic Solver	UT-1018 (LOW)	High Pressure Separator	USC-101	8
- Semair History	G 67-1028 (HIGH)	Low Pressure Separator (V-102)	M9C-102	~
Final Element History	(B LT-1028 (LOW)	Low Pressure Separator (V-102)	USC-102	8
Failure Rates Based on Testing Failure Rates For OL Verification	. LT-110 (LOW)	Compressor Lube OI	USC-104	



Testing reports include:

- Sensor
- Logic Solver
- Final Element
- Sensor History
- Logic Solver History
- Final Element History

8.7 Failure Rate Based on Testing Reports

	operorana	A CONTRACTOR DESIGNATION OF THE OWNER OWNER OF THE OWNER OWNE				~	_
ENEXIS VERT	160	Texas City Gas Plant		Signed in as Ed	ward Mars	zal of Her	iein
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Generate Report	illia:	Туре	Description	Failure Rate			
ti SiL Verification	- 0		117				7
ni SRS Ni Sensora	-10	Axial Displacement Sensor - Generic	No special diagnostics - for use with OB/G sample plant only	SE-07			
5) Final Dements 5) Testing	0	Custom Configuration from Fault free for FT Compensated Flow	Custom Configuration from Fault Tree for PT Compensated Flow				
Failure Rates Based on Telting Process Connection	.0	Cuttom Pressure Transmitter	Pressure Transmitters Used in Plant. A	6E-06			
Sensor Interfaces Sensor Types Logic Solver Types Final Element Interfaces Final Element Turas	6	Hame Detector - Det-Tronics X3301 / X3302 Flame Detector (Infrared / Analog Output)	Flame Detector - Manufacturer Det-Tronics - Model: X3301 / X3302 - IR Flame Detector - Analog Output - Configured for High or Low Trip - Low and High Signal («4 mA & >20 mA) PLC Diagnostics	2.936-08			
id Failure Rates For SiL Verification		Flame Detector - Generic - UV/IR Detection	Flame Detector - Generic - UV/IR Detection	68-06			

Failure Rate Based on Testing Reports Include:

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

8.8 Failure Rates for SIL Verification Reports



Failure Rate for SIL Verification reports Include:

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

8.9 Exercise 8

Create some reports for the General Oil and Gas Operating Company Chemical City Gas Plant SIS. Refer to *Appendix A* the required plant information.

• Generate a SIL Verification Details report for the entire SIS along with an IPF List of the entire SIS



- Generate a cause-and-effect diagram
- Generate a failure rate based on testing report of the sensor type "Level Transmitter Generic"



Section 9 – Settings

Section 9 – Settings

In Vertigo, display, reporting, data base, and calculation methods can be customized based on user preferences. These preferences can be viewed and modified in the Study Settings form. The study settings form is accessed by clicking on the Setting Settings button in the navigation bar.

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NTT-LEAT	Ser Allegenolie 2.	Study Settings									
* Add have itt Tag	UN Description	Fault Tolerance Calculation Hode (IEC) Fallure Rate Ubiory (Kene CSRS Tracked Fields	01511 - 2016 •	GROND (Final Lie Tag (STOP)	Section 1	Civitinut Civitinut Loope	Lope: Science	31.10	0.00	
USC-1890	Enort Parts (F-10) Low-Low Oricharde, Pressure Closes Ad Baceflow Valve	ar IPF ar HAZOP Reference - W. Seport - W. Date	50	φt	00V-103 (QL09E)	1001	foot	UIS PLO			Ē
UTIC 1944	Gas Conversion ID 1941 High High Dacharpe Practaura Block Conversion	- 20 Revision - 20 Node - 20 Devision - 20 Page	50	uT.	0-164-M (970P)	1001	5001	9/9 PLC			
USC-1948	Bas Construint (C 1041 High High Declarge, Tencerative Stoor, Conservation	Description LOPA Reference Lopic & Coentron Process Safety Time	5.0	ot	C-104-M (STOP)	1001	foot	SIS FLC		9	
UBC-1940	Gas Concessor IC 104/Low-Low Lube Of Pressure Stool Centerator	ar Testing ar Robes ar Sancer	50	iet.	0-104-M (STOP)	1001	1001	\$15.PLC		2	£
1990-1940	Gen Conversion (C 359) Lovi Lov Lobe, Of Level Store, Conversion	S Final Dervent	tate] [Cancel]	61	C-15448 (STOP)	1001	1001	BIS PLC		8	
UBC-104E :	Gas Constantion	SHF SHL 1 17-10	6- 1001 SO	eit)	0-104-M	1001	1001	SIS PLC		3	K

From the Study Settings window the user can modify:

- Which calculation mode is used for fault tolerance
- Which data library is used
- Which fields are shown in the detailed worksheets

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Post Instructional Quiz

- 1. What section of the Vertigo application is used to move between the different sections and pages?
 - a. The grid control
 - b. The overview page
 - c. The project manager application
 - d. The navigation bar
- 2. Many of the grids in the Vertigo application allow for sorting, filtering, and even editing multiple records at one time through a context menu. How is the connect menu displayed?
 - a. By selecting context menu from the navigation bar
 - b. By right-clicking on an item in a grid
 - c. By hovering over a hyperlink in a grid
 - d. By entering "context menu" into the command line
- 3. The document list makes it easy to view documents that are referenced by the SIS design basis by...
 - a. Storing the name of the document to allow the user to look it up manually
 - b. Storing the document in the Vertigo database for easy automatic access
 - c. Storing a hyperlink to the location of the document in the user's document management system
 - d. Vertigo does not store information about reference documents
- 4. Collections of instruments that are all common or related to each other so that they can be grouped for purposes such as cause-and-effect diagram development are called what in Vertigo?
 - a. Safety Instrumented Systems
 - b. Safety Instrumented Functions
 - c. IPF Groups
 - d. Major equipment items
- 5. What is the Vertigo page that is the central point for SIL verification and includes an inventory of all the functions in the study, including the inputs and outputs instruments to the functions?
 - a. SIL Verification Summary
 - b. IPF List
 - c. Revision Tab
 - d. Study Settings Page



- 6. How can data be entered into a Vertigo study with respect to failure rates of different types of Instruments?
 - a. It can be pulled in from the Kenexis Standard database
 - b. It can be pulled in from a custom database developed by users
 - c. It can be entered directly into the project database
 - d. All of the above
- 7. When a subsystem is too complex to be modeled as a standard voting arrangement the data for subsystem PFD and STR can be directly entered into the database instead of entering failure rates and requiring calculation, what type of entry is this referred to in Vertigo?
 - a. Markov Model
 - b. Complex System Assessment
 - c. Black Box Model
 - d. Distributed Computing Model
- 8. PFD and STR can be calculated in what other Kenexis software application and directly connected to a Vertigo database?
 - a. Kenexis Open PHA HAZOP/LOPA Software
 - b. Kenexis Open Audit Audit Tracking and Documentation Software
 - c. Kenexis Effigy Fire and Gas Mapping Software
 - d. Kenexis Arbor Fault Tree Analysis Software
- 9. How can you tell if an SIS component type, such as a level transmitter, has failure rate data that is no longer consistent with the library from which it was imported?
 - a. The user needs to manually compare the databases
 - b. On the Sensor Type page the "Current with Library" button will be red
 - c. The calculation validation report will flag the data as old
 - d. There is no way to verify that the project data is current with the library
- 10. Where in vertigo can you access the Beta Factor Estimation tool for estimating a common cause failure percentage for SIS component subsystems?
 - a. Next to the Beta Factor Label on any details form (sensor, logic solver or final element)
 - b. Select Beta Factor Tool from the Navigation Bar
 - c. The Beta Factor tool is a separate application in the Kenexis Integrated Safety Suite
 - d. Vertigo does not provide tools to assist in Beta Factor estimation, a literature search is required



- 11. Which format of logic description is employed in the safety requirements specifications section of Vertigo?
 - a. Text Narrative
 - b. Cause-and-Effect Diagrams
 - c. Sequential Function Charts
 - d. Binary Logic Diagrams
- 12. If a result of a SIL verification calculation is being displayed as "NaN", or not a number, an error exists in the data entered to perform the calculation. How can the user obtain a list of errors identified by Vertigo during calculation?
 - a. Submit a request to support@kenexis.com
 - b. Generate a SIL Verification Data Verification log by clicking on its icon in the Navigation Bar
 - c. View the SIL Verification Summary Page
 - d. Export the data file to Excel and check the error log
- 13. What test duration should be used for automatically performed diagnostics that are performed every device scan in devices like smart transmitters and logic solvers?
 - a. 0 hours
 - b. 1 Hour
 - c. 8 hours
 - d. 72 hours
- 14. Which term should be included into the SIL verification calculation (by clicking on its checkbox) when tests are not always performed while the plant is shutdown for turn-around, and require a bypass of the function because the plant is in operation?
 - a. Include Common Cause
 - b. Trip on Detected Failure
 - c. Online Testing
 - d. Imperfect Testing
- 15. Which of the following is not an SRS section in Vertigo?
 - a. Operating Procedures
 - b. General Requirements
 - c. Data Sheets
 - d. Cause-and-Effect Diagrams



- 16. Where does the user go to add or remove items that are shown on SRS datasheets and their associated reports?
 - a. Overview Page
 - b. Study Settings
 - c. Datasheet content cannot be modified
 - d. Add or Remove data in exported reports using Word or Excel
- 17. What part of the bypass authorization form is displayed when the type of bypass requires a non-redundant instrument that the SIF is entirely dependent upon to be put into bypass?
 - a. Identification Section
 - b. Alternate Protection Plan Section
 - c. Bypass Risk Analysis Section
 - d. Authorization Section
- 18. Which standard from API defines the standard classifications or types of events that are tracked and report up through management?
 - a. API 14C
 - b. API 500
 - c. API 754
 - d. API 2500
- 19. When a Vertigo report is generated, all the data in the database in included in the report because filtering and selecting specific data is not possible?
 - a. True
 - b. False
- 20. Which report will show a failure rate of a type of SIS component based on the actual test data collected in Vertigo's test tracking functionality?
 - a. SIL Verification Reports
 - b. Safety Requirements Specification Reports
 - c. Failure Rate Based on Testing Reports
 - d. Failure Rates for SIL Verification Reports



Background Information

This section contains background information on a sample facility that is used as a basis for discussion for seminars and training classes. The sample facility is intended to present typical equipment utilized in the process industries in order to provide a realistic training environment, while keeping the process very small so that an entire facility can be analyzed during a single seminar or class.

The sample facility contains equipment that is similar to that which would be used for a natural gas production process and a high-head pumping system that would be similar to charge systems in some high-pressure refining units such as hydrotreaters and hydrocrackers.

It is important to note that this type of facility would not serve a real process purpose in isolation and is thus not entirely genuine. It is important for attendees at the training classes and seminars that use this sample plant to focus on the principles and techniques that are being discussed, and not to dwell on perceived inconsistencies or process engineering related issues related to the sample plant. This will ensure a beneficial training experience.

Process Description

Overview

The General Oil & Gas Operating Company's production facility located in Chemical City, TX processes hydrocarbon fluids coming out of natural gas wells located in production platforms. The wells discharge the production fluids into a main production header, which in turn supplies the facility with feedstock. In the first stage of the separation process (high pressure stage), the production fluids enter a high-pressure separator where the liquid and gas components are separated at a specific temperature and pressure. The gas leaving the high-pressure separator is predominantly composed of lighter hydrocarbons and does not need any additional treatment. The gas leaves the facility via the export gas pipeline to neighboring gas processing companies. In the second stage of the separation process (low pressure stage), the liquid from the first stage enters the low-pressure separator and flashes at a specific temperature and pressure. The gas stream from the low-pressure separator is compressed and the compressed gas combines with the gas leaving the high-pressure separator. The liquid from the low-pressure separator is considered to be stabilized for processing purposes and it is pumped into the high-pressure export liquid pipeline. The



major equipment used in this process, includes a High-Pressure Separator, Low-Pressure Separator, Export Pump and Gas Compressor are described in the following sections.

High-Pressure Separator (V-101)

Hydrocarbon fluids enter the high-pressure separator (V-101) through a pressure reducing valve (PV-101A) which reduces the pressure from approx. 700 psig (production header pressure) to 350 psig (first stage operating pressure). The pressure in the separator is maintained by the pressure control valve PV-101B. Flashing occurs in the vessel causing separation of gas and liquid components. Reduction in flow velocity causes the liquid droplets to drop out of the gas stream. The separator vessel provides the retention time needed for effective gas-liquid separation and provides a surge volume necessary to handle intermittent surges of liquid. The liquid level in the vessel is maintained by the level control valve LV-101A.

As the hydrocarbon fluids come into contact with the inlet diverter, most of the liquid falls into the liquid section and the gas flows over the inlet diverter. The gas stream continues to flow horizontally above the liquid section and small drops of liquid not separated by the inlet diverter are separated out by gravity. Drops of liquid that are too small to be separated by gravitational force are removed from the gas stream by a demister pad.

The gas leaves the high-pressure separator and enters the export gas pipeline to neighboring gas processing facilities. Over pressure protection of the high-pressure separator is provided by relief valve PSV-101.

Low Pressure Separator (V-102)

The liquid from the high-pressure separator enters the low-pressure separator through the level control valve LV-101A. The operating pressure in the low-pressure separator is maintained at 50 psig to flash off the lighter hydrocarbons into the gas phase and partially stabilize the liquid phase. The vapor and liquid disengage similar to V-101. The gas is sent to compressor C-104 and the partially stabilized liquid is pumped out using pump P-103. Over pressure protection of the low-pressure separator is provided by relief valve PSV-102.



Export Pump (P-103)

The partially stabilized hydrocarbon liquid from V-102 is pumped using high-pressure pump P-103 to the export liquid pipeline. P-103 is a multistage pump that discharges the liquid at a pressure of 2200 psig needed to transport the hydrocarbon liquid several miles before it can be further processed. The export pipeline is a common pipeline used by a number of production facilities that are all pushing liquid into the pipeline, as a result backflow from the pipeline back into the production facility is a concern. A pressure relief valve PSV-103 protects the pump from damage in case of a blocked flow in the export liquid pipeline.

Gas Compressor (C-104)

The gas stream leaving the low-pressure separator V-102 at a pressure of 50 psig enters compressor C-104 where its pressure is increased to 350 psig to match the gas pressure leaving the high-pressure separator. The pressure controller PIC-104A controls pressure from the compressor to the export gas pipeline. The pressure controller senses changes in separator pressure and sends a signal to either open or close the control valve PV-104A accordingly. Controller FIC-104 provides anti-surge control by "spilling back" enough material through FV-104 to the low-pressure separator and prevents surging. Over pressure protection of the suction and discharge sides of the compressor are provided by pressure relief valves PSV-104A and PSV-104B respectively.

Support Facilities

The support efforts include:

- 1. A site with roads
- 2. Security with perimeter chain link fencing a guard house and an entry gate
- 3. Utilities to enable the process to work: electricity; fuel oil or diesel; instrument air and water
- 4. Safety systems include fire water deluge, personnel protection, and escape
- 5. Vent systems which discharge to a flare header and flare



Process Flow Diagram





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Piping and Instrumentation Diagrams

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Plot Plan – Equipment Layout





PHA Risk Ranking Matrix and Tables

Risk Matrix







Severity

S	Category	Safety Description	Environmental Description	Commercial Description
0	None	No significant safety consequence	None	None
1	Very Low	Minor injury - first aid	Small release with minimal clean up requirements	Less than \$50,000
2	Low	Lost time injury not requiring extended hospitalization	Moderate release limited to onsite damage with moderate cleanup effort	\$50,000 to \$500,000
3	Moderate	Severe injury (extended hospitalization, dismemberment)	Large release with limited offsite impact, requires significant onsite clean up	\$500,000 to \$5,000,000
4	High	Single fatality	Large release offsite with extensive clean up and damage to sensitive areas	\$5,000,000 to \$50,000,000
5	Very High	Multiple fatalities	Very large release offsite with extensive clean up and permanent damage to several sensitive areas	Greater than \$50,000,000

Likelihood

		T	
L	Category	Description	Recurrence
0	None	Not expected to occur	N/A
1	Very Low	Possible to occur, but not expected to occur in the lifetime of the plant, either at the plant or at a similar facility in industry	1,000 years
2	Low	Not expected to occur in the lifetime of the plant, but expected to occur within the lifetime of the plant at a similar facility in industry	100 years
3	Moderate	Expected to occur within the lifetime of the plant	10 years
4	High	Expected to occur about once per year	1 year
5	Very High	Expected to occur many times per year	0.1 years

Risk Ranking

Risk Ranking	Category	Description
I	Low	Risk is low and/or sufficiently controlled - no additional risk reduction measures are required
Ш	Moderate	Risk is moderate - additional controls could be considered, but are not required
Ш	High	Risk is high and may not be sufficiently controlled - additional risk reduction measures should be considered
IV	Very High	Risk is high and is not be sufficiently controlled - additional risk reduction measures are required, and additional operations vigilance measures are required in order to operate the plant in the interim prior to implementing risk reduction measures
V	Intolerable	Risk is intolerably high - the facility cannot operate in this state. Additional risk reduction measures or process redesign to reduce risk shall be performed prior to allowing the plant to operate



SIL Selection Risk Ranking Matrix and Tables

Risk Matrix - Safety



Severity - Safety

Severity - S	Category	Description	TMEL-S
0	None	No significant safety consequence	
1	Very Low	Minor injury - First Aid	1E-02
2	Low	Lost time injury not requiring extended hospitalization	1E-03
3	Moderate	Severe injury (extended hospitalization, dismemberment)	1E-04
4	High	Single fatality	1E-05
5	Very High	Multiple fatalities	1E-06



Likelihood

Likelihood Category		Description	Recurrence	
0	None	Not expected to occur	N/A	
1	Very Unlikely	Possible to occur, but not expected to occur in the lifetime of the plant, either at the plant or at a similar facility in industry	1,000 years	
2	Unlikely	Not expected to occur in the lifetime of the plant, but expected to occur within the lifetime of the plant at a similar facility in industry	100 years	
3	Occasional	Expected to occur within the lifetime of the plant	10 years	
4	Frequent	Expected to occur about once per year	1 year	
5	Very Frequent	Expected to occur many times per year	0.1 year	

SAMPLE PROCESS

Risk Matrix - Environment

Severity - E	Category	Description	TMEL -E	Risk Matrix						
				Likelihood						
				0	1	2	3	4	5	
				Risk Ranking	Risk Ranking	Risk Ranking	Risk Ranking	Risk Ranking	Risk Ranking	
0	None	None	1E+00	0	0	0	0	0	0	
1	Very Low	Small release with minimal clean up requirements	1E-02	0	0	0	1	2		
2	Low	Moderate release limited to onsite damage with moderate clean-up effort	1E-03	0	0	1	2	3	4	
3	Moderate	Large release with limited offsite impact requires significant onsite clean up	1E-04	0	1	2		4	5	
4	High	Large release offsite with extensive clean up and damage to sensitive areas	1E-05	0	2	3	4	5	6	
5	Very High	Very large release offsite with extensive clean up and permanent damage to several sensitive areas	1E-06	0	3	4	5	6	7	



Risk Matrix - Commercial

Severity - C		Category	Description		Risk Matrix					
	Soverity									
	- C			C	0	1	2	3	4	5
				Risk Ranking	Risk Ranking	Risk Ranking	Risk Ranking	Risk Ranking	Risk Ranking	
	0	None	None		0	0	0	0	0	0
	1	Very Low	Less than \$50,000	1E-02	0	0	0	1	2	3
	2	Low	\$50,000 to \$500,000	1E-03	0	0	1	2	3	4
	3	Moderate	\$500,000 to \$5,000,000	1E-04	0	1	2	3	4	5
	4	High	\$5,000,000 to \$50,000,000	1E-05	0	2	3	4	5	6
	5	Very High	More than \$50,000,000	1E-06	0	3	4	5	6	7

Appendix 2 – Quiz Solutions

Post Instructional Quiz Solution

- 1. sections and pages?
 - (d) The Navigation Bar
- 2. Many of the grids in the Vertigo application allow for sorting, filtering, and even editing multiple records at one time through a context menu. How is the connect menu displayed?

(b) By right-clicking on an item in a grid

3. The document list makes it easy to view documents that are referenced by the SIS design basis by...

(c) Storing a hyperlink to the location of the document in the user's document management system

4. Collections of instruments that are all common or related to each other so that they can be grouped for purposes such as cause-and-effect diagram development are called what in Vertigo?

(c) IPF Groups

5. What is the Vertigo page that is the central point for SIL verification and includes an inventory of all the functions in the study, including the inputs and outputs instruments to the functions?

(b) IPF List

6. How can data be entered into a Vertigo study with respect to failure rates of different types of Instruments?

(d) All of the above

7. When a subsystem is too complex to be modeled as a standard voting arrangement the data for subsystem PFD and STR can be directly entered into



Appendix 2 – Quiz Solutions

the database instead of entering failure rates and requiring calculation, what type of entry is this referred to in Vertigo?

(c) Black Box Model

8. PFD and STR can be calculated in what other Kenexis software application and directly connected to a Vertigo database?

(d) Kenexis Arbor Fault Tree Analysis Software

9. How can you tell if an SIS component type, such as a level transmitter, has failure rate data that is no longer consistent with the library from which it was imported?

(b) On the Sensor Type page the "Current with Library" button will be red

10. Where in vertigo can you access the Beta Factor Estimation tool for estimating a common cause failure percentage for SIS component subsystems?

(a) Next to the Beta Factor Label on any details form (sensor, logic solver or final element)

11. Which format of logic description is employed in the safety requirements specifications section of Vertigo?

(b) Cause-and-Effect Diagrams

12. If a result of a SIL verification calculation is being displayed as "NaN", or not a number, an error exists in the data entered to perform the calculation. How can the user obtain a list of errors identified by Vertigo during calculation?

(b) The Navigation Bar

13. What test duration should be used for automatically performed diagnostics that are performed every device scan in devices like smart transmitters and logic solvers?

(a) 0 hours

14. Which term should be included into the SIL verification calculation (by clicking on its checkbox) when tests are not always performed while the plant is


Appendix 2 – Quiz Solutions

shutdown for turn-around, and require a bypass of the function because the plant is in operation?

(c) Online Testing

- 15. Which of the following is not an SRS section in Vertigo?
 - (a) Operating Procedures
- 16. Where does the user go to add or remove items that are shown on SRS datasheets and their associated reports?
 - (b) Study Settings
- 17. What part of the bypass authorization form is displayed when the type of bypass requires a non-redundant instrument that the SIF is entirely dependent upon to be put into bypass?

(b) Alternate Protection Plan Section

18. Which standard from API defines the standard classifications or types of events that are tracked and report up through management?

(c) API 754

19. When a Vertigo report is generated, all the data in the database in included in the report because filtering and selecting specific data is not possible?

(b) False

20. Which report will show a failure rate of a type of SIS component based on the actual test data collected in Vertigo's test tracking functionality?

(c) Failure Rate Based on Testing Reports

