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PREFACE

SIL Solver® is an advisory software package intended for use in the verification of the Integrity Level (IL) of Protective Instrumented Functions (PIF). This package is a reliability block diagram based calculation tool. It uses fault tree analysis equations to verify the integrity level (IL) of protective instrumented functions (PIF). SIL Solver® uses globally recognized standards and methodologies to analyze components, subsystems, and PIFs, such as:

- ANSI/ISA 84.00.01-2004 (IEC 61511)
- ISA TR84.00.02
- IEC 61511
- IEC 61508
- CPQRA

PURPOSE OF THIS GUIDE

This guide contains information to help the user use SIL Solver®. The guide presents information in a tutorial format. This guide is intended to explain the basic functions of the software.

CONVENTIONS

In this guide, an implied carriage return occurs at the end of each line, unless otherwise noted. The user Presses the ENTER or TAB to exit from an input box.

<table>
<thead>
<tr>
<th>Example</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edit</td>
<td>Words in bold indicate that the user enters or Clicks button or menu</td>
</tr>
<tr>
<td>RETURN</td>
<td>Words in bold capital letters indicate names of keys and key sequences</td>
</tr>
<tr>
<td>Type/Click</td>
<td>Words in initialize indicate response needed</td>
</tr>
</tbody>
</table>
SECTION 1  DEFINITIONS

The following definitions are from the Center for Chemical Process Safety, *Guidelines for Safe and Reliable IPS* (2007).

1. Architecture—The physical organization, interconnection, or integration of the equipment of a system that operates according to the design basis.

2. Common Cause Failure—Failure of more than one device, function, or system due to the same cause.

3. Dangerous Failure—Failure affecting equipment within a system, which causes the process to be put in a hazardous state or puts the system in a condition where it may fail-to-operate when required.

4. De-Energize To Trip—Circuits where the final elements are energized under normal operation and the removal of power source (e.g., electricity, instrument air) causes the instrumented protective system to take its defined action.

5. Demand—See “Process Demand.”

6. Detected Failure—Failure found through diagnostics or through the operator's normal observation of the process and its equipment. Synonyms include announced, revealed and overt.

7. Detected Fault—See “Detected Failure.”

8. Diagnostic Coverage—Fractional decrease in the probability of dangerous failure resulting from diagnostics that report faults to the operator and take a specified action on fault detection.

9. Diverse—Use of independent and different means to perform the same function. Diversity may include the use of different physical methods, technology, manufacturers, installation, maintenance personnel and/or environment.

10. Energize To Trip—Circuits where the final elements require the power to take or maintain the safe state.

11. Failure—Termination of the ability of equipment to operate as specified.

12. Failure Rate—Limit when \( \Delta t \) goes to 0 of the expected rate at which equipment failures occur in the time interval \( t \) to \( t + \Delta t \) given that no failures have occurred until time \( t \).

13. Fault—Abnormal condition resulting in degraded operation or critical failure.

14. Fault Tolerant—Voting architecture that allows an equipment subsystem to continue to operate in the presence of one or more hardware or software faults.
15. Final Element–Device that takes action on the process or process equipment. For an instrumented protective function (IPF), the final element takes action on the process to achieve or maintain the safe state. The final element boundary includes the signal connection to the logic solver and the devices required to take action on the process.

16. Function Test–See “Proof Test.”

17. Logic Solver–That portion of an instrumented system performing one or more logic functions.

18. Mean Time to Repair–The average time to identify a device failure, to repair it, and return it to normal operation.

19. On-line–Process equipment is operational (i.e., running, producing product).

20. Off-line–Process equipment is not operational (i.e., shutdown).

21. Process Demand–A process condition (or event) that requires a protective system to take action to achieve or maintain a safe state of the process.

22. Proof Test–A physical inspection and witnessed test, or series of tests, executed to demonstrate that the equipment operates according to the design basis and is maintained in the “as good as new” condition.

23. Protective Function–Function implemented to achieve or maintain a safe state of the process when unacceptable process conditions are detected to reduce the risk of an identified hazardous event. The protective function may be further classified in terms of the consequence severity and risk reduction requirement.

24. Protective Instrumented Function (PIF)–A protective function allocated to a protective instrumented system with an integrity level (IL) necessary to achieve the required risk reduction for an identified hazardous event.

25. Random Failure–Failure whose occurrence is unpredictable, which results from various degradation mechanisms in the hardware.

26. Redundancy–Use of two or more devices, systems, or layers to perform the same function.

27. Reliability–The probability that equipment operates according to its specification for a specified period of time under all relevant conditions. It is one of the core attributes of a protection layer.

28. Safety Instrumented System (SIS)–Composed of a separate and independent combination of sensors, logic solvers, final elements, and support systems that are designed and managed to achieve a specified safety integrity level. An SIS may implement one or more safety-instrumented functions (SIFs).

29. Safety Integrity Level (SIL)–Represents one of four discrete ranges used to benchmark the integrity of each SIF and the SIS, where SIL 4 is the highest and SIL 1 is the lowest.
30. Safety Requirements Specification (SRS)–Compilation of information and documentation that constitutes a design basis for the safety instrumented system. It may include logic narratives, Input/Output (I/O) list, cause & effect matrix, logic flow charts, system overview drawings, integrity level calculations, etc.

31. Sensor–A measurement device (instrument) or combination of devices that detect process variables or conditions (e.g., transmitters, transducer, process switches, and toxic gas detectors). The sensor boundary includes the process connection, sensor, transmitter, and signal connection to the logic solver.

32. Spurious Trip–Refers to a process shutdown, or disruption, due to the spurious operation of equipment. Other terms often used include nuisance trip and false shutdown.

33. Spurious Trip Rate (STR)–Expected rate (number of trips per unit time) at which a process shutdown, or disruption, occurs due to the spurious operation of equipment. Other terms used include nuisance trip rate and false shutdown rate.

34. Systematic Failure–Failure related in a deterministic way to a root cause, which can only be minimized by effective implementation of the protective management system.

35. Test Interval–Time period between two successive proof tests.

36. Verification–Activity of reviewing, inspecting, checking, testing, or by other means determining and documenting whether the outcome of work processes, activities or tasks conform to specified requirements and traceable input information.

37. Voting–Specific configuration of equipment within a subsystem. Voting is often expressed as MooN (M out of N). “N” designates the total number of devices (or channels) implemented; “M” designates the minimum number of devices (or channels) out of N required to initiate, take, or maintain the safe state. Also called voting system or voting architecture.
## SECTION 2 ABBREVIATIONS AND SYMBOLS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ANSI</td>
<td>American National Standards Institute</td>
</tr>
<tr>
<td>$\beta$ (beta)</td>
<td>Beta Factor or Common Cause Factor</td>
</tr>
<tr>
<td>BPCS</td>
<td>Basic Process Control System</td>
</tr>
<tr>
<td>DC</td>
<td>Diagnostic Coverage</td>
</tr>
<tr>
<td>DI</td>
<td>Diagnostic Interval</td>
</tr>
<tr>
<td>DTT</td>
<td>Deenergize To Trip</td>
</tr>
<tr>
<td>ETT</td>
<td>Energize To Trip</td>
</tr>
<tr>
<td>FTA</td>
<td>Fault Tree Analysis</td>
</tr>
<tr>
<td>IEC</td>
<td>International Electrotechnical Commission</td>
</tr>
<tr>
<td>IL</td>
<td>Integrity Level</td>
</tr>
<tr>
<td>ISA</td>
<td>Instrumentation, Systems and Automation Society</td>
</tr>
<tr>
<td>$\lambda$ (lambda)</td>
<td>Failure Rate</td>
</tr>
<tr>
<td>MTTF</td>
<td>Mean Time To Failure</td>
</tr>
<tr>
<td>PFD</td>
<td>Probability to Fail on Demand</td>
</tr>
<tr>
<td>PIF</td>
<td>Protective Instrumented Function</td>
</tr>
<tr>
<td>PIS</td>
<td>Protective Instrumented System</td>
</tr>
<tr>
<td>PLC</td>
<td>Programmable Logic Controller</td>
</tr>
<tr>
<td>SIL</td>
<td>Safety Integrity Level</td>
</tr>
<tr>
<td>SIS</td>
<td>Safety Instrumented Systems</td>
</tr>
<tr>
<td>STR</td>
<td>Spurious Trip Rate</td>
</tr>
<tr>
<td>STRate</td>
<td>Spurious Trip Rate</td>
</tr>
<tr>
<td>TI</td>
<td>Test interval</td>
</tr>
</tbody>
</table>
Toolbars are used throughout SIL Solver®. The following is a summary of the various toolbar functions:

- **Deletes the datasheet in view (deletes not permitted for SIL datasheets)**
- **Close**
- **Save**
- **Allows print options to be selected**
- **Allows new datasheet to be entered into database**
- **Edit of current selected user datasheet (edits not permitted for SIL datasheets)**
- **Recalculates required if edit(s) is/are performed on an existing datasheet.**
- **Search database**
- **Go to first record of database**
- **Go back one record**
- **Go forward one record**
- **Go to last record**
- **Revision level button**

Tool tips are available on the icons by running your mouse over them as to their function.
SECTION 4  BASIC PROJECT OPERATIONS

SIL Solver® has many user-friendly features that make it easy to verify the Integrity Level (IL) of Protective Instrumented Functions (PIF). SIL Solver® also calculates the Mean Time to Failure Spurious (MTTFSp), allowing the user to optimize the PIF to attain the appropriate balance between safety and reliability. Since the user can select various test intervals for the analysis of components and subsystems, SIL Solver® can provide an excellent tool for evaluating capital and maintenance costs.

These basic project operations instructions are intended to familiarize the user with the SIL Solver® interface. The process will be to create a project, open same, create a protective function, open same, select and add needed data devices, complete the protective function revision level documentation, and etc.

After creating a project and without opening this project, you close SIL Solver® the project will disappear from the project list. Also, if you try to use the copy and rename features, you will receive a similar message.

![Operation Status](image)

The project has not been created yet, so it cannot be copied. You will be able to copy after project creation.

This is the result of the databases, folders, and subfolder for a project not being created until the project is open.

Open SIL Solver®

Start SIL Solver® from the All Programs listing under Windows.

First time only on initial startup an error may occur due to the various Windows versions. See Installation of SIL Solver®, installer problems.
Figure 4. 1 Project Start View

Options - Default Settings

SIL Solver® default settings are: date American (month day, year) format: project folder location “C:\SILSolver_Projects”; test reporting “color.” If these defaults meet your needs, skip to Create Project. Otherwise Click Options to change SIL Solver® defaults to your personal preferences.

Date Selection

Click Options. From the Setup menu, Click American or European (day month year) date to select. The date format chosen will be in the lower right hand corner. The dates printed on the reports will reflect your date preference.

Figure 4. 2 Project Start, Setup menu Options: American or European Date
Project Folder Location

Click Options. From the Setup menu, Click Project Folder Location. This opens a Browse for Folder window. The project folder may be located in any designated location. Click OK or Double Click. Now selected, this folder will be displayed on the Project Start screen in the lower left hand corner. Warning: Problems have occurred with mirrored drives. Some SIL Solver® features, such as rename and delete project, have not work properly when using a mirrored drive.

⚠️ Warning: When creating or selecting the SIL Solver® Project Folder Location, if a network location is selected remember that every time SIL Solver® is used to close it before the computer is disconnected from the network, failing to do it, will cause a corruption on the SIL Solver® tables.

If your folder exists, locate the folder. Click OK.

If your project folder does not exist, locate the disk or folder where you want the project folder. Click Make New Folder. Type your folder name over the New Folder in the input box. Click OK.
**Click OK** to select this folder for your future projects. **Click Cancel** will maintain the old default project folder location. The project folder location will be displayed on the Project Start screen in the lower left hand corner.

Note: If you create a folder in the wrong location and want to remove this folder, locate the folder. Right **Click**. Select **Delete** from the browse windows menu. There is a slower response than Microsoft Explorer, but it works.

**Test to Text and Test to Color**

![Figure 4.5 Project Start, Setup menu Options: Test to Text and Test to Color Selection](image)

**Click Options.** From the Setup menu, **Click Test to Text** or **Test to Color**. This will be use in the reporting of “Have Targets Been Met?” format located on the Protective Function screen. The reports will print the test as “Yes/No.”

**Clicking Test to Text** toggles the reporting of the test success or failure to text display (yes/no). **Clicking Test to Color** toggles the test reporting to red/green boxes.

![Figure 4.6 Project Start, Options -Results of Test to Text and Test to Color on protective function screen](image)

**Create A Project**

Creating a project is the starting point for any PIF analysis in SIL Solver®. Once a project is created, the user adds the PIFs that are to be analyzed. The suggested structure uses the Unit designation for the customer ID and an abbreviated process name (CHEM3) or project designation as the project.

Any time you attempt to add, copy, or rename a project that already exists in the projects database, you will receive this message. Project names must be unique within a project folder location.
From the Project Start, Click Add Customer & Project. This will enable the Customer and Project input boxes.

Type 2-5 characters into the first input box then Enter or Tab. Type 2-10 characters into the second input box then Enter or Tab and Click or Enter on the Save.

IF before your save your input you decide to abort the Add Customer & Project, Click the X.

The X will cancel the process.

The Project will be added to the project list and to the projects database. For this project, the Customer ID is “TRIAL” and the Project ID is “TRIAL.” Remember until you open this project it is a name only in the project list and the project database.
Note: For the remainder of this guide, the "Customer ID and Project ID" will be referred to as the "Project."

Open A Project

Any SIL Solver® projects that are located in the project folder location will auto-connect. This means that the project folder location is scanned for available projects and these projects are retrieved into the project list.

If you want to hide projects from the project list, use Microsoft Explorer to move the project folders from the project folder location. If you want to add projects, exit SIL Solver®, copy the project folder into the project folder location, open SIL Solver® and these projects will auto-connect.

To navigate through a long list of projects, Click into the project list. Press the Shift key and the first character of the project’s name. Example: If your project starts with a Y, you will hold down the Shift key and type a "Y." This is also available under the protective functions. You could also use the scroll bar on the right of the project list.

From the Project list, Click Project to process. Click Open Project or Double Click on the project. A subfolder is now created under the project folder location and added to the project list. The name would be TRIAL_TRAIL.

![Figure 4. 8 Project Start - Open Project](image)

This process will enable the protective function side and disable the project side.
Close A Project And Close The Protective Function

*Click Close Project* closes a protective function and a project. *Once the project is open, another project cannot be opened until you Click Close Project.*

![Figure 4. 9 Project Start - Close the Open Project](image)

**Close SIL SOLVER®**

To close SIL Solver®, *Click Close SIL Solver* on the lower left corner or the red X in the upper right hand corner.

![Figure 4. 10 Protect Start - Close SIL Solver®](image)
SECTION 5  BASIC PROTECTIVE INSTRUMENTED FUNCTION (PIF)

Create Protective Function

After opening your project, the protective function side is enabled and the project side is disabled. Since there are no protective function records, only the Add Protective Function is enabled. When protective function list has protective function(s) available, the other buttons will be enabled.

A protective function ID has a maximum length of 10 characters with a minimum length of 2 characters. This is typically a protective function or interlock number. Typically, the name is alphanumeric and is traceable to the SRS documentation. Where possible, protective function name should be limited to 8 characters to support the division of functions into subparts when

Figure 5. 11 Project Start - Disabled view of Project list - Enabled view of Protective Function list
complex functions are analyzed and to support multiple cases for a single function when optimizing the PIF design.

From the Project Start, **Click Add Protective Function**. This will enable the protective function input boxes. Protective Function names can be easily changed at any time within SIL Solver®. For this example, the protective function is named “SF1 CASE 1”

**Click Save** after entering the protective function name. You will notice the buttons on the protective function side are enabled now that there is a PIF in the protective function list.

If before your save your input you decide to abort the **Add Protective Function**, **Click X**.

**Open A Protective Function**

To navigate through a long protective function list, **Click** to highlight a protective function and **Press the Shift** and the first character of the project’s name. Example: If your protective function’s name starts with a Y, you will **Press the Shift** and type a “Y.” This is also available under Projects.

After opening the project, **Click Protective Function** to begin the work process, **Click Open Protective Function** or **Double Click** on the protective function list.

**Close A Protective Function**

**Click Close Project** to close project. **Once the project is open, another project cannot be open until you Click Close Project.**

**Figure 5.12 Project Start - Close the open project**
SECTION 6  PROTECTIVE FUNCTION

The protective function screen consists of six main parts (Figure 6.1 Protective Function Tabs - View)


2. Protective function targets

3. Protective function results

4. Have the protective function targets been met?

5. Printing protective function see SECTION 11. Accessing the Data Sheets see SECTION 9.

6. Protective Function tabs
Project Identifiers

This identifies the specific Project and Protective Function that is being processed. These Protective Function identifiers cannot be changed from this screen. If a change is needed, from the Project Start, **Rename** is available for the Project (Section 7 Advanced Project Operations - Rename) and the Protective Function (Section 8 Advanced Protective Function Operations - Rename) identifiers.

Import Availability

The Import feature is available in PF documentation, Inputs, and Action 1. Import is possible from other protective functions within the same project and also all protective functions from other projects inside the SIL Solver® project folder. For example, some protective functions have very similar logic, so it is only necessary to change minor items such as tag name(s).

---

**PROTECTIVE FUNCTION TABS VIEW**

![PROTECTIVE FUNCTION TABS VIEW](image)

**Figure 6.1 Protective Function Tabs View (PROTECTIVE FUNCTION Documentation)**
Enter Target Values For Protective Functions

When a protective function is opened you have the opportunity to enter target values. Target values are not required for operation of SIL Solver®, but are provided for documentation purposes. The software also uses these target values in the automatic check described in section 6.9.D.

**PFDAVG**–This is the probability to fail on demand average. It should be entered in exponential format, such as X.XXE-XX. If exponential format is not used, the automatic check provided by the software will not work.

**IL**–SIL Solver® performs automatic lookup based on Table 3 in IEC 61511.

**MTTFspurious years**–This is the mean time to failure spurious. The units are years. It should be entered as number format.

**The STRate per year**–This is calculated automatically by SIL Solver® based on the entered MTTFspurious.

Protective Function Results

The protective function results are updated with each change to the Protective Function. The format and description are consistent with the target values.

![Figure 6.2 Protective Function Results](image)

Check Results Against The Target Values

![Have Targets Been Met?](image)

Target values for PFD and spurious trip rate can be entered into SIL Solver® so that it compares the target numbers with the calculated values and reports discrepancy. If the PIF does not meet the target values, changes to the design or maintenance strategy should be considered. If the overall PFD is not met, changes to the SIF design or maintenance strategy are likely required. When the STR is not met, the consequence of spurious trip should be evaluated and a cost-benefit analysis should be performed. If the consequence is acceptable or the cost-benefit ratio is poor, the target STR should be formally changed.
As the protective function is modeled, when the test to color option is chosen, the color of the boxes changes to notify the User to see easily whether the protective function is meeting the target. The boxes turn “red” if the target values are not met. Conversely, if the target values are met, the boxes turn “green.”

If PFD\textsubscript{AVG} result is greater than target value, the box remains “red.”

If the SIL result is less than target value, the box remains “red.”

If the MTTFspurious is less than the target value, the box remains “red.”

**PF DOCUMENTATION TAB**

SIL Solver® provides a documentation screen for use in recording the following:

- Process hazard that the protective function is designed to address
- Logic description of the protective function
- Reference documents that were used as supporting information for the analysis
- Comments

Note: For instructional purposes, additional protective functions with device information were created.

![Figure 6.4 Protective Function – Options: Documentation Menu](image)

**Import - Options: Documentation menu**

Click inside the documentation list. **Right Click.** From the Documentation menu, **Click Import.** A list of protective functions from all your projects available for import will display. You cannot select the protective functions that you are processing.

**Double Click** on protective function to import the data. Selected protective function documentation will be imported. Once imported, any existing documentation data will be over written with the data from the selected project – protective function. It is changed without impacting any other protective function and no other information from the project – protective function is imported.
Warning: The import function will cause any existing documentation data on the current tab to be over written.

![Double-click to select](image1)

**Figure 6.5 Protective Function - Select Project to Import**

![Double-click to select](image2)

**Figure 6.6 Project Function – Filter Check Box**

The import list default is to display all projects in the project folder location. To display the current project protective function(s) only, Click **Current Project** box. To return to the import list default uncheck the **Current project** box with a Click **Current Project** box.

**Edit - Options: Documentation menu**

You may want to use the available options on the documentation menu for editing: undo, cut, copy, or paste.
INPUTS TAB

SIL Solver® provides an Inputs tab for use in recording the following SIL Solver® Inputs (Figure 6.7), allowing the entry of non-redundant and redundant devices. A maximum of five entries can be made in each non-redundant and redundant section. The difference between the two types of entry is as follows:

Non-redundant: This is used when the correct action of multiple devices is required for the safe action to occur. For example, if a low flow trip is only active when the temperature exceeds a specified set point, both the flow transmitter and temperature transmitter must perform correctly.

Redundant: This is used when the correct action of any of the multiple devices will result in the safe action. For example, if both high temperature and high pressure are used to detect a runaway condition, the correct action of either transmitter will result in the safe action.

Figure 6. 7 Protective Function Inputs Tab View

The Import feature is last on the right click Inputs menu (Figure 6.8). Use this feature only when a new protective function is being created within a project. Otherwise, if you create entries and later want to use the import to include the entries from another protective function, your existing entries will be overwritten. You will need to use the import feature first, then modify or add any additional entries. See instructions: Import – Inputs menu.
The percent contribution to the overall $PFD_{AVG}$ and $MTTF_{SP}$ of each subsystem is displayed on each screen as you complete device selection.

The percent contribution is calculated as follows:

$$Percent \ Contribution = \frac{Subsystem \ Result}{Overall \ System \ Result}$$

To enter an input device into SIL Solver® it is necessary to select a device from the database. The devices are sorted alphabetically by device ID. The database is accessed using the dropdown arrow and scroll bar. The device can be selected quickly by typing in the first character of the device ID, then selecting the device from the dropdown.

The voting architecture and test interval for the device subsystem must be selected next. This enables the SAVE button, allowing the selection of Non-redundant and Redundant architecture for multiple device subsystems.
After selecting the voting architecture, you have the option of entering tag name(s) for the device(s). The tag names are not required, but are included for documentation purposes.

Non-redundant subsystems: This is used when the correct action of multiple device subsystems is required for the safe action to occur. When you **Click the ?**, the following tip is displayed:

![Non-Redundant Tip](image)

**Figure 6.10 The ? for Non-Redundant - Inputs Tab**

The dangerous failure of any component (or subsystem) will result in a failure of the protective function. The spurious failure of any component (or subsystem) will potentially result in a spurious event. The flow device technology and voting architecture are selected using the select box as shown in Figure 6.9. The PFD$_{AVG}$ values for each subsystem include the common cause contribution to the PFD$_{AVG}$ based on the common cause factors selected in the datasheet.

The input screen models the non-redundant device subsystems as follows:
Redundant subsystems: This is used when the correct action of any of the multiple device subsystems will result in the safe action. When you Click ?, the following tip is displayed.

Any listed component (or subsystem) will detect the hazardous event. As discussed under non-redundant subsystems, each subsystem architecture is selected using the drop down button. After selection of a device and a voting architecture, shown in Figure 6.9, the device must be placed as redundant or non-redundant. For example, if temperature is measured by redundant devices, each device is placed by a Click on the Save button to the right of the redundant portion of the screen. The PFD_{AVG} values for each subsystem include the common cause contribution to the PFD_{AVG} based on the common cause factors selected in the datasheet. Therefore, the calculations assumes that the redundant subsystems are sufficiently diverse from either a technology, installation, access, or maintenance standpoint that additional common cause contribution does not need to be considered. If common cause should be considered, the appropriate values should be entered manually under input manual on the next screen.

The input screen models the redundant device subsystems as follows:

\[ PFD_{\text{avg}} = \sum_{i=1}^{n} PFD_{\text{avg}} \]

\[ STR = \sum_{i=1}^{n} STR_{i} \]

⚠️ Warning: The SAVE button is not activated until the voting architecture and test interval are selected for each device.
Delete – Options: Inputs menu

To delete any entry, Click to highlight the entry. Right Click. From the Inputs Menu, Click Delete. There is no warning. The entry will be removed from the Inputs list and the protective function database.

View Project Sheet – Options: Inputs menu

Right Click on an entry. Click View Data Sheet. Depending on when the protective function was created, this may not be the current version of the device. Click Close or the red X to return.

Figure 6.12 Project Sheet View - Inputs menu
Go to Data Sheet – Options: Inputs menu

Right Click on an entry. From the Inputs menu, Click Go to Data Sheet. This selection will take you directly to the SIL Solver® Data Sheet. The device sheets are described later in this guide.

Edit Tag Name – Options: Inputs menu

To edit the listed tag name, Right Click on the entry. From the Inputs menu, Click Edit Tag Name. Type tag name into input box. Click Save.

Go to Data Sheet – Options: Inputs menu

Right Click on an entry. From the Inputs menu, Click Go to Data Sheet. This selection will take you directly to the SIL Solver® Data Sheet. The device sheets are described later in this guide.

What if? – Options: Inputs menu

You can play what-if scenarios by selecting a previously entered value. Right Click. From the Inputs menu, Click What-if?. The existing value is displayed in blue above the technology selection dropdown. The dropdown auto-selects the previous value, allowing you to rapidly adjust the device technology, voting architecture, or test interval as desired. After selecting from the drop down, Click Save.

To abort the process, Click Cancel to retain the previously entered value.
Import – Options: Inputs menu

⚠️ Warning: The import function will cause any existing data on the input tab to be over written.

The Non-Redundant and Redundant devices from the selected project will be retrieved into the Inputs without impacting any other protective function and no other information within the project – protective function.

Click the non-redundant or redundant list. Right Click. From the Inputs menu, Click **Import**. A list of your projects available for import will display. You cannot select the one that you are processing. **Double Click** on protective function to import the data.

![Figure 6.15 Protective Function - Select Project to Import - Inputs](image)

![Figure 6.16 Project Function – Filter Check Box](image)

The import list default is to display all projects in the project folder location. To display the current project protective function(s) only **Click Current Project** box. To return to the import list default uncheck the Current project with a **Click Current Project** box.

Selected project – protective function will be imported. Once imported, any existing data will be overwritten with the inputs data from the inputs of the selected project – protective function. The
Inputs, Non-Redundant and Redundant, are changed without impacting any other protective function and no other information within the project – protective function.

*Click Cancel.* Selected project will not be imported.

---

**Figure 6.17 Overwrite confirmation – Inputs**

*Click OK.*

---

**INPUT MANUAL TAB**

The manual entry for input architectures allows a maximum of 2 manual entries. The manual entry is used for modeling devices or architectures that are not included in SIL Solver®. The manual entry must include the PFDAVG and STR. All other entries are provided for documentation purposes and are treated as text by the program. For example, if the user enters 2oo10D voting in the input boxes, this is treated as text and SIL Solver® does not modify any of the other values typed into the row. The user must enter the value of the PFDAVG and STR, associated with the device failure rate, voting architecture, and test interval, as well as any common cause failure potential.

---

**Figure 6.18 Input Manual Tab View**

**Figure 6.19 - Buttons to convert the voting logic - Manual Entry**

*Click Redundant* or *Non-Redundant* button to convert the voting logic of the two entries into redundant (AND) logic or non-redundant (OR) logic. The selected entry is then added to the PIF as a redundant or non-redundant input. For help with the redundant or non-redundant selection, *Click “?”* shown next to the entry area.
Figure 6. 20 Options: Manual Entry for Input - Manual Entry menu

Edit – Options: Manual Input menu

To edit entry, Right Click on entry. From the Manual Input menu, Click Edit. The entries will be inserted into the input boxes allowing editing. When completed, Click Save.

Delete - Options: Manual Input menu

Click device. To delete entry, Right Click. From the Manual Input menu, Click Delete

LOGIC SOLVER TAB

The most prevalent error made in modeling PIFs is forgetting to enter the logic solver. This occurs because it is same in all of the functions in the project, so the user tends to focus on the inputs and actions. Always check the Summary tab to make sure there are an input, logic solver, action, and support system, as required.

The logic solver specification is based on type, voting, and proof test interval. The equipment type includes the diagnostics and voting architecture. Review the logic solver data sheet assumptions to make sure that they match the system specified. A proof test of the logic solver involves testing its diagnostics, components, and support systems. Logic solvers cannot be tested on-line, so it must be capable of meeting the requirements at the expected turnaround.
Add - Logic Solver

For the Logic Solver entry, use the drop down to Select the Logic Solver from the Logic Solver database. Voting drop down will be enabled. Select Voting. Type Tag Name. Click Save.

![Logic Solver After Choosing Logic Solver and Voting](image)

If there is an existing entry, the Logic Solver drop down will automatically delete the existing Logic Solver entry.

![Logic Solver menu](image)

Edit Tag Name – Options: Logic Solver menu

To edit the listed tag name, Right Click in the tag name area. From the Logic Solver menu, Click Edit Tag Name. Type tag name into the input box. Click Save.

![Edit Tag Name - Inputs menu](image)

Delete - Logic Solver

To delete the Logic Solver entry, Click Delete.

SUPPORT SYSTEM TAB

Support system analysis must be included for energize to trip and double acting valve applications. If all of the actions are energize to trip, the failure of the power must be included in the analysis by selecting the appropriate power supply tested and the expected turnaround. If only one action is
energize to trip, the power supply is selected as an output related to the final element it supports in taking action on the process.

In general protective equipment should be designed to fail safe on loss of support systems, such as the power supply, instrument air, hydraulic supply, or communications. When protective equipment requires a support system to achieve the safe state, the support system is included in the calculation.

Two types of support systems are provided in SIL Solver®: instrument air and power. Instrument air should be used when air-to-move valves is implemented. Power should be included when energize to trip action is implemented. Power is entered at the support system level if all of the actions are energize to trip. Otherwise, power should be entered as an output for a specific action and final element. For example, an interposing relay may de-energize to close a contact that energizes a motor control circuit.

---

**Figure 6. 25 Support System After Choosing Support System**

**Add Support System**

For the Support System entry, use the drop down to Select the Support System from the Support System database. **Click Save**.

---

**Figure 6. 26 Support System Completed View**

If there is an existing entry, the Support System drop down will automatically delete the existing Support System entry.

---

**Figure 6. 27 – Options: Support System Menu**
Edit Tag Name – Options: Support System menu

To edit the listed tag name, Right Click in the tag name field. From the Support System menu, Click Edit Tag Name. Type tag name into the input box. Click Save.

Delete Support System

To delete the Support System entry, Click Delete.

ACTION 1 – ACTION 5 TABS

SIL Solver® accommodates up to five sets of parallel actions: Action 1, Action 2, Action 3, Action 4 and Action 5. For example, in response to an overpressure scenario you may close steam isolation valves to a re-boiler (process action 1), open cooling water valves to a condenser (process action 2), close reactant A feed isolation valves (process action 3), close reactor B feed isolation valves (process action 4), and open reaction kill valves (process action 5).

Please be aware that it is very unusual to have a protective function with five separate process actions. Normally only one or two actions are required for safe operation.
Figure 6. 29 Options: Action menu - Action 1 – Action 5

Note: Import is available in Action 1. The Action 2 – Action 5 Action menu will not show the import feature.

Each Action screen represents a single process action that must take place to ensure safe operation. Each process action can be executed using up to three subsystems and each subsystem can consist of three devices. For example, a process action can be executed using three valve subsystems in series and each valve subsystem can consist of an interposing relay, a solenoid, and a valve (See Figure 6.30-38). Please note that many PIFs utilize only an actuator and final element. Each output action is calculated as follows:

\[
PFD_{\text{AVG}} = (PFD_{O1} + PFD_{A1} + PFD_{FE1}) \times (PFD_{O2} + PFD_{A2} + PFD_{FE2}) \times (PFD_{O3} + PFD_{A3} + PFD_{FE3})
\]

\[
STR = (STR_{O1} + STR_{A1} + STR_{FE1}) + (STR_{O2} + STR_{A2} + STR_{FE2}) + (STR_{O3} + STR_{A3} + STR_{FE3})
\]

All screens provide the percent contribution of each action to the overall PFD\text{AVG} and MTTF\text{spurious}. The percent contribution is calculated as follows:

\[
\text{Percent Contribution} = \frac{\text{Action Result}}{\text{Overall System Result}}
\]

While valves are being used for this example, the final element could also be a compressor or pump shutdown using a relay in the motor control circuit.
The relationship of the three devices that comprise the subsystem is established using the checkboxes on the upper right hand side of the action screen. The three devices are designated as output (e.g., relay), actuator (e.g., solenoid) and final element (e.g., valve). The 1, 2, and 3 checkboxes define the first subsystem, the second subsystem, and third subsystem, respectively. To establish the correct relationships, you must determine whether you are adding an output, actuator, or final element. Then, select 1, 2 or 3 to assign the device to a specific subsystem.

As an example, Action 1 screen will be used. The other action screens are utilized similarly with the exception of the Action menu right click Import feature. It is available on Action 1 only. In the instructions provided below, simply substitute Action 2, Action 3, Action 4, or Action 5 for Action 1.

**Step 1 in Entering Action 1**

Step 1. For the interposing relay, select the “RELFO,” the voting architecture, and test interval. Next, select the appropriate check box to assign it to a specific location in the overall system. For the example, this is being entered in as the first subsystem, so “1” is selected. After entering the target values, Click SAVE to continue.
Step 2 in Entering Action 1

Select the solenoid valve with the appropriate voting architecture and test interval. This solenoid will be de-energized by the relay selected in Step 1, so the “1” is checked again. Click **SAVE** to continue.

Step 3 in Entering Action 1

Select the block valve with the appropriate voting architecture and test interval. The air is removed from the actuator of this valve using the solenoid selected in Step 2, so the “1” is checked again.

Step 4 in Entering Action 1

The first subsystem has now been added. The architecture can be reviewed by examining the arrangement field.
Step 5 in Entering Action 1

Step 5. To add a second subsystem repeat Steps 1 through 4 checking column 2, likewise for the third subsystem check column 3. The tag names can then be edited later.

SIL Solver® is not sensitive to the order of data selection. You can enter the devices in any order as long as the proper relationships are established. Consequently, you can select the relay, voting, and test interval, followed by selecting the “1”, “2”, and “3.” Click **Save**.

You can then select the solenoid valve, voting, and test interval, followed by selecting the “1”, “2”, and “3.” Click **Save**.

You can then select the block valve, voting, and test interval, followed by selecting the “1”, “2”, and “3.” Click **Save**.

You can then select the final element, voting, and test interval, followed by selecting the “1”, “2”, and “3.” Click **Save**.
Delete – Options: Action menu

To delete an entry, Click to highlight the entry. Right Click. From the Action menu, Click Delete. There is no warning. The entry will be removed from the Action list and the protective function database.

View Project Sheet – Options: Action menu

Click on device in Action list. Right Click. From the Action menu, Click View Data Sheet.

Depending on when the protective function was created, this may not be the current version of the device. This feature shows the data in the project database, not the device database. The data used in a protective function is pulled from the device database into the project database when the protective function was created. The View Project Sheet selection therefore allows the user to view the data that was available and used at the time of protective function creation. This data may be different from the data provided in the current SIL Solver® database due to on-going revision.

Click Close or the red X to return.
To return to the current protective function tab, simply Click Close or red X.

**Go to Datasheet – Options: Action menu**

For any input or action device entered into the database, you can view the SIL Solver® database associated with the device.

*Click the device. Right Click. Click Go to Datasheet*, which shows the complete datasheet for the specific device. This data is pulled from the SIL Solver® database at the time of selection. This data may be different from what is currently in the protective function sheet due to modification of the database since the time of protective function correction. This selection will take you directly to the SIL Solver® Data Sheet. The device sheets are described Section 9 Access to Datasheets.

To exit, simply Click Close.

**Edit Tag Name – Options: Action menu**

To edit the listed tag name, Right Click on entry. From the Action menu, Click Edit Tag Name. Type tag name into input box. Click Save.

![Edit Tag Name - Action menu](Figure 6. 40)

**What if? - Options: Action menu**

You can play what-if scenarios by selecting a previously entered value. Right Click.. From the Inputs menu, Click What-if?.

![What if? View prior to selection Action menu](Figure 6. 41)

The existing value is displayed in blue above the technology selection dropdown. The dropdown auto-selects the previous value, allowing you to rapidly adjust the device technology, voting.
architecture, or test interval as desired. Also the select the block valve previously selected “A1A1” has been checked. After you select from the drop down, Click **Save**.

To abort the process, **Click Cancel** to retain the previously entered value.

**Import – Options: Action menu**

To import click inside the Action 1 list. **Right Click**. From the Action menu, **Click Import**. A list of your projects – protective functions available for import will display. You cannot select the one that you are processing. **Double Click** on protective function to import the data. Selected project will be imported. Once imported, any existing data in Action 1 – Action 5 will be over written with the data that exists in the selected protective function. This imports all action data found in Action 1 – Action 5 tabs not just Action 1. The action data is changed without impacting any other information.

![Figure 6. 42 Options: Action menu - Action 1 – Action 5](image)

Remember import is available in Action 1. The Action 2 – Action 5 Action menu will not show the import feature.
The import list default is to display all projects in the project folder location. To display the current project protective function(s) only click the Current Project box. To return to the import list default, uncheck the Current project with a click on the Current Project box.

You will lose previous entries, if you wait to import. A warning message is displayed as follows:

*Click OK*. Selected project – protective function will be imported.
Click Cancel. Selected project will not be imported.

Common Cause Factor – Action 1 Tab

The common cause factor for inputs is included in the SIL Solver® device database. In contrast, actions built by the user require the common cause factor selection to be entered by the user.

The common cause factor selected with each process action output can be entered into SIL Solver® using the drop down list of common cause factors (beta factors.) SIL Solver® calculates the common cause factor PFD_{AVG} as follows:

\[
CCF \, PFD_{avg} = \frac{\text{Common Cause Factor}}{100} \times (PFD_{avg}^{4\text{IOL}} + PFD_{avg}^{4\text{AI}} + PFD_{avg}^{4\text{IF}})
\]

Consequently, the devices that you want utilized in the common cause factor PFD_{AVG} calculation should be entered as subsystem 1. In SIL Solver® common cause factor can be included for each output action. If you wish to consider common cause factor for the overall outputs for the function only, simply select which output subsystem that you want to use for the common cause factor contribution and enter these as subsystem 1 on the associated action page.

![Dropdown for selecting common cause factor for the subsystem - Action Tab](image)

**ACTION M TAB**

The Action M (manual) tab allows you to manually enter data for output combinations. These values may be obtained from separate fault tree analysis or reliability block diagrams.

**Add - Manual Entry for Action Architecture**

The device ID, tag name, voting, and test interval are entered as text into SIL Solver®. The PFD_{AVG} and STRate must be entered in exponential format and are used in the calculation of the overall results. After completing the fields in the data entry, Click Save.
Delete – Manual Entry for Action Architecture

To delete the Manual Entry for Action Architecture’s data, Click Delete.

**SUMMARY TAB**

The Summary tab in SIL Solver® provides an overview of the percent contribution of each subsystem on the overall PFD and STR. This value represents the percentage of the overall PFD and STR that is attributable to the subsystem. When the PIF design does not meet the target initial changes should address the subsystem that has the highest percent contribution. Changes to the test interval, voting architecture, and alternative device selection may be considered. Note that in many cases, the information entered on the Action tabs is the main contributors to the PFD due to the difficulty of complete on-line testing. The performance of such PIFs can be improved through implementation of means to facilitate on-line testing.
Access to Protective Function Revision Level

The summary sheet has a protective function revision level. When this button is selected, a revision control form opens and any modifications can be described with new revision noted. This revision level button opens the same database as the protective function revision level button on the Project Start. The data only needs to be entered in once. The user is provided two points to enter this information for convenience purposes. The current information may be printed at the bottom of the reports. See Section 10 for instructions to completing this documentation.
Advance project operations allow the flexible of cloning an existing project (copy), renaming an existing project (rename), and permanently removing an existing project (delete). Remember that a project to be copied or renamed must have been opened at least once for SIL Solver® to locate the project folders and databases. If not, you will receive a similar message that the project has not been created yet so it cannot be copy. You will be able to copy after project creation. There is a similar message for rename.

Note: the project drop down menu is in the order of most used. If you want to add projects created in another folder, close SIL Solver®, copy the project folder(s) into the project folder location, open SIL Solver® and these projects with auto-connect. For example, copy the project folder from the SIL Solver® directory on User #1’s computer project folder location on User #2’s computer. Do not use Windows Explorer to copy a project creating two projects or to rename your project or the project folders outside of SIL Solver®. This will result in errors. There is data within each database that links to other database.

Copy – Options: Project menu

Once you have created a project, you may have project with functions that are very similar, or you may want to run cases where you change the test intervals or system configuration on just a few of the inputs or outputs.

From the project list, Click a project. Right Click. From the Project menu, Click Copy.
Type in input boxes a new Customer ID Project ID.

See Section 4 Basic Project Operations for requirements. Click OK. You have created another project identical to the select project.

To abort the process, Click Cancel.

The entered project's name must be unique. If SIL Solver® determines that the project name already exists, the process will be cancelled.

Rename – Options: Project menu

From the project list, Click on project. Right Click. From the Project menu, Click Rename.
Figure 7. 48 Rename - Project menu

Type a new Customer ID Project ID into the input boxes.

See Section 4 Basic Project Operations for requirements. Click OK. You have changed the name of your old project to the entered name. Click Cancel. This will abort the process.

The rename project’s name entered must be unique. If SIL Solver® determines that the project name already exists, the process will be cancelled. This will abort the process.

**Delete** - Options: Project menu

From the project list, Click on project. Right Click. From the Project menu, Click Delete.

A warning message will be displayed. This process will permanently remove the folders and all associated databases. These files are not available for recovery. These files will not be in the recycle bin. When delete is selected, it is permanent.

⚠️ Warning: Clicking Delete permanently removes the project. These are not recoverable.
Click **Yes** to remove this project's databases and protective functions folders. **Click No.** This will abort the process. Not shown.

Possible problem: If the user creates a folder(s) under a project folder, the project folder or the unknown subfolder will not be deleted by SIL Solver® and a message will be generated. The project list will appear as if the project was deleted, but the next time you open SIL Solver® it will be one of the projects in the project list. Use Windows Explorer to delete this project folder with its contents.

![Operation Status](image)

Figure 7. 50 Folder(s) in Project Folder

Windows Explorer may also be used to deleted or move the project folder to different location. Neither will affect SIL Solver® future processing.
Advance protective function operations allow the flexible of cloning an existing function (copy), renaming an existing protective function (rename), connecting protective function copied into the project folder or one that was previously disconnect, removing from the protective function list (disconnect) and permanently removing an existing function (delete). Remember a protective function to be copied or renamed must have been opened at least once for SIL Solver to locate the project folders and databases. If not, you will receive a similar message that the project has not been created yet so it cannot be copy. You will be able to copy after project creation. There is a similar message for rename.

Figure 8.1 Protective Function menu

Copy – Options: Protective Function menu

Once you have created a protective function, you may have other functions that are very similar or you may want to run cases where you change the test intervals or system configuration on just a few of the inputs or outputs. There are two short-cuts available for creating these new protective function models:

1. You can create a new function as discussed previously, then follow the instructions to import the protective function documentation, inputs, or actions from another protective function into the one that is open.
2. You can use the copy protective function on the Project Start. This creates an exact duplicate of the original protective function. You can then edit the new function as desired.

From the project list, **Click** a protective function. **Right Click.** From the Protective Function menu, **Click Copy.**

**Type** the new name for the Protective Function into the input box. See Section 5 Basic Protective Function Operations for requirements. **Click OK.**

![Figure 8. 2 Enter New protective function](image)

**Note:** The new protective function name that you entered must be unique to this project. If SIL Solver® determines that the protective function name already exists, the process will be cancelled.

![Figure 8. 3 New name was found.](image)

**Rename - Options: Protective Function menu**

From the protective function list, **Click** on the protective function to be renamed. **Right Click.** From the Project menu, **Click Rename.**
Figure 8.4 Rename - Options: Protective Function menu

Type a new name into the input box.

See Section 5 Basic Protective Function Operations for requirements. Click OK. You have changed the name of your old protective function to the entered name. Click Cancel. This will abort the process.

The rename protective function’s name entered must be unique. If SIL Solver® determines that the protective function name already exists, the process will be cancelled. The rename process will be aborted.

Connect All PFs - Options: Protective Function menu

Why do you need this? Protective Functions that are currently connected to SIL Solver® are shown in the protective function listing. As you eliminate testing options or cases, you may wish to remove these from the protective function listing to prevent the need to scroll through a long list to find a specific protective function. Or if you have disconnect a protective function because you wanted to print the project without that protective function printing but now want to continue processing. Or, if using Windows Explorer, you have copied or moved a protective function into the project folder location subfolder to one of your projects. For example, copied the protective function folder from the SIL Solver® directory on User #1’s computer to the project folder location on User #2’s computer. In this example, the same project name is assumed.

From the protective function list, Click on protective function. Right Click. From the Protective Function menu, Click Connect all PFs. All protective function located under the project will be available for processing.

Disconnect - Options: Protective Function menu

To remove a protective function from the protective function listing, Click the Protective Function. Right Click. From the Protective Function menu, Click Disconnect. This process does not delete
the folder or files from the folder; it removes it from the protective function listing only. After
disconnect from the protective function listing, you could reattach the protective function to SIL
Solver® by re-entering the Protective Function ID using Connect all PFs.

**Delete - Options: Protective Function menu**

From the Protective Function list, Click on protective function. Right Click. From the Protective
Function menu, Click Delete.

A warning message and confirmation will be displayed.

![Warning and confirmation needed](image)

**Figure 8. 5 Warning and confirmation needed to Are you sure?**

*Click Yes* will remove the protective function. *Click No* to cancel process and an Aborted message
will be displayed. Not shown.

Possible problem: If the user creates a folder(s) under a protective function folder, the protective
function folder and unknown subfolder will not be deleted by SIL Solver® and a message will be
generated. The protective function list will appear as if the protective function was deleted, but from
Windows Explorer you can see the folder or if you use the Connect All PFs, it will be connect as
one of the protective function in the protective function list. Use Windows Explorer to delete this
protective function folder with its contents.

![Operation Status](image)

**Figure 8. 6 Deletion could not be completed**

Using Windows Explorer, you can delete or move the project folder out of the project folder
location. Neither will affect SIL Solver® future processing.
SECTION 9  ACCESS TO DATASHEETS

Data Sheets allows you to open the device sheets, logic solver sheets, and support system sheets databases. You also can access these from the Go to the device sheet from Inputs and Action (1-5).

From the Project Start or from the Protective Function screen, Click Data Sheets. From the Data sheets menu, Click Device Sheets.

DEVICE SHEETS

The device sheet database is available. From this screen, you can view the default datasheets, which are tagged as data source SIL, or any device sheets that you have entered into the database. This Device sheet includes a toolbar with icons defined in Section 3. Remember tool tips are available on the icons by running your mouse over them.

Searching for a Device ID – Tool bar

From the toolbar, Click Search. When the Search window opens you have the option to sort the devices by Data ID (SVDS) or by Data Source (SRC). Click in the area directly above the first column to change sort option. Once you have chosen the sort option you may type the first letter to quicken your search. To sort the devices by Description, Click Description. Then use the scroll bar to find the device. Double Click on device to retrieve.
Figure 9. 3 Search for Device datasheet

Or from the toolbar, Click Arrows to go to the next data sheet in the database.

Figure 9. 4 Data Sheet View – Device Sheets
You can add your own projects specific datasheets. Modify or delete is not allowed to any data associated with the default database (Data Source is “SIL.”) If you attempt to make a change, a message will be displayed.

Figure 9.5 if you attempt to change default data

The authorization level is restricted to prevent unauthorized changes to the default database. This is an administrative function that is not accessible by users. If you receive a message requiring a password, Click No.

Figure 9.6 Project Start

New – Tool bar

Data Sheets can be added to the device sheets, logic solver sheets, and support system sheets. To add a project specific datasheet from the toolbar, Click New.

The data source is tagged with the Project Start Customer ID (SRC), however, it can be changed to a generic name for the company projects. The SRC and Device ID input boxes are enabled.

Type 2-5 characters into the second input box, then Click OK. The SRC and the device ID are used for the protective function drop down device selection and must be unique from all other datasheets.
If the device ID entered exists in the device database, you will receive a warning message that this device already exists. SIL Solver® will then display that datasheet.

**Device ID – Data Sheets**

The Device ID is used on the protective function sheet for selecting the device for the analysis. It should be made as descriptive as possible, but is limited to five characters. The **Device Type** field allows an extended description of the device to be shown on the datasheet (45 characters). If additional notes are required, these can be entered in the **Notes** field at the bottom of the datasheet. Notes area can be used to list the boundary of the device, exclusions, comments, data source, etc.

---

**Click Delete** to abort entry.
Device Entry – Data Sheet

The data is entered into the data entry fields as follows:

Fail dangerous failure rate per year--This is the total dangerous failure rate for the device and is a required entry. The units are in failures per year. The value should be entered in exponential format.

Fail spurious failure rate per year--This is the total safe + dangerous detected failure rate for the device and is a required entry. The units are in failures per year. The value should be entered in exponential format.

⚠️ Warning: Always enter the failure rates in exponential format. If other formats are used, the software will default the field value to 0.

Mean time to repair (hours)--This is the MTTR assumed in the safety requirements specification for the device. The units are in hours. The value should be entered in number format.

Common Cause Factor Dual Mode--This is the beta factor for a dual redundant subsystem. The system expects the value to be a percentage, so a beta factor of 2% would be entered as 2.0.

Common Cause Factor Triple Mode--This is the beta factor for a triple redundant subsystem. The system expects the value to be a percentage, so a beta factor of 2% would be entered as 2.0.

Diagnostic Interval (hours)--This is the time interval between automatic on-line diagnostic tests. The units are in hours. The value should be entered in number format. For example, a deviated transmitter can be detected and alarmed within a couple of scans. However, safe operation requires that the operator acknowledge the fault and institute alternative safe operating procedures. The diagnostic interval is generally considered to at least two minutes.

Diagnostic Coverage in Simplex Mode--This is the diagnostic coverage present for a single device. In many cases, the failure rate data provided in the published literature already take into account the diagnostics contained within the device itself. Consequently, this diagnostic coverage is generally limited to some type of external diagnostics, e.g., partial stroke testing. The system expects the value to be a percentage, e.g. 40% would be entered as 40.

Diagnostic Coverage in Dual Mode--This is the diagnostic coverage present due to the comparison of dual redundant devices. The system expects the value to be a percentage, e.g. 80% would be entered as 80.
Diagnostic Coverage in Triplicated Mode—This is the diagnostic coverage present due to the comparison of triple redundant devices. The system expects the value to be a percentage, e.g. 80% would be entered as 80.

Selecting Voting – Data Sheets

![Voting Drop down](Figure 9. 10 Voting Drop down)

The voting is selected using a drop down. The architectures are as follows:

1001
1001D
1002
1002D
2002
2002D
1003
1003D
2003
2003D
3003
3003D

Each voting architecture corresponds to an equation provided in Section 12.

Test Interval – Data Sheets

![Check boxes for Test interval Selection](Figure 9. 11 Check boxes for Test interval Selection)

SIL Solver® includes twelve pre-designated test intervals. Click the Ck All to select all the test intervals. Individual test intervals may be selected by checking the box next to the desired test interval. If other test intervals are desired, these can be entered in number format in the Other field.
Add Voting Architectures – Data Sheets

The Save button will not become active until a voting architecture is selected. Click Save. The device data, voting architecture, and test interval calculations will be performed. The PFDAVG and spurious trip rate numbers are then displayed in the data sheet list.

For more architectures or test intervals, repeat the previous steps. The results are always sorted by architecture followed by test interval.

No calculations will be performed if the fail dangerous and fail spurious failure rates are not entered.

Delete Device User Entered Data Sheet – Tool bar

From the tool bar, Click Delete. You will receive a confirmation to continue.
Figure 9.13 Confirmation to Continue
Click **Ok** to remove the device sheet. **Click Cancel** to abort the delete process.

**Delete Testing Interval - Options: Data Sheet menu**
From the device list, **Click on Device**. **Right Click**. From the Data sheet menu, **Click Delete**.

There is no confirmation or warning. There is no “undo.” Once deleted, the data line will need to be re-created.

**Edit Data in Existing Sheet – Tool bar**
Once you have built a user data sheet, you may need to change assumptions made in the data entry area. Use the arrows to page through the database or **Click Search**. **Locate** your Device ID. **Double Click**. Now that your device is in view, **Click Edit**. Next, go to the field that you want to change. Change the value of the field using the appropriate format.

**Click Recalculate** to update the data sheet list results. The Save will not be enabled. Any change to device entry does not require a **SAVE**.
Figure 9.15 After Clicking Edit, delete or recalculate available

Note: If you have added this device sheet to a project, the prior device information within the project will remain. The project data sheet is not updated with any change to a SIL Solver® Device Sheet.

Until you click the Recalculate button after data modifications, the testing interval information will not be updated. However, if you also added a Test Interval, the save will be enabled. Click Save. The re-calculation will occurred in the Save procedure. The testing interval information would be updated.

Print Data Sheets – Tool bar

From the toolbar, Click Print. A printing device options will be displayed.

Figure 9.16 Printing device options - Individual Device Reports

- Data ID List is a complete listing of devices and abbreviations in SIL Solver® database including user devices.
Figure 9.17 Example: Data ID List

Current Datasheet + Architecture.

- This report includes all available voting architecture and device notes at the end of the report.

Figure 9.18 Example: Individual Device Datasheet with Architecture
Current Datasheet

- This report is the same as the previous report minus the Architecture.

Figure 9. 19 · Example: Current Datasheet w/o Architecture

All SIL Datasheets.

- This report is identical to Current Datasheet report for all original devices in SIL Solver® database.

All User Datasheets

This report is identical to Current Datasheet report for devices added by user to the SIL Solver® database.

Revision Level – Tool bar

Even though the Device Sheet database revision level may not be altered by users, for hard copy documentation users may print this information. From the tool bar, Click Revision Level.
Figure 9. 20 Data Sheets Version Information

*Click Print.*

Figure 9. 21 Print Data Sheets Version Information

*Click OK.*

Close Data Sheets - Tool bar

To close and return to where you selected **Data Sheets**: the Project Start or Protective Function, or Go to Data Sheet. *Click Close* or the red X in the upper right hand corner.

**LOGIC SOLVER SHEET**

**Data Sheets** allows you to open the device sheets, logic solver sheets, and support system sheets databases. You may access the data sheets by selecting the **Go to the device sheet** from the right click menu in the Inputs and Action (1-5) tabs.

From the Project Start or from the Protective Function screen, *Click Data Sheets*. From the Data sheets menu, *Click Logic Solver Sheets*.

Figure 9. 22 Project Start Data Sheet Access - Options: Data sheets menu
Figure 9.23 Protective Function Data Sheet Access – Options: Data sheets menu

From this screen, you can view the default datasheets, which are tagged as data source SIL, or any device sheets that you have entered into the database. This Logic Solver sheet includes a toolbar with icons defined in Section 3. Remember tool tips are available on the icons by running your mouse over them.

Figure 9.24 Logic Solver Sheet View

Searching for a Device ID - Tool bar

From the toolbar, Click Search. When the Search window opens, Double Click on data sheet to retrieve. Or from the toolbar, Click Arrows to go to the next Logic Solver device in the database.
Figure 9. 25 Logic Solver Search

Notes area can be used to list the boundary of the device, exclusions, comments, data source, etc.

New – Tool bar

The Device ID is used on the protective function Logic Solver Tab for device selection. The Device ID should be made as descriptive as possible, but is limited to 5 characters. Characters in excess of 5 will be truncated. The Device ID field allows an extended description of the device to be shown on the datasheet. If additional notes are required, these can be entered in the Notes field at the bottom of the datasheet.

Figure 9. 26 New Device Detail - Logic Solver tool bar
The data is entered into the data entry fields as follows:

Voting--the architecture of the logic solver.

$PFD_{AVG}$--the average probability to fail on demand. The value should be entered in exponential format.

Spurious trip rate per year--This is the spurious failure rate for the logic solver. The units are in failures per year. The value should be entered in exponential format.

⚠️ Warning: Always enter the failure rates in exponential format. If other formats are used, the software will default the field value to 0.

Add Voting Architectures Or Test Intervals

The **Save** is not active until an entry is made in the voting architecture field. For more architectures or test intervals, repeat the previous steps. The results are always sorted by architecture followed by test interval.

⚠️ Warning: The **Save** button will not become active until the voting architecture is entered.

Delete Device – User Entered Logic Solver Sheet

From the toolbar, **Click Delete**. You will receive a confirmation to continue.
Figure 9.29 Confirmation to Continue

Click **Ok** to remove the device sheet. **Click Cancel** to abort the delete process.

Delete Testing Interval - Options: Logic Solver menu

From the Logic Solver list, **Click on Device**. **Right Click**. From the Logic Solver menu, **Click Delete**.

There is no confirmation or warning. There is no “undo.” Once deleted, the data line will need to be re-created.

Figure 9.30 Detail showing Delete action – Options: Logic Solver menu

Print – Tool bar

Figure 9.31 Reports Available Options
The report format for all SIL Data Sheet report is same as above. When User Data Sheets report is chosen, it is only user’s entered data that will be printed. None of the “SIL” devices will be included in the report.

Revision Level – Tool bar

Even though the Logic Solver Sheets database revision level may not be altered by users, for hard copy documentation users may print this information. From the tool bar, Click Revision Level.

Click Print.
Click OK.

Close - Tool bar

To close and return to where you selected Data Sheets: the Project Start or Protective Function, Click Close or the red X in the upper right hand corner.

**SUPPORT SYSTEM SHEET**

Data Sheets allows you to open the device sheets, logic solver sheets, and support system sheets databases. When you select Support System Sheets, the support system datasheet will open. Access screen includes a toolbar with icons defined in Section 3. You also may use the Go to the device sheet from Inputs and Action (1-5) to access the sheets.

From the Project Start, or from the Protective Function screen, Click Data Sheets. From the Data sheets menu, Click Support System Sheets.

![Figure 9. 35 Project Start Data Sheet Access - Options: Data sheets menu](image)

![Figure 9. 36 Protective Function Data Sheet Access – Options: Data sheets menu](image)

From this screen, you can view the default datasheets, which are tagged as data source SIL, or any device sheets that you have entered into the database. This Support System sheet includes a
toolbar with icons defined in Section 3. Remember tool tips are available on the icons by running your mouse over them.

![SIL Solver Support System Data Sheet](image)

**Figure 9. 37 Support System Sheet View**

**New Device – Tool bar**

The Device ID is used on the protective function **Support System Tab** for device selection. The Device ID should be made as descriptive as possible, but is limited to 5 characters. Characters in excess of 5 will be truncated. The Device ID field allows an extended description of the device to be shown on the datasheet. If additional notes are required, these can be entered in the **notes** field at the bottom of the datasheet.
The data is entered into the data entry fields as follows:

**PFD\textsubscript{AVG}**—the average probability to fail on demand. The value should be entered in exponential format.

Spurious trip rate per year—This is the spurious failure rate for the logic solver. The units are failures per year. The value should be entered in exponential format.

⚠️ **Warning:** Always enter the PFD\textsubscript{AVG} and Spurious Trip Rate in exponential format. If other formats are used, the software will default the field value to 0.

**Delete Device – User Entered Support System Sheet**

From the tool bar, Click **Delete**. You will receive a confirmation to continue.

*Figure 9. 38 New Device Detail - Support System tool bar*

*Click Ok* to remove the device sheet. *Click Cancel* to abort the delete process.
Print – Tool bar

Figure 9. 40 Reports Available Options

Figure 9. 41 Print Options Current Data Sheet + Architecture

All SIL Data Sheet report is same as above. All User Data Sheets are only the sheets that not “SIL.”

Revision Level – Tool bar

Even though the Support System Sheets database revision level may not be altered by users, for hard copy documentation users may print this information. From the tool bar, Click Revision Level.
Figure 9. 42 Support System Version Information

*Click Print.*

Figure 9. 43 Print Data Sheets Version Information

*Click OK.*

**Close the Support System Sheets**

To close and return to where you selected *Data Sheets*: the Project Start or Protective Function, *Click Close* or the X in the upper right hand corner.
SECTION 10  PROTECTIVE FUNCTION/PROJECT DOCUMENTATION

Documentation of both the Project and the individual Protective Functions may be completed at any time. Options are provided to support revision tracking at the Project and Protective Function level. When you print you will have the ability to choose which information is displayed in the report footer.

PF Revision Level Documentation

The user is provided two points to enter this information for convenience purposes. The data only needs to be entered in once. From the Protective Function side of the start screen click the PF revision level button. When this button is selected a revision control form opens and any modifications can be described with new revision noted. This revision level button opens the same database as the PF revision level button on the Summary Tab.

Click PF Revision Level

Figure 10.1 From protective function Summary Tab or From Project Start

New – Tool bar

You can add as many revisions as you need. The latest revision will be the one printed. If you want to add a new revision, from the toolbar, Click New. Blank input boxes will display for editing.
Figure 10.2 Protective Function Revision Level Completed

Click **Save**.

**Delete – Tool bar**

Click **Delete**. Version will delete without a warning or confirmation. There is no undo.

**Print – Tool bar**

Click **Print**. Will print the information on the protective function revision level sheets. Report not shown.

**Close – Tool bar**

To close and return the Project Start, **Click Close** or the red X in the upper right hand corner.
Project Revision Level Documentation

Prior to printing a project, complete the Project Revision Level documentation. The project documentation can be skipped until needed for the printing of reports.

From the project list, Click the Project processing. *Click Project Revision Level*

**New – Tool bar**

*Type* the project information into the input boxes. *Click Save*. You will choose if the project information or the protective function will print on the reports.
Click **Save**.

**Delete – Tool bar**

*Click Delete*. Version will delete without a warning or confirmation. There is no undo.

**Print – Tool bar**

*Click Print*. Will print the information on the Project Revision level sheets. Report not shown.

**Close – Tool bar**

To close and return the Project Start, *Click Close* or the red **X** in the upper right hand corner.
SECTION 11 REPORTS IN SIL SOLVER®

Reports may be generated on a Project level or a Protective Function level. The main difference is the scope of the data. The project reports print all the protective function connected the project. The protective function level prints only that protective function processing within the project. The guide will show you how to use the print at project level. Refer to these instructions when printing at protective function level.

From the Project Start, Click on the Project you wish to print, Click Print Project.

![Image of Project and Protective Function Reports Available Options]

Figure 11.1 Project and Protective Function Reports Available Options

Report Printing for Project

The default is All Protective Function Reports and Function Revision information. If you are printing at the project level, you may want the Project Revision information to print. Make sure you have updated the project revision information database.

Click Project Revision information. If you want the protective function revision information to print leave the default.

The All Protective Function Reports includes all four of the Protective Functions listed under the Select the reports you want to print. Click Protective Function Reports to enable the user to choose any combination of the individual reports.
Report Details for Project and Protective Function Levels

The four Protective Function Reports that may be printed all at once or individually selected are as follows:

Protective Functions Documentation

- This report has header information about the project; the information entered into tabs; the information entered into the PF Doc tab of the Protective Function, chosen project or the Protective Function current revision level, executed person\date and approval person\date.

![Protective Function Documentation](image)

Figure 11.2 Protective Function Documentation Tab

Protective Function Details

- This report has header information about the project; the information entered into tabs; Inputs through Action M (including devices, voting architecture, testing intervals, PFDavg.
and STR) of all devices in the Protective Function, the Project and the Protective Function current revision level, executed person\date and approval person\date.

---

### Figure 11.3 Protective Function Details Report Example

<table>
<thead>
<tr>
<th>SRC</th>
<th>Device ID</th>
<th>Tag Name(s)</th>
<th>Yielding TI (yr)</th>
<th>PFDavg</th>
<th>STR (yr)</th>
<th>PFD %</th>
<th>STR %</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIL</td>
<td>LT01F1</td>
<td>72971241712126</td>
<td>2.00E-2</td>
<td>2.65E-04</td>
<td>1.00E-04</td>
<td>1.00E-04</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.00E-04</td>
<td>1.00E-04</td>
<td>1.00E-04</td>
<td>1.00E-04</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.00E-04</td>
<td>1.00E-04</td>
<td>1.00E-04</td>
</tr>
</tbody>
</table>

---

**Note:**
- PFDavg: Probability of Failure on Demand
- STR (yr): System Time to Recovery
- PFD %: Probability of Failure on Demand Percentage
- STR %: System Time to Recovery Percentage

---

**Report Ver No.:** 10  | **Function Verified by:** John Doe |  10-06  
---

**Function Rev No.:** 0  | **Function Approved by:** Joye Doherty |  10-06  
---

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Page 87 of 122
Protective Function Results Summary

- This report has header information about the project, the information reported in Protective Function Summary tab. The Project and the Protective Function current revision level, the Project or the Protective Function executed person\date and approval person\date.

Figure 11. 4 Protective Function Results Summary Example
Protective Function Data Summary

- This report has header information about the project, the device information including failure rate data used in SIL Solver calculations. The Project and the Protective Function current revision level, the Project or the Protective Function executed person/date and approval person/date.

![Protective Function Data Summary](image)

Figure 11.5 Protective Function Data Summary Example
**Project Data Device Sheets**

This report will print information on each unique device that is used in the project. This report is available only at the Project level. If you check this report at protective function level, you will receive a message.

![Operation Status](image)

*Figure 11. 6 Project Data Device Sheets chosen at PF level*

**Project Level Device Report**

- Project Device Datasheets. This report includes a header with project information, a datasheet for each device used in the Project including all information from the Protective Function datasheet and the datasheet notes. The description includes the reference sources for the rates. Project Datasheets will only include the devices that are within the current revision of Protective Functions and will only print them once regardless of how many times a device is used with in the project.
## Protective Function Data Summary

<table>
<thead>
<tr>
<th>Customer ID</th>
<th>TRIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project ID</td>
<td>TRIAL</td>
</tr>
<tr>
<td>Data Source</td>
<td>SIL</td>
</tr>
<tr>
<td>Device ID</td>
<td>BVBSM</td>
</tr>
<tr>
<td>Device Type</td>
<td>BLOCK VALVE-BUTTERFLY-FTC-PS MONTH</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fail Dangerous Failure Rate (1/yr)</td>
<td>3.333E-02</td>
</tr>
<tr>
<td>Fail Safe Failure Rate (1/yr)</td>
<td>6.667E-03</td>
</tr>
<tr>
<td>Mean Time to Repair (hrs)</td>
<td>72.00</td>
</tr>
<tr>
<td>Common Cause Factor Dual Mode (%)</td>
<td>0.00</td>
</tr>
<tr>
<td>Common Cause Factor Triple Mode (%)</td>
<td>0.00</td>
</tr>
<tr>
<td>Diagnostic Interval (hrs)</td>
<td>730.00</td>
</tr>
<tr>
<td>Diagnostic Coverage in Simplex Mode (%)</td>
<td>70.00</td>
</tr>
<tr>
<td>Diagnostic Coverage in Dual Mode (%)</td>
<td>0.00</td>
</tr>
<tr>
<td>Diagnostic Coverage in Tripllated Mode (%)</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**Notes**

Calculations assume that provisions are made to maintain safe operation during any on-line testing, on-line maintenance, or fault response activities.

Spring return, pneumatically-operated butterfly valve, operating in a standby (dormant) mode of operation.

Safe state specified is fail closed. Valve closes when air is removed from actuator.

The solenoid failure rate is NOT INCLUDED in the above calculation. The appropriate voting architecture should be listed separately as the actuating device on the SIL Verification Sheet.

Partial stroke involves movement of the valve from the full open position, which is confirmed using limit switches, position transmitters, or visual confirmation.

Calculation assumes that the valve is not bypassed or mechanically limited during the test, so that the fail-safe condition can be achieved if a process demand occurs during the test.

Calculation assumes that the partial stroke test is performed using equipment and instrumentation that provide a positive confirmation that the valve is returned to the fully operational state after completion of partial stroke testing. Calculation assumes that a full-stroke test of the valve is performed at the specified testing interval.

*Data Source:* Compilation of the following data sources:

Page Numbers in SIL Solver Reports

Reports from SIL Solver do not include page numbers. To add page numbers save report as a PDF, then using a program such as Adobe Acrobat’s Add header & footer tool, insert page numbers using the header tab and reducing the top margin to .4 to align numbers with title.
SECTION 12  INTRODUCTION TO SIL SOLVER® MATHEMATICS

SIL Solver® utilizes reliability block diagrams with fault tree equations to calculate the probability to fail on demand (PFD_{AVG}) and the MTTFspurious of the protective instrumented function (PIF).

The reliability block diagram technique involves determining the PFD_{AVG} for the field sensors (FS), logic solver (LS), final elements (FE), and support systems (SS). The field sensors are the inputs required to detect the hazardous condition. The logic solver accepts these inputs and generates correct outputs that change the state of the final elements in order to mitigate the hazardous condition. The support systems are those systems that are required for successful functioning of the PIF. If the valves are air-to-move, the instrument air supply must be analyzed. If the PIF is energize-to-trip, the power supply must be considered as part of the PIF. The PFD_{AVG} for the inputs and outputs is calculated based on the architecture of each subsystem and utilizes assumed data for the dangerous failure rate ($\lambda_D$), test interval (TI), diagnostic coverage (DC), and mean time to repair (MTTR). Once the individual PFDs for each input, logic solver, output and support system are known, these PFDs are summed for the PFD_{PIF}.

$$PFD_{PIF} = \sum PFD_{FS} \oplus \sum PFD_{LS} \oplus \sum PFD_{FE} + \sum PFD_{SS}$$

The spurious trip rate (STR) for the inputs and outputs is calculated using the architecture of each subsystem and assumed data for the spurious failure rate ($\lambda_{SP}$) and mean time to repair (MTTR). Once the individual STR for each input, logic solver, and output are known, these STR values are summed for the STR_{PIF}.

$$STR_{PIF} = \sum STR_{FS} \oplus \sum STR_{LS} \oplus \sum STR_{FE} + \sum STR_{SS}$$

Simplex devices are used to implement many protective instrumented functions. The 1oo1 equation shown below is used to model simplex devices when no external diagnostic coverage is provided in the PIF design. The SIL Solver® software uses the architecture description "1oo1" to represent this equation.

$$PFD_{avg} = \frac{\lambda_D \cdot TI}{2} + \lambda_D \cdot MTTR$$
\[ MTTF^{SP} = \frac{1}{\lambda^{SP}} \]

The PIF design may utilize diagnostic coverage to improve the on-line detection of dangerous faults. The 1001 equation shown below is used to model simplex devices when external diagnostic coverage is provided in the PIF design. The SIL Solver® software uses the architecture description “1001D” to represent this equation.

The diagnostic interval (DI) is incorporated into the equation to allow modeling of diagnostic routines that occur at an extended interval. For example, this equation can be used to model the partial stroke test of a block valve. The diagnostic interval would be the partial stroke test interval. The test interval would be the full functional test interval. The diagnostic coverage that is provided by the specific partial stroke testing equipment would be determined using failure modes and effects analysis.

\[ PFD_{avg} = \frac{(1 - DC) * \lambda^D * TI}{2} + \frac{DC * \lambda^D * DI}{2} + \lambda^D * MTTR \]

\[ MTTF^{SP} = \frac{1}{\lambda^{SP}} \]
Dual redundant devices in a 1oo2 architecture are often used when fail safe operation is critical. The 1oo2 equation shown below is used to model dual devices when no external diagnostic coverage is provided in the PIF design. The SIL Solver® software uses the architecture description "1oo2" to represent this equation.

\[
PFD_{avg} = \left[ \frac{(1 - \beta) \lambda^D \cdot TI}{2} + (1 - \beta) \lambda^D \cdot MTTR \right]^2 + \left[ \frac{\beta \lambda^D \cdot TI}{2} + \beta \lambda^D \cdot MTTR \right]
\]

\[
MTTF^{SP} = \frac{1}{2 \lambda^{SP}}
\]

The PIF design may utilize diagnostic coverage to improve the on-line detection of dangerous faults. The 1oo2 equation shown below is used to model dual devices when external diagnostic coverage is provided in the PIF design. The diagnostic interval (DI) is incorporated into the equation to allow modeling of diagnostic routines that occur at an extended interval. For small diagnostic intervals, the contribution of the terms containing DI is generally negligible. The SIL Solver® software uses the architecture description "1oo2D" to represent this equation.

The 1oo2D equation is used to model 1oo2 voting devices where only one device must function correctly for the safe state to be achieved and external diagnostic coverage is provided in the PIF design. For example, external diagnostic coverage may be provided by comparing the analog signals of two transmitters and issuing a deviation alarm on unacceptable deviation.

This equation should not be used for dual redundancy that normally operates in a 2oo2 mode and on detection of fault converts to a 1oo1 architecture. While this redundancy is marketed as "1oo2D," the failure models are actually 2oo2D (see 2oo2 section).

\[
PFD_{avg} = \left[ \frac{(1 - DC) \lambda^D \cdot TI}{2} + DC (1 - \beta) \lambda^D \cdot DI \right]^2 + \left[ \frac{(1 - DC) \beta \lambda^D \cdot TI}{2} + DC \beta \lambda^D \cdot DI + \beta \lambda^D \cdot MTTR \right]
\]

\[
MTTF^{SP} = \frac{1}{2 \lambda^{SP}}
\]
Dual redundant devices in a 2oo2 architecture are often used when fail reliable operation is important. The 2oo2 equation shown below is used to model dual devices when no external diagnostic coverage is provided in the PIF design. The SIL Solver® software uses the architecture description “2oo2” to represent this equation.

\[
PFD_{avg} = 2 \left[ \frac{\lambda^D * TI}{2} + \lambda^D * MTTR \right]
\]

\[
MTTF^{SP} = \frac{1}{2 * \lambda^{SP} * \lambda^{SP} * TI}
\]

The PIF design may utilize diagnostic coverage to improve the on-line detection of dangerous faults. The 2oo2 equation shown below is used to model dual devices when external diagnostic coverage is provided in the PIF design. The diagnostic interval (DI) is incorporated into the equation to allow modeling of diagnostic routines that occur at an extended interval. For small diagnostic intervals, the contribution of the terms containing DI is generally negligible. The SIL Solver® software uses the architecture description “2oo2D” to represent this equation.

The 2oo2D equation is used to model 2oo2 voting devices where both devices must function correctly for the safe state to be achieved and external diagnostic coverage is provided in the PIF design. For example, external diagnostic coverage may be provided by comparing the analog signals of two transmitters and issuing a deviation alarm on unacceptable deviation.

This equation should be used for dual redundancy that normally operates in a 2oo2 mode and on detection of fault converts to a 1oo1 architecture. While this redundancy is marketed as “1oo2D,” the failure models are actually 2oo2D.

\[
PFD_{avg} = 2 \left[ \frac{(1 - DC) * \lambda^D * TI}{2} + \frac{DC * \lambda^D * DI}{2} + \lambda^D * MTTR \right]
\]

\[
MTTF^{SP} = \frac{1}{2 * \lambda^{SP} * \lambda^{SP} * MTTR}
\]
Triplicated, redundant devices in a 2oo3 architecture are often used when fail safe operation is important, but on-stream reliability is also important. In 2oo3 voting, two of the devices must fail dangerously in order for the safety system to fail on demand. From a reliability perspective, it also requires the failure of two devices spuriously in order for the PIF to spuriously trip. The 2oo3 equation shown below is used to model triplicated devices when no external diagnostic coverage is provided in the PIF design. The SIL Solver® software uses the architecture description “2oo3” to represent this equation.

\[
PFD_{avg} = 3 \left[ \frac{(1 - \beta) \cdot \lambda_D \cdot TI}{2} + (1 - \beta) \cdot \lambda_D \cdot MTTR \right]^2 + \left[ \frac{\beta \cdot \lambda_D \cdot TI}{2} + \beta \cdot \lambda_D \cdot MTTR \right]
\]

\[
MTTF_{SP}^{SP} = \frac{1}{6 \cdot \lambda_{SP} \cdot \lambda_{SP} \cdot TI}
\]

2oo3D

The PIF design may utilize diagnostic coverage to improve the on-line detection of dangerous faults. The 2oo3 equation shown below is used to model triplicated devices when external diagnostic coverage is provided in the PIF design. The diagnostic interval (DI) is incorporated into the equation to allow modeling of diagnostic routines that occur at an extended interval. For small diagnostic intervals, the contribution of the terms containing DI is generally negligible. The SIL Solver® software uses the architecture description “2oo3D” to represent this equation.

The 2oo3D equation is used to model 2oo3 voting devices where two of the three devices must function correctly for the safe state to be achieved and external diagnostic coverage is provided in the PIF design. For example, external diagnostic coverage may be provided by comparing the analog signals of three transmitters and issuing a deviation alarm on unacceptable deviation.

\[
PFD_{avg} = 3 \left[ \frac{(1 - DC) \cdot (1 - \beta) \cdot \lambda_D \cdot TI}{2} + \frac{DC \cdot (1 - \beta) \cdot \lambda_D \cdot DI}{2} + (1 - \beta) \cdot \lambda_D \cdot MTTR \right]^2 + \left[ \frac{(1 - DC) \cdot \beta \cdot \lambda_D \cdot TI}{2} + \frac{DC \cdot \beta \cdot \lambda_D \cdot DI}{2} + \beta \cdot \lambda_D \cdot MTTR \right]
\]

\[
MTTF_{SP}^{SP} = \frac{1}{6 \cdot \lambda_{SP} \cdot \lambda_{SP} \cdot MTTR}
\]
Triplicated redundant devices in a 1oo3 architecture are sometimes used when fail safe operation is absolutely critical. The 1oo3 equation shown below is used to model triplicated devices when no external diagnostic coverage is provided in the PIF design. The SIL Solver® software uses the architecture description “1oo3” to represent this equation.

\[
PFD_{avg} = \left[ \frac{(1-\beta) * \lambda^D * TI}{2} + (1-\beta) * \lambda^D * MTTR \right]^3 + \left[ \frac{\beta * \lambda^D * TI}{2} + \beta * \lambda^D * MTTR \right]
\]

\[
MTTF^{SP} = \frac{1}{3 * \lambda^{SP}}
\]

The PIF design may utilize diagnostic coverage to improve the on-line detection of dangerous faults. The 1oo3 equation shown below is used to model triplicated devices when external diagnostic coverage is provided in the PIF design. The diagnostic interval (DI) is incorporated into the equation to allow modeling of diagnostic routines that occur at an extended interval. For small diagnostic intervals, the contribution of the terms containing DI is generally negligible. The SIL Solver® software uses the architecture description “1oo3D” to represent this equation.

The 1oo3D equation is used to model 1oo3 voting devices where only one device must function correctly for the safe state to be achieved and external diagnostic coverage is provided in the PIF design. For example, external diagnostic coverage may be provided by comparing the analog signals of three transmitters and issuing a deviation alarm on unacceptable deviation.

\[
PFD_{avg} = \left[ \frac{(1-DC) * (1-\beta) * \lambda^D * TI}{2} + \frac{DC * (1-\beta) * \lambda^D * DI}{2} + (1-\beta) * \lambda^D * MTTR \right]^3 + \left[ \frac{(1-DC) * \beta * \lambda^D * TI}{2} + \frac{DC * \beta * \lambda^D * DI}{2} + \beta * \lambda^D * MTTR \right]
\]

\[
MTTF^{SP} = \frac{1}{3 * \lambda^{SP}}
\]
3oo3

Triplicated, redundant devices in a 3oo3 architecture are sometimes used when on-line operation is extremely critical. The 3oo3 equation shown below is used to model triplicated devices when no external diagnostic coverage is provided in the PIF design. The SIL Solver® software uses the architecture description “3oo3” to represent this equation.

\[
PFD_{avg} = 3 * \left[ \frac{\lambda^D * TI}{2} + \lambda^D * MTTR \right]
\]

\[
MTTF^{SP} = \frac{1}{3 * \lambda^{SP} * \lambda^{SP} * TI * TI - \lambda^D * MTTR}
\]

3oo3D

The PIF design may utilize diagnostic coverage to improve the on-line detection of dangerous faults. The 3oo3 equation shown below is used to model triplicated devices when external diagnostic coverage is provided in the PIF design. The diagnostic interval (DI) is incorporated into the equation to allow modeling of diagnostic routines that occur at an extended interval. For small diagnostic intervals, the contribution of the terms containing DI is generally negligible. The SIL Solver® software uses the architecture description “3oo3D” to represent this equation.

The 3oo3D equation is used to model 3oo3 voting devices where all devices must function correctly for the safe state to be achieved and external diagnostic coverage is provided in the PIF design. For example, external diagnostic coverage may be provided by comparing the analog signals of three transmitters and issuing a deviation alarm on unacceptable deviation.

\[
PFD_{avg} = 3 * \left[ \frac{1 - DC}{2} * \lambda^D * TI + \frac{DC}{2} * \lambda^D * DI + \lambda^D * MTTR \right]
\]

\[
MTTF^{SP} = \frac{1}{3 * \lambda^{SP} * \lambda^{SP} * \lambda^{SP} * MTTR * MTTR}
\]
## SECTION 13  DEVICE ID

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<td>SVDHS</td>
<td>SOLENOID VALVE DTT frequent stroke</td>
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<tr>
<td>SVDHW</td>
<td>SOLENOID VALVE DTT high wattage</td>
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<td>SOLENOID VALVE - ETT - NOT MONITORED</td>
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<td>SVETM</td>
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<td>TAMPP</td>
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<td>TTTLS</td>
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<td>UPSET</td>
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<tr>
<td>VARSD</td>
<td>VARIABLE SPEED DRIVE STOP</td>
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## SECTION 14  TROUBLESHOOTING GUIDE

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<tr>
<th>PROBLEM</th>
<th>TIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error message at initial startup of SIL Solver®. Cannot find file MSVCR70.dll</td>
<td>Due to the various Windows versions, the installer occasionally has difficulty in locating a file required for program operation. On the initial startup, SIL Solver® will display a message related to its inability to locate a file named “MSVCR70.dll.” To correct this error, simply use Microsoft Explorer to locate “MSVCR70.dll.” Then, COPY this file to the SIL Solver® installation folder. If the default installation location was chosen, the file should be placed under C:\Program Files\SILSOLVER.</td>
</tr>
<tr>
<td>Data in protective function sheet keeps showing zero</td>
<td>You are not using exponential format: X.XXE-XX.</td>
</tr>
<tr>
<td>Data in datasheet displays zero event though I entered a number</td>
<td>You are not using exponential format: X.XXE-XX.</td>
</tr>
<tr>
<td>Changed data in datasheet, but the values in the table did not update</td>
<td>You did not <strong>Click Recalculate</strong>.</td>
</tr>
<tr>
<td>Cannot add devices under the input screen for the protective function</td>
<td>You have not selected a device and/or voting architecture</td>
</tr>
<tr>
<td>Cannot add devices under the output screen for the protective function</td>
<td>You have not selected a device and/or voting architecture</td>
</tr>
<tr>
<td>Cannot add logic solver under the logic screen of the protective function</td>
<td>You have not entered architecture for the logic solver.</td>
</tr>
<tr>
<td>Cannot modify the database</td>
<td>You are attempting to edit default data under the protective function screen. This is not permitted.</td>
</tr>
<tr>
<td>Message appears “A password required to edit datasheets. Do you know the password?”</td>
<td>This message indicates that you are attempting to modify the default database. This password is not provided to SIL Solver® users to ensure the integrity of the database. You are allowed to add or modify your personal datasheets only.</td>
</tr>
</tbody>
</table>
SECTION 15 END-USER SITE LICENSE AGREEMENT

This End-User License Agreement (the “License”) is a legal agreement for the SIS-TECH Applications, LLP’s (“SIS-TECH Applications”) software product, which includes computer software and may include associated media, printed materials, “online” or electronic documentation, databases, calculation algorithms, and related materials known collectively herein as “SIL Solver®.”

BY INSTALLING, COPYING OR OTHERWISE USING SIL SOLVER®, THE CONSUMER (“End-User”) AGREES TO BE BOUND BY THE TERMS OF THIS LICENSE. The End-User must indicate his/her agreement to be bound by the terms of the License by pressing the “I ACCEPT” button on SIL Solver® installation program, or else End-User will not be able to install SIL Solver®. If the End-User does not agree to the terms of the License, he/she may not install or use SIL Solver®. End-User may, within 30 days of initial purchase of a copy of SIL Solver®, return the entire copy of SIL Solver® (including all computer media, packaging and documentation) to SIS-TECH Applications or to a SIS-TECH Applications’ authorized representative for a refund of the amount paid for SIL Solver®, in which event End-User rights under this License are immediately terminated.

End-User must represent and warrant to SIS-TECH Applications that he/she has the capacity and authority to enter into this License on his/her own behalf, as well as on behalf of the owner of the computer on which SIL Solver® is being installed. For the purposes of this License, the owner of the computer is the individual or entity that has legal title to the computer or that has the possessory interest in the computer if it is leased or loaned by the actual title owner.

Therefore, subject to the following terms and conditions, SIS-TECH Applications grants to End User a non-transferable (except as otherwise provided herein), non-exclusive license (“License”) to use SIL Solver® only as indicated below.

ARTICLE 1: GENERAL COPYING RESTRICTIONS. End-User shall make copies of SIL Solver® only to the extent necessary to utilize SIL Solver®. Unauthorized copying of SIL Solver® (including any modification of SIL Solver® or merger with other applications or software) and the acquisition and use of unauthorized copies of SIL Solver® is expressly prohibited by law, and may be subject to both severe criminal and civil penalties for which End User may be liable for fines, damages, and attorney’s fees. Violators will be prosecuted to the maximum extent possible. SIS-TECH Applications has the right to terminate this License and to take legal action if the terms of this License are violated.

ARTICLE 2: ARCHIVAL COPIES. End-User may make up to two (2) archival back-up copies of SIL Solver® diskettes, but only if such copies are for End-User’s personal use within the scope of this License.

ARTICLE 3: PROPRIETARY RIGHT OF SIL SOLVER®. The SIS-TECH Applications logo, software, manuals, documentation, and other support materials comprising or supplied with SIL Solver® are owned by SIS-TECH Applications as trade secrets and/or proprietary information, and except as set forth herein, shall not be copied, lent, transferred, or otherwise disclosed without the
prior written consent of SIS-TECH Applications. Except to the extent that such restriction is unenforceable under local law, End-User may not reverse engineer, decompile, or disassemble SIL Solver®, which is licensed as a single product, and its component parts may not be separated for use on more than one computer. You may not modify, amend, or create derivative works of SIL Solver®.

ARTICLE 4: CUSTOMER SERVICE. End-User shall obtain customer service directly from SIS-TECH Applications or its authorized distributor unless such service becomes unavailable.

ARTICLE 5: TERMINATION OF END USER LICENSE. If any of the terms and conditions of this License is broken by End-User, in addition to all other legal rights and remedies, SIS-TECH Applications may terminate this License. Otherwise, the license granted herein shall be perpetual. Upon termination, End-User shall use its reasonable efforts to return SIL Solver® to SIS-TECH Applications, including copies thereof, whether modified, merged, or included with other software. SIS-TECH Applications understands that End-User’s backup and archival and storage procedures may create copies of the SIL Solver® that cannot reasonably be removed from archival storage. The provisions of this License, which protect the proprietary rights of SIS-TECH Applications, shall continue in force after termination for a term of three (3) years.

ARTICLE 6: GOVERNING LAW. When entered into in the United States, this License shall be interpreted in accordance with the laws of the State of Texas. Otherwise, this License will be interpreted in accordance with the laws of the United States or such other law as may be required to protect the legitimate interests of SIS-TECH Applications.

ARTICLE 7: ASSIGNABILITY AND SUBLICENSES. End-User shall have no authority under this License to assign or sublicense the rights granted hereunder, except that End-User may assign and/or sublicense this License to any entity that acquires substantially all of the assets to which the License pertains. Except as otherwise provided herein, any assignment of the License is void. Notwithstanding the foregoing, SIL Solver® may be incorporated as a component of a larger system of software for resale by another software manufacturer. In the event of such resale under this Article 7, the terms and conditions of this License which protect SIL Solver® shall be incorporated in documents governing resale in such fashion as shall be necessary to protect the interests of SIS-TECH Applications hereunder. For purposes of this License, any such original software manufacturer shall be considered an End-User bound hereunder.

ARTICLE 8: FEE. The license fee due under this License shall be comprised of the price paid by End-User for SIL Solver®. This license fee shall entitle End-User to technical support and upgrades for a term of one (1) -year from the point of shipment of SIL Solver® to End-User. At the end of one (1)-year, End-User may extend technical support and upgrades on an annual basis for an additional fee.

ARTICLE 9: COMPLETE AGREEMENT. This License constitutes the entire agreement between SIS-TECH Applications and End-User.

ARTICLE 10: EXPORT REGULATIONS. End-User agrees that it will not, directly or indirectly, export or transmit any SIS-TECH Applications products covered by this License to any country to which such export or transmission is restricted by applicable regulations or statutes of the United States.
States or any agency thereof, without the prior written consent of the Office of Export Administration of the U.S. Department of Commerce, Washington, D.C. 20230 and of any other required governmental agency.

ARTICLE 11: SEVERABILITY. In the event that any provision hereof shall violate or be unenforceable under any applicable statute, ordinance, or rule of law of any jurisdiction, such provision shall be deemed null and void to the extent of such violation or unenforceability without invalidating such provision in any other jurisdiction and without invalidating any other provision hereof.
SECTION 16  DISCLAIMER OF SOFTWARE WARRANTIES AND LIABILITIES

1. SIS-TECH APPLICATIONS’ SIL SOLVER® IS DISTRIBUTED AND LICENSED “AS IS.” ALL WARRANTIES, EITHER EXPRESSED OR IMPLIED, ARE DISCLAIMED AS TO QUALITY, PERFORMANCE, OR MERCHANTABILITY, WHETHER EXPRESSED, IMPLIED OR STATUTORY, HIDDEN DEFECTS, OR FITNESS FOR ANY PARTICULAR PURPOSE. SIS-TECH APPLICATIONS MAKES NO REPRESENTATIONS ABOUT THE SUITABILITY OF THE INFORMATION CONTAINED IN THE DOCUMENTS AND RELATED GRAPHICS PUBLISHED AS PART OF SIL SOLVER® FOR ANY PURPOSE. END USER BEARS THE ENTIRE RISK RELATING TO THE ITS USE OF THE PRODUCT.

IN NO EVENT WILL SIS-TECH APPLICATIONS BE LIABLE FOR ANY SPECIAL, DIRECT, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OR ANY DAMAGES WHATSOEVER RESULTING FROM THE LOSS OF USE, DATA OR PROFITS, WHETHER IN AN ACTION OF CONTRACT, NEGLIGENCE OR OTHER TORTUOUS ACTION, ARISING OUT OF OR IN CONNECTION WITH THE USE OR PERFORMANCE OF SIL SOLVER®. SIS-TECH APPLICATIONS DOES NOT WARRANT THAT THE OPERATION OF SIL SOLVER® WILL BE UNINTERRUPTED OR ERROR FREE.

HEREIN. SIS-TECH APPLICATIONS AND/OR ITS DESIGNATED DISTRIBUTORS MAY MAKE IMPROVEMENTS AND/OR CHANGES IN SIL SOLVER® DESCRIBED HEREIN AT ANY TIME.

IN ANY CASE, SIS-TECH APPLICATIONS’ ENTIRE LIABILITY UNDER ANY PROVISION OF THIS LICENSE SHALL BE LIMITED TO THE GREATER OF THE AMOUNT ACTUALLY PAID FOR SIL SOLVER® OR US$50.00.

2. Limited Warranty. SIS-TECH Applications warrants the diskettes to be free of defects in materials and workmanship under normal use for ninety (90) days after purchase. During the 90-day period, a defective diskette may be returned upon authorization by SIS-TECH Applications to SIS-TECH Applications or an authorized SIS-TECH Applications distributor identified by SIS-TECH Applications and it will be replaced without charge. Replacement of a diskette is the sole remedy in the event of a defect. This warranty gives specific legal rights. There may be other rights, which vary from state to state.

Notwithstanding anything to the contrary herein, SIS-TECH Applications warrants that End-User’s use of the SIL Solver® will not infringe any intellectual property rights of third parties. Notwithstanding anything to the contrary herein, if any suit, action, or claim is made by a third party that End-User’s use of the SIL Solver® constitutes infringement of any intellectual property right owned by a third party, and the SIL Solver® is used by End-User in accordance with this License, then SIS-TECH Applications will indemnify and hold End-User harmless, with respect to any such action, claim, or suit, and will undertake or have undertaken, at its expense, the legal defense or negotiations for settlement of such suit or action.

The limited warrant related to defective diskettes is void if failure of SIL Solver® has resulted from accident, abuse, misapplication, use of SIL Solver® other than as described in the documentation.
issued by SIS-TECH Applications, use of SIL Solver® in combination with other software products that are not described as being compatible in the documentation issued by SIS-TECH Applications, or the End-User breaches the terms of this License.

End-User’s exclusive remedy for any breach of the Limited Warranty related to defective diskettes is for End-User to give notice of the breach to SIS-TECH Applications, a copy of the purchase order, and a description of the alleged breach, and then, at SIS-TECH Applications’ option, SIS-TECH Applications shall either: (a) return the price End-User paid for SIL Solver® (at which time End-User rights under this License are deemed terminated); or (b) repair or replace SIL Solver®. The Limited Warranty period for any replacement of defective diskettes will be extended for the remainder of the original warranty period or thirty (30) days after the replacement product is delivered to End-User, whichever is longer. End-User remedies described in this paragraph are exclusive remedies related to defective diskettes, and shall not be deemed to fail of their essential purpose so long as SIS-TECH Applications is willing to repair or replace SIL Solver® or return the price that was paid for SIL Solver®.

COPYRIGHT NOTICE. SIL Solver® is protected by copyright laws and international copyright treaties, as well as other intellectual property laws and treaties. All title and copyrights in and to SIL Solver® (including but not limited to images and texts incorporated in SIL Solver®) are owned by SIS-TECH Applications. Copyright © 2007 SIS-TECH APPLICATIONS, LLP, 12727 Featherwood Drive, Houston, TX 77034 U.S.A. All rights reserved.
SECTION 17    MAINTENANCE AGREEMENT

1. ADDRESSES AND COMMUNICATIONS

SIS-TECH Applications, LLP
12621 Featherwood, Suite 120
Houston, TX 77034
Tel: 281-922-8324
Email: info@SIS-TECH.com

2. DEFINITIONS

Agreement
Terms and Conditions of the SIS-TECH Applications Maintenance and Priority Support Program.

Discrepancy
A defect in the distribution media or a material difference between the operation of the Maintained Software and the description of the operation of the Maintained Software as provided in current end-user documentation provided for the Maintained Software by SIS-TECH Applications.

Error
A demonstrable instance of incorrect operation of the software that impacts Licensee’s ability to use the functionality described in the documentation.

Error Correction
A solution generated in the form of a patch or software version that corrects the error without causing additional problems or a correction or clarification of the software documentation.

Maintained Software
The registered copy of the SIS-TECH Applications’ SIL Solver® Product. If the Licensee of the Maintained Software is a corporation or other entity, the “user” as used in this Agreement refers to that corporation or entity.

Patch
A fix to a program error

Support Contact
The person authorized to communicate with SIS-TECH Applications to request and receive the Maintenance Services. The Support Contact may be an end user, an employee, or an agent or consultant of the company. The Support Contact should be knowledgeable about how the Maintained Software is being used and about the computer/operating system on which the Maintained Software is executed.
3. APPLICABILITY OF SIS-TECH APPLICATIONS SOFTWARE LICENSE AGREEMENT

Please read these terms and conditions carefully as they constitute the entirety of the customer’s agreement relating to the SIS-TECH Applications corporation. This Agreement and all subject software, documentation, and media are subject to the terms and conditions of the SIS-TECH Applications End-User Software License Agreement that exists between the end-user and SIS-TECH Applications, including the Disclaimer of Warranty and Limitation of Liability.

4. MAJOR UPGRADE RELEASE

The SIS-TECH Applications release of a major upgrade of the Maintained Software will contain a new set of software and may contain replacements for all or some of the existing documentation set. There is no pre-determined timeframe for major upgrade release. If this Maintenance Agreement is still in effect, SIS-TECH Applications will provide the major upgrade without additional charge. If the supported Maintained Software is no longer covered by a Maintenance Agreement, the end-user will be required to purchase the desired upgrade.

5. FIXES TO REPORTED DISCREPANCIES

In response to a confirmed Discrepancy in the Maintained Software, SIS-TECH Applications shall use reasonable efforts to provide, on an as-needed basis and at its sole discretion, a Correction in the form of a workaround, support release, update disk, immediate correction disk or electronic transfer equivalent, component replacement, patch, major upgrade release, or other suitable form. When provided under this Agreement, such Correction will be provided without additional charge. SIS-TECH Applications reserves the right to discontinue Maintenance Services without notice on a past workaround, support release, update disk, immediate correction disk, or electronic transfer equivalent, component replacement, patch, or other form of Correction after a subsequent major upgrade release, support release, or update disk or electronic transfer equivalent containing a Correction of the Discrepancy is available.

6. ACCESS TO SIS-TECH APPLICATIONS PRODUCT SUPPORT STAFF

SIS-TECH Applications Product Support Staff are available via email to give the end-user assistance and advice on SIS-TECH Applications products or to receive Discrepancy reports, during normal working hours at our main office listed above. We may allocate the end-user support request based on availability of staff and experience to a named individual at our discretion. If the Product Support Staff are not available for immediate response, they will respond as soon as reasonably possible. The end-user may also use regular or overnight delivery services or telephone once assigned to a named individual to communicate with our Product Support Staff.

7. SOFTWARE NOT COVERED BY THIS AGREEMENT

Altered or modified Maintained Software.

Any combination of Maintained Software and other software not covered by this Agreement.

A Release of Maintained Software for which Maintenance Services has been discontinued.
Discrepancies caused by end-user negligence or fault.

Discrepancies resulting from hardware malfunction.

Discrepancies that do not significantly impair or affect the operation of the Maintained Software.

Maintained Software used on a computer or operating system other than that specified by the end-user and accepted by SIS-TECH Applications on the Maintenance Registration Form.

8. END-USER RESPONSIBILITIES

End-user agrees to report all suspected Discrepancies through the Support Contact to the SIS-TECH Applications Product Support Staff. Reports will include a description sufficient for SIS-TECH Applications Product Support Staff to reproduce the suspected Discrepancy. Failure to provide an adequate description may cause delays in responding to the Discrepancy.

End-user agrees to use reasonable efforts to assist SIS-TECH Applications in its efforts to find Corrections to confirmed Discrepancies reported by the end-user. End-user agrees to install and use the newest release or change disk for the Maintained Software sent to end-user by SIS-TECH Applications within thirty (30) days of receipt. In all contacts with SIS-TECH Applications Product Support, end-user agrees to provide the product serial number given to end-user by SIS-TECH Applications, along with end-user name and the name and address of the company or Support Contact contracted for the maintenance.

9. ADDITIONAL SERVICES AND CHARGES

SIS-TECH Applications may offer additional services such as training and consulting under separate agreements. Such services can be performed at a site and time mutually agreeable. These services are normally charged on a time-and-materials basis including expenses and are subject to availability.

SIS-TECH Applications reserves the right to charge for services outside of the range of normal support services. Services considered outside of the range of normal support services are (1) debugging application coding errors in a customer's application; (2) debugging problems in non-SIS-TECH Applications supported products or in combinations of SIS-TECH Applications supported and non-supported products where the problem occurs in the non-SIS-TECH Applications product; and (3) other cases where it is judged highly likely that the suspected problem is not the responsibility of SIS-TECH Applications Software.

When a situation occurs where a reported problem is likely to fall outside of the range of supported services, end-user will be advised of the potential of incurring charges to have SIS-TECH Applications work on the problem. An estimate of the cost of the additional services will be prepared and delivered to the end-user, by appropriate means, for approval and agreement. Should SIS-TECH Applications determine that the problem is indeed caused by a supported product, no charges will be incurred. However, if it is proven that the problem is not the responsibility of SIS-TECH Applications, the end-user will be charged for the time spent at the rates specified in the estimate/service agreement. Should the end-user not agree that the requested service falls out of the bounds of supported services, SIS-TECH Applications sales
person will be your representative at SIS-TECH Applications to mediate the issue for you. SIS-TECH Applications, upon prior notice, reserves the right to charge for unusual or excessive support person time or telephone expenses in connection with the Maintenance Services provided under this Agreement. Reasonable shipping, handling, media, and user documentation charges in connection with the provision of the upgrades and service shall be payable by the end-user.

10. PAYMENT

The annual Maintenance Fee must be paid prior to expiration of the current Maintenance Agreement period. The Maintenance Fee is as determined in the SIS-TECH Applications Software Price List as of the Maintenance Expiration date. SIS-TECH Applications is not responsible for notifying the end-user of the impending Maintenance Agreement Expiration Date. It is the end-user’s responsibility to exercise the option to renew maintenance prior to the Maintenance Expiration Date. To register for a further year of maintenance under this Agreement, simply pay the current maintenance fee prior to the Maintenance Expiration Date and the end-user will continue to receive maintenance services. If the Maintenance Agreement expires, the end-user must purchase an upgrade to the current version of the product in order to register for a new maintenance period. All extended maintenance agreements are for a minimum term of one year and are non-refundable. The term of this Agreement will commence on the date of purchase and shall continue for a period of one calendar year.

11. TERMS AND TERMINATION

This agreement will be effective and services provided hereunder will commence as of the completion of SIS-TECH Applications 1) acceptance of payment of the appropriate Maintenance Fee or initial product purchase with Maintenance; 2) registration of this Agreement on receipt of the Maintenance Registration Form; and 3) ascertaining proof of proper license for the Software designated on the Maintenance Registration Form. The services provided hereunder will cease on the last business day of the month of the Maintenance Period that is one year from the commencement of services under this Agreement. The Maintenance Period commences as determined by SIS-TECH Applications as of the date of product purchase with maintenance, maintenance renewal, or maintenance commencement, as appropriate. SIS-TECH Applications may change the Maintenance Fee without notice, which fee shall become effective upon renewal of this Agreement. This Agreement will remain in effect unless terminated upon fifteen (15) days written notice by either party by reason of any violation of the terms and conditions of this Agreement. The extended maintenance agreement entitles the holder to the following benefits for the period of the agreement:

The option to upgrade to the latest release version available of the product(s) the maintenance agreement Covers without additional charge. Such upgrades will be subject to the terms and conditions of the license Agreement of the upgraded version of the product. Upgrades only apply to new versions of the product on the same platform as the licensed software covered by the maintenance agreement.

Access to extended email technical support by a Support Contact or End-user for the duration of the agreement, subject to provisions listed below.
SIS-TECH Applications will undertake commercially reasonable efforts to provide technical assistance under this agreement, but cannot guarantee that any or all of customer's inquiries will be solved, that any response will be error-free, or that all response time goals will be met. SIS-TECH Applications, from time to time, discontinues products and versions, discontinues support of selected products and versions, or discontinues or modifies any or all support services. The services provided are "as-is" without warranty of any kind. SIS-TECH Applications does not warrant that the services provided will meet customer's requirements, that the services will result in error-free solutions, or that defects in any licensed Software can be corrected. Furthermore, SIS-TECH Applications does not warrant or make any representations regarding the use or the results of the services in terms of correctness, accuracy, reliability, or otherwise.

No oral or written information or advice given by SIS-TECH Applications or its authorized representatives shall create a warranty or in any way increase the scope of this warranty. To the maximum extent permitted by applicable law, SIS-TECH Applications further disclaims all warranties, including without limitation any implied warranties of merchantability, fitness for a particular purpose, title and non-infringement. The entire risk arising out of the use or performance of the services remains with customer. To the maximum extent permitted by applicable law, in no event shall SIS-TECH Applications or its affiliates be liable for any consequential, incidental, direct, indirect, special, punitive, or other damages whatsoever (including, without limitation, damages for loss of business profits, business interruption, loss of business information, or other pecuniary loss) arising as a result of providing services or the use of or inability to use the services, even if SIS-TECH Applications has been advised of the possibility of such damages. Because some states or jurisdictions do not allow the exclusion or limitation of liability for consequential or incidental damages, the above limitation may not apply in certain circumstances. Notwithstanding anything contained herein, in no event shall SIS-TECH Applications be liable to customer for any claim in tort, contract, equity, or otherwise arising in connection with this agreement exceeding the aggregate the amount paid for services. SIS-TECH Applications grants customer a non-exclusive license to use the support given hereunder (and any information and other proprietary material included therein) to the extent such use would be permitted in the SIS-TECH Applications End User License Agreement that applies to the SIS-TECH Applications product(s) to which extended maintenance pertains. This is the full and final agreement between the customer and SIS-TECH Applications relating to extended maintenance and supersedes any promises, representations or agreements relating to the subject of this agreement, including without limitations, any agreements offered by any other persons. The acceptance of any Purchase Order placed by customer is expressly made conditional on customer's assent to the terms set forth herein, and not those contained in customer's purchase order or any other business form. SIS-TECH Applications reserves the right to withdraw maintenance services on any or all Maintained Software or other products, and to alter the prices, terms, and conditions of the Maintenance Program, in advance of any maintenance renewal. Any such withdrawal or alterations will amend the Maintenance Program between the end-user and SIS-TECH Applications as of the next renewal date.

12. MISCELLANEOUS

The end-user may not assign this Agreement to a third party without the prior written consent of SIS-TECH Applications. This Agreement and the SIS-TECH Applications End User Software License Agreement shall be the only Agreements between SIS-TECH Applications and the end-user with respect to the Maintained Software. These agreements cannot be modified except in
writing and with the approval of both parties. These Agreements supersede all prior agreements, oral or written, relating to the Maintained Software. The laws of the state of Texas shall govern the validity of these agreements, the construction of their terms, and the interpretation of the rights and duties of the parties.
This section provides hardware, software, and security requirements and installation instructions. It contains the following sections:

Hardware and Software Requirements

Installing SIL Solver®

The remaining sections of this guide describe SIL Solver® and how you can use it to analyze components, subsystems, and PIFs.

Hardware, Software And Security Requirements

SIL Solver® has the following hardware and software requirements:

- A Microsoft operating system personal computer, 64MB of memory recommended
- A CD-ROM drive
- Microsoft Windows 2000, NT, Millennium, or XP
- Full administrative rights during installation. Read, write, and modify rights on the default folders are required during normal use of SIL Solver®.

Attention Users Who Have a Prior Version of SIL Solver® Installed

On un-install of SIL Solver®, the SIL_Data folder is removed and customer database records would be lost. These instructions apply only to the prior SIL Solver® customer who want to save their customer database records.

Some antivirus, Antispyware does not allow this program to run, and they should be disabled when the tool is going to be run. If disabling is not an option, from quarantine, restore this file.

The specific steps for copying your database folder (SIL_Data) may vary depending on the location of your installation. These instructions assume you have the rights to create a folder on your local C: drive. If not, the folder can be copied anywhere except within the SIL Solver® folders.

Note: To locate the SIL Solver® folder: an easy method is from the short cut icon to run SIL Solver®. Click once to highlight the word SIL Solver®. Pause there. Tool tip will display giving you the location of your installation.

1. From Windows Explorer, locate the installation folder of SIL Solver®. Double Click on the SIL Solver® folder. You will see a folder named SIL_Data. Click once to highlight this folder. Right Click. From the drop down menu, select “Copy”. To paste this to your local
disk C, Click once to highlight C: disk. Right Click and select from the drop down menu “Paste”.

2. SILSolver_Merge_Extract.exe will be included on your installation CD. Insert your CD. When the installation program launches automatically using Autoplay, Click Cancel.

Choose Run from the Start menu.

In the Run box, type D:\SILSolver_Merge_Extract.exe (replace the D letter with the correct letter for your CD-ROM drive) or Click Browse to locate. Click OK.

3. Or from Windows Explorer, locate, and then Double Click SILSolver_Merge_Extract.exe.

This is self extracting EXE that executes SILSolver_Merge.exe.

Appendix 1. 1 Extract and Merge Customer Database

4. Follow the instructions by selecting your old SIL_Data and then selecting your new installation folder, default c:\SILSolver\SIL_Data.

On completion, the old SIL_Data databases will be renamed to their database name plus “old”.

Installation of SIL Solver®

SIL Solver® is compatible with the install and uninstall utility included in Microsoft Windows operating systems. SIL Solver® is designed to install quickly from the CD-ROM included in the software package. The default program directory is C:\Program Files\SILSolver. The installation directory may be changed during the software installation.
SIL Solver® creates two folders on the “C” drive. These folders are C:\SILSolver_projects and C:\SILSolver_CR_DbF. C:\SILSolver_projects is the default folder for project created. This folder can be moved or multiples of this project folder can be created. C:\SILSolver_CR_DbF contains the Crystal Reports needed to print reports, SIL Solver® Guide, and SIL Solver® Version Changes. In addition in this folder, the Crystal Reports temporary databases are created so read/write, and modify rights is essential for the correct operation of SIL Solver®. This folder can NOT be moved.

Although the specific steps for installing SIL Solver® may vary depending on the type of installation that is performed, the installation should follow these same general steps.

**WARNINGS TO READ BEFORE YOU BEGIN**

1. Read all instructions carefully.
2. Close all programs prior to installation.
3. Prior to installing the program, make sure that you have the necessary administrative rights to do so.

Insert the SIL Solver® CD into your CD-ROM drive.

The installation program should launch automatically using Autoplay. If the installation program does not launch automatically, perform the following steps:

Choose **Run** from the **Start** menu.

In the **Run** box, type **D:\setup** (replace the D letter with the correct letter for your CD-ROM drive)

*Click OK* to activate the installation program.

The SIL Solver® install shield wizard will open. *Click* the “next” button to advance through the screens.
Appendix 1. 2 Initial screen for the Install wizard

The welcome screen for the Install Shield Wizard.

Appendix 1. 3 Installation wizard welcome screen

Read the end-user license agreement carefully. The end-user license is provided in “End-User Site License Agreement” section for your convenience. If you accept the terms, check the “I accept the terms in the license agreement. If you do not accept the terms, SIL Solver® will not install.”
Appendix 1. 4 End-User License Agreement

The installation default location is C:\Program Files\SILSolver. The installation location can be changed to any designated location by Clicking Change.... You can select any destination location. Warning: Problems have occurred with mirrored drives. Some SIL Solver® features, such as rename and delete project, have not work properly when using a mirrored drive.

Appendix 1. 5 Install wizard destination folder
Appendix 1.6 Changing the destination folder

Once the destination folder is selected, the software installation will commence.

Appendix 1.7 Installation is occurring
Appendix 1. 8 Install wizard is complete

During installation, on some systems, the installer will display a dimmed CANCEL pop-up screen for approximately 60 seconds. During this period, the installer is verifying the registry. This action is considered normal and CANCEL should not be selected unless there are other indications that there are problems with the installation.

INSTALLER PROBLEMS

The installer occasionally has difficulty in locating a file required for program operation. On the initial startup, SIL Solver® will display a message related to its inability to locate a file named “MSVCR70.dll.” To correct this error, simply use Microsoft Explorer to locate “MSVCR70.dll.” Then, copy this file to the SIL Solver® installation folder. If the default installation location was chosen, the file should be placed under C:\Program Files\SILSolver.