SaSI Innovation Company Limited

GENERAL INFORMATION - InnoSIF™ v1

Revision No: 1
6th February 2022

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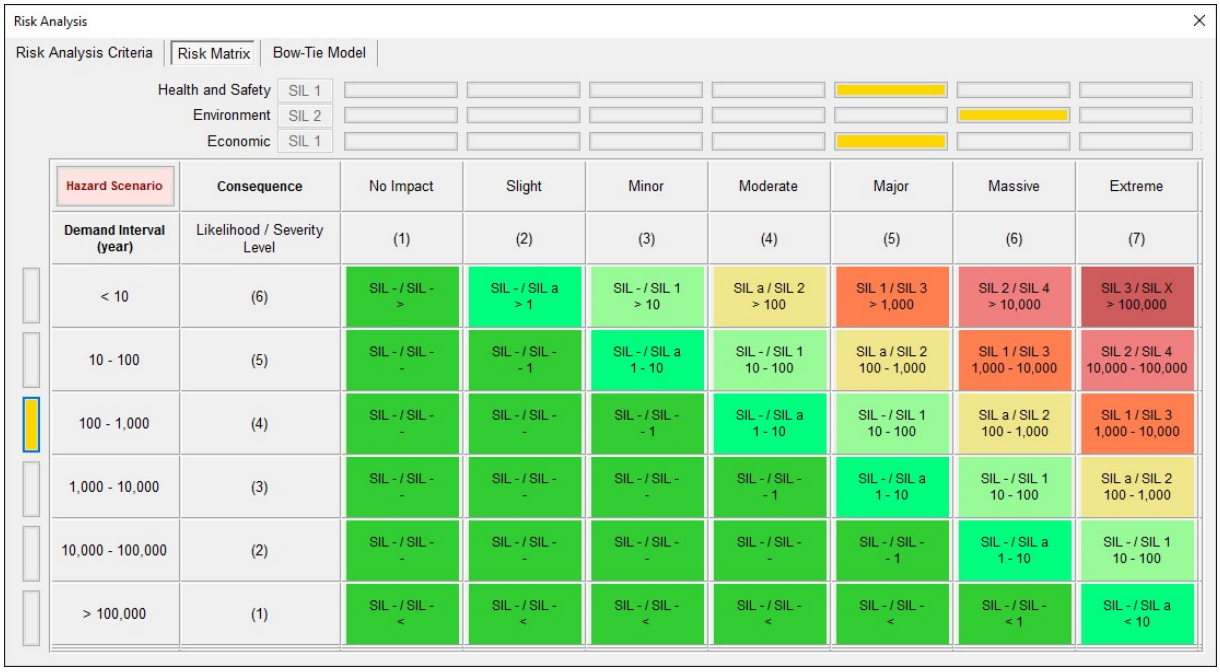
INTRODUCTION

InnoSIF™ is a sophisticated tool aiding the SIL assessment by making complicated process simplified, yet realistic and flexible based on data optimization concept. Users can customize any data to reflect a real-life plant based on their experience. The ambiguous risk assessment will be eliminated by Smart risk matrix and/or Bow-tie modelling upon user's preference. With the flexibility of SIF design developed by InnoSIF™, there are no complex systems that cannot be evaluated.

SMART RISK MATRIX



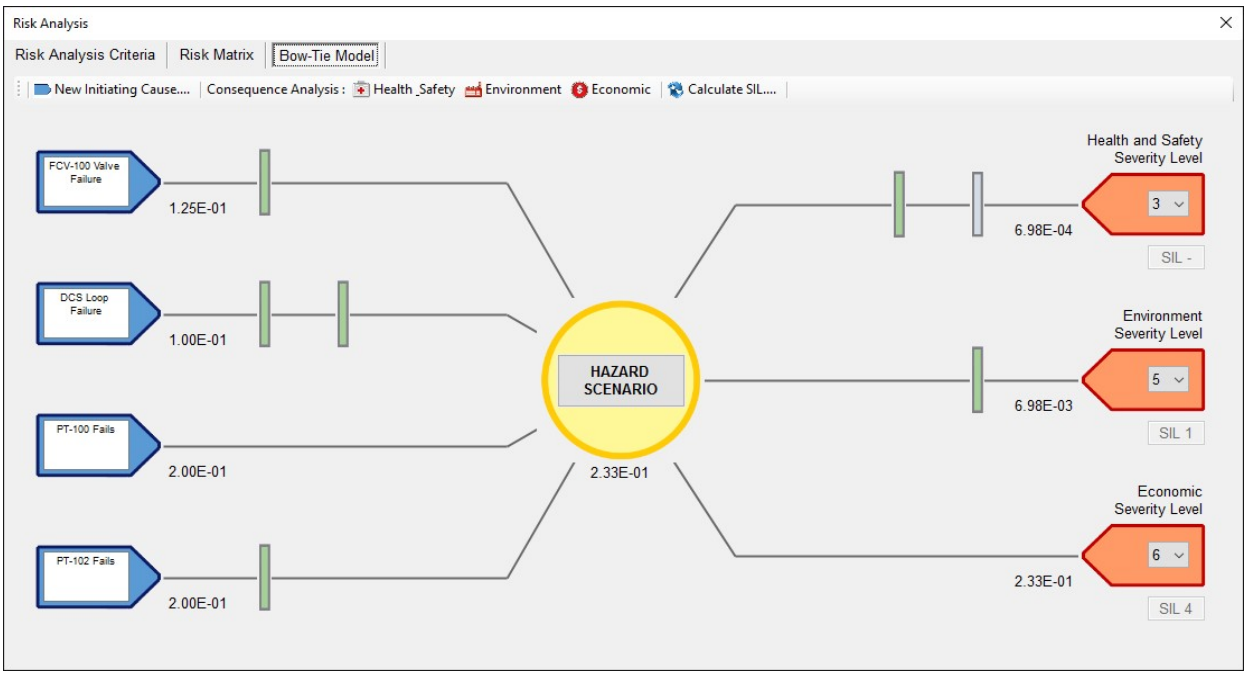
Smart Risk Matrix is customizable tool for developing risk criteria. It can be set to any sizes by combination of rows and columns from 1x1 up to 8x8. Three (3) aspects of consequence; personnel safety, environment and economic will be aligned into one matrix via acceptable/tolerable criteria as user's safety policy, and then Smart matrix will automatically transforms the criteria to be SIL level and Risk Reduction Factor (RRF).

Consequence :

Severity Criteria	Level	Tolerable Risk (year-1)	Acceptable Risk (year-1)	Health & Safety Impact	Environmental Impact	Economic Impact
No Impact	1	100	1	No Safety Concern	No Impact	< 100 USD
Slight	2	10	0.1	RWDC (<30 Days)	Slightly Impact	100 - 1,000 USD
Minor	3	1	0.01	RWDC (>30 Days)	Localized Impact	1 - 10 kUSD
Moderate	4	0.1	0.001	LWDC (<30 Days)	Corporate Emer. R...	10 - 100 kUSD
Major	5	0.01	0.0001	LWDC (>30 Days)	Community Emer. ...	100 k - 1 MUSD
Massive	6	0.001	0.00001	Disability	Regional Assistance	1 - 10 MUSD
Extreme	7	0.0001	0.000001	Fatality	International Assis...	> 10 MUSD

Simplified Risk Criteria Development for Consequence Analysis

DETAILED RISK ANALYSIS WITH BOW-TIE MODEL

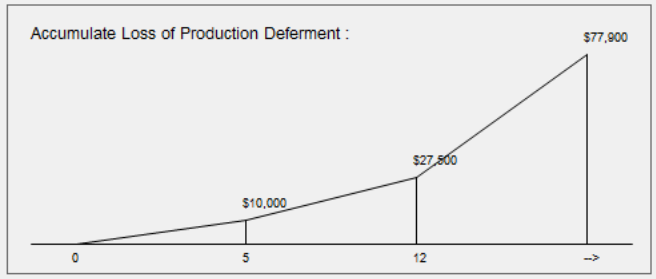


Bow-tie model is a famous risk assessment methodology. It can develop a hazard scenario in graphical and take account of the Layer of Protection analysis (LOPA) technique for detailing the consequence severity evaluation.

PRODUCTION LOSS EQUATION (PLE)

Production loss equation (PLE) is a good practice to make high resolution of the economic impact assumption on the hazardous event, The PLE can be built one or more cases depending on the production loss scenario specific on the evaluated plant.

Start(Hrs)	End(Hrs)	Loss(per Hr)
0	5	2000
5	12	2500
12	0	300



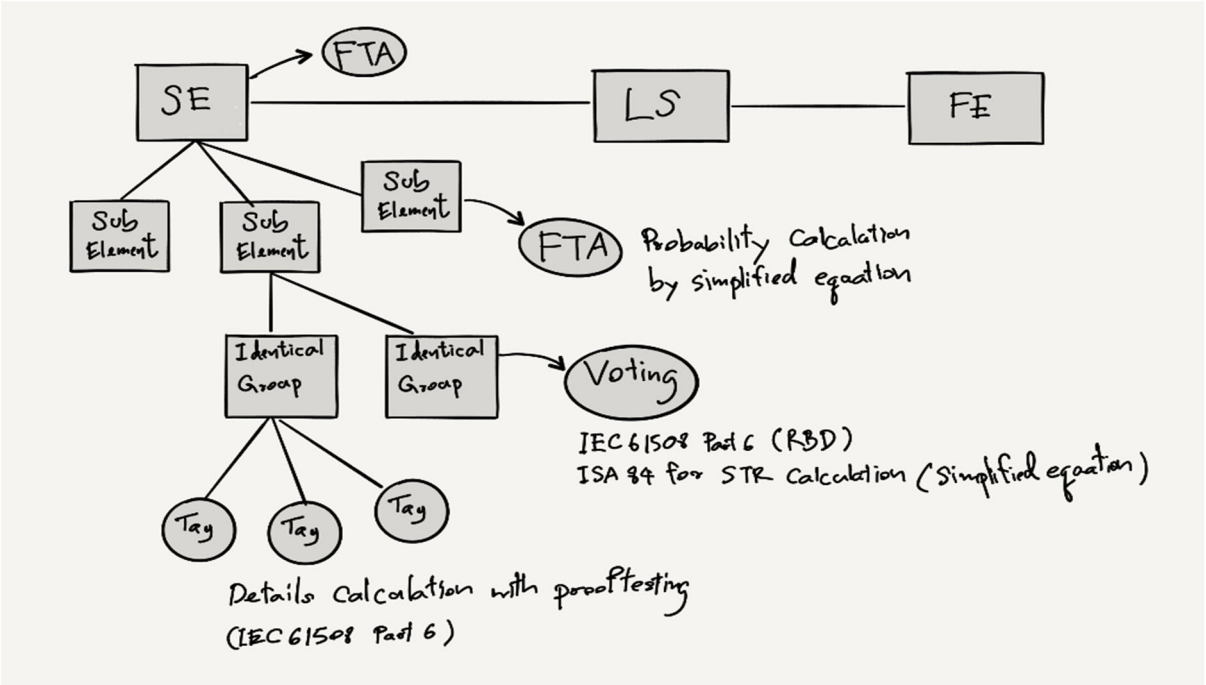
PRIOR USE DEVICE JUSTIFICATION

InnoSIF™ provides guideline for device justification as IEC61511 prior use requirements. User can develop different justification cases as many as they want and export reports out for approval process.

ALARP DEMONSTRATION

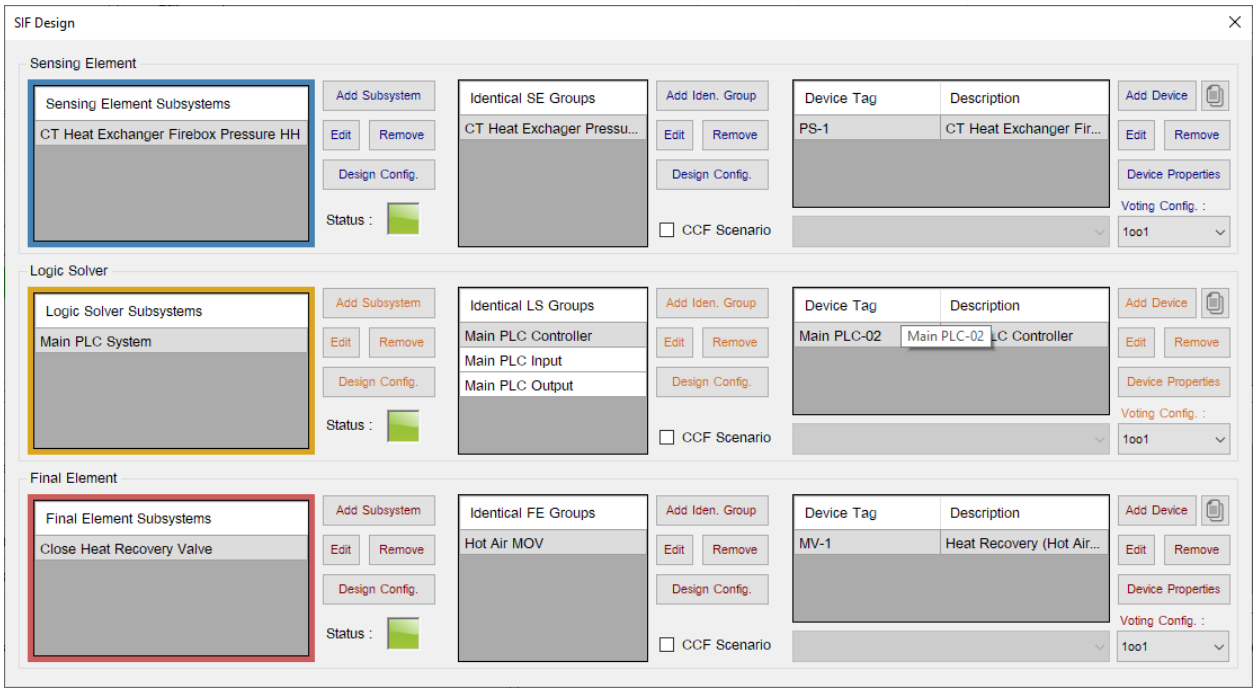
"As Low As Reasonably Practicable" or ALARP concept applied for economic justification when decision making required to choose a fit-for-purpose SIF design among several alternative designs.

SIF DESIGN CONCEPT



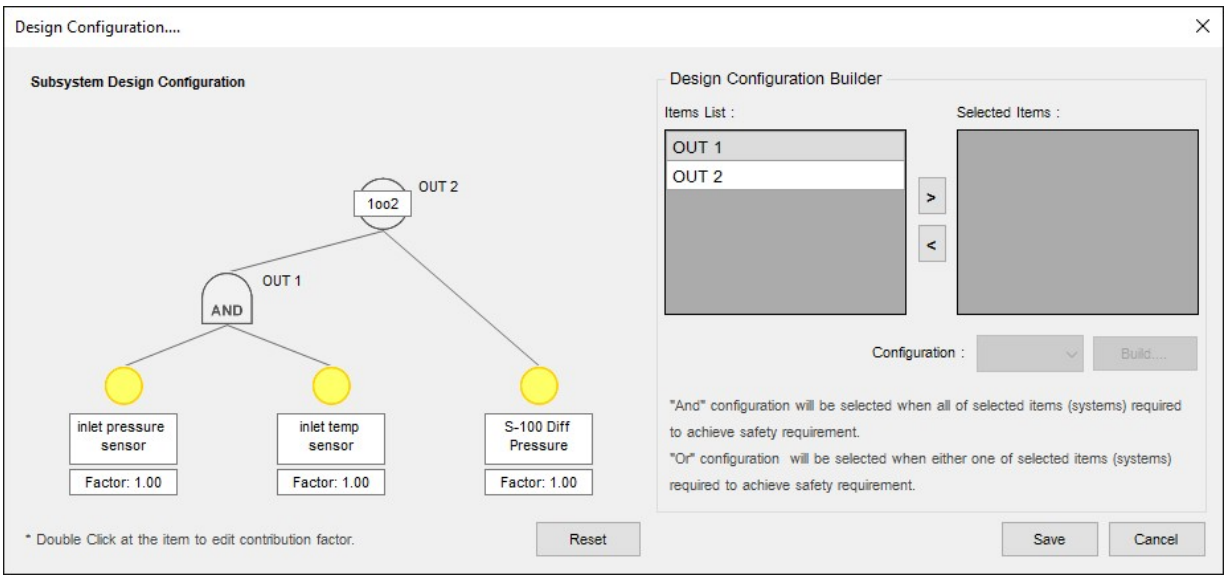
SIF design concept of InnoSIF™ is more flexible to develop a complex SIF. To simplify process of design, InnoSIF™ provides user-friendly interface to build a complete SIF design in one page. The subsystem configuration can be developed using Fault Tree Analysis modelling (FTA), which helps users demonstrate their design in graphical.

COMPLETE SIF DESIGN IN ONE PAGE



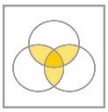
Complex SIF can be easier designed in one page with simplified process. The SIF design concept implemented in InnoSIF™ is more flexibility, No SIF is too complex to achieve in InnoSIF™.

FAULT TREE ANALYSIS (FTA) FOR SUBSYSTEM DESIGN CONFIGURATION



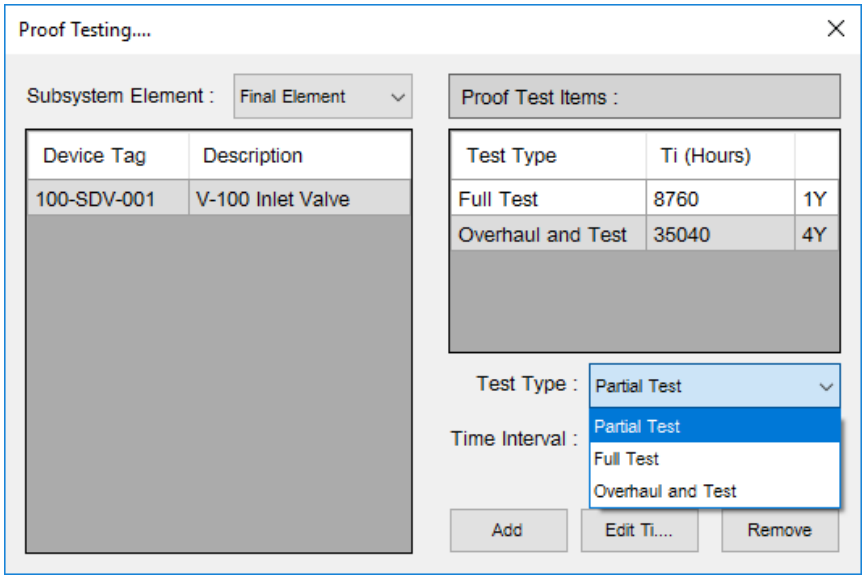
Subsystem design configuration task is frustrated the most SIF designer in complex SIF. Fault Tree Analysis (FTA) helps designer to simplify it, and make complex SIF calculation achieved in easier way. FTA model can help users demonstrate their design in visualization concept, it can reduce error on SIF design process.

β-FACTOR ESTIMATOR



Common cause failure (CCF) or β-factor is an important parameter required in PFD calculation. InnoSIF™ provides a systematic method to estimate the β-factor as the technique provided by IEC61508 Part-6.

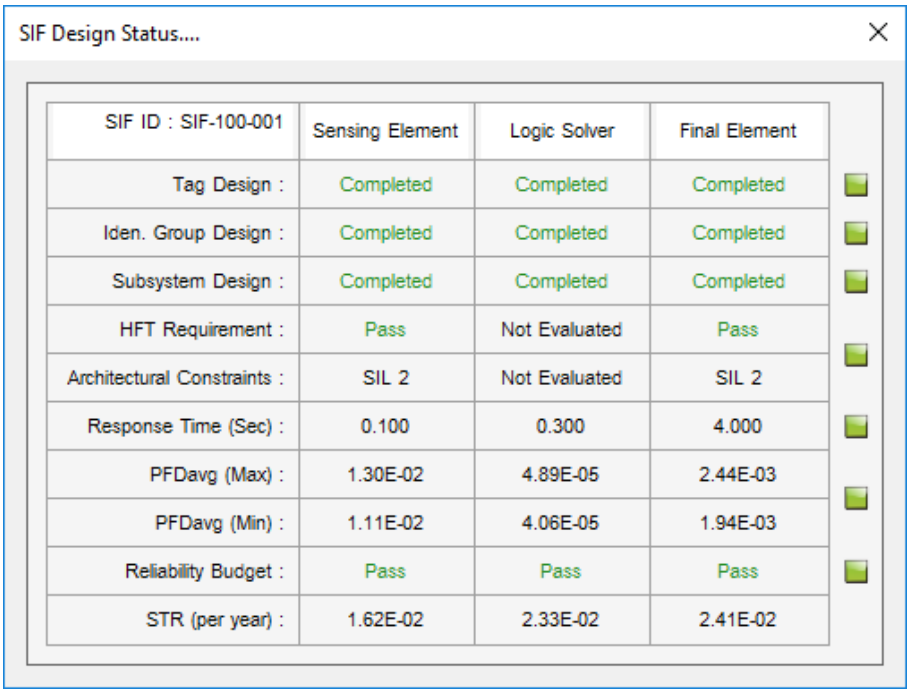
PROOF TEST ASSIGNMENT



The proof test assignment screen makes this task simplified and faster as all devices / components in a SIF are combined into one point of configuration, so proof testing tasks can be assigned to any devices in a SIF easily.

SIF DESIGN VERIFICATION DASHBOARD

With SIF design verification dashboard, it is very easy to point out what is the SIF design problems. User can correct the SIF design faster and easier. Design optimization is very simple task for any users with SIF design verification dashboard functionality.



SIF ID : SIF-100-001	Sensing Element	Logic Solver	Final Element
Tag Design :	Completed	Completed	Completed
Iden. Group Design :	Completed	Completed	Completed
Subsystem Design :	Completed	Completed	Completed
HFT Requirement :	Pass	Not Evaluated	Pass
Architectural Constraints :	SIL 2	Not Evaluated	SIL 2
Response Time (Sec) :	0.100	0.300	4.000
PFDavg (Max) :	1.30E-02	4.89E-05	2.44E-03
PFDavg (Min) :	1.11E-02	4.06E-05	1.94E-03
Reliability Budget :	Pass	Pass	Pass
STR (per year) :	1.62E-02	2.33E-02	2.41E-02

REPORTING CAPABILITY

InnoSIF™ is built-in with report generating tool. Related SIL study data can be easily exported in MS Excel format and SIL study results will be generated as individual SIF report, it is very useful for developing of Safety Requirement Specification (SRS) document.

Causes and Effects Diagram

Causes and Effects diagram is very useful tool for safety validation process. It shows relationship among sensing devices condition and final elements action that function in the logic solver. User can verify correctiveness of a SIF action, easily.

Participation Matrix

Participation matrix is another useful feature to summarize the members participation of each SIF in the SIL study workshop. This will enable traceability for users or auditors to track the right members when some particular information may be required.

SIL STUDY PARTICIPATION MATRIX			SIF-100-001	SIF-100-002	SIF-100-003	SIF-100-004	SIF-100-005	SIF-100-006	SIF-100-007	SIF-100-008	SIF-200-001	SIF-200-002	SIF-200-003	SIF-200-004	SIF-500-001	SIF-500-002	SIF-500-003	SIF-600-001
01	Mario K.	Facilitator	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
02	Peter C.	Process	X		X	X		X	X						X	X		X
03	Oneil A.	Mechanical		X	X		X	X		X	X		X	X	X		X	X

Safety Requirements Specification (SRS)

SaSI Innovation Company Limited

SIL Study Project

ABC Plant

Unit 1100

Document No.ECG-2022-C000XX-1001

6th February 2022

Rev	Date	Revision Note	Prepared By	Approved By
0	6-FEB-2022	Issue for Approval	Mario K.	Peter S.

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Safety Requirements Specification (SRS) - General Information

Project :	SIL Study	**Plant :**	ABC Plant
Client :	SaSI Innovation Company Limited	**Unit :**	1100
Description :	-	**Prepared By :**	Mario K.

STUDY TEAM	
Full Name	Role
Mario K.	Facilitator
Peter S.	Project Manager
Michael O.	Operation
Robert P.	Process Engineer
Naomi S	Maintenance
Kim C. J.	Technical Safety

DOCUMENT REFERENCE		
Document Name	Document Code	Revision
Drying Room Schematic	-	2/3/2022

SIF LIST		
SIF ID	Description	Function Group
SIF-ARS-001	Hot Air Fan, High Inlet Temperature (TT-4)	CT Heat Exchanger
SIF-ARS-002	Air-to-Air Heat Exchanger, Low Air Flow (FT-1)	Air-to-Air Heat Exchanger
SIF-ARS-003	CT Heat Exchanger, High Firebox Pressure (PS-1)	Hot Air Fan

Safety Requirements Specification (SRS) - SIL Classification

Project :	SIL Study	**Plant :**	ABC Plant
Client :	SaSI Innovation Company Limited	**Unit :**	1100
Description :	-	**Prepared By :**	Mario K.

TOLERABLE / ACCEPTABLE CRITERIA - HEALTH & SAFETY

Severity	Level	Tolerable Freq.	Acceptable Freq.	Consequence
Extreme	7	0.000001	0.000001	Multiple fatalities
Massive	6	0.00001	0.00001	Single fatality
Major	5	0.0001	0.0001	PDC, >1 LWDC
Moderate	4	0.001	0.001	LWDC, >1 RWDC
Minor	3	0.01	0.01	RWDC, >1 First-Aid
Slight	2	0.1	0.1	First-Aid
No Impact	1	1	1	No impact

TOLERABLE / ACCEPTABLE CRITERIA - ENVIRONMENT

Severity	Level	Tolerable Freq.	Acceptable Freq.	Consequence
Extreme	7	0.000001	0.000001	Very serious
Massive	6	0.00001	0.00001	Irreparable, Public
Major	5	0.0001	0.0001	Irreparable, Localized
Moderate	4	0.001	0.001	Major LOPC
Minor	3	0.01	0.01	Minor LOPC
Slight	2	0.1	0.1	Slightly Impact
No Impact	1	1	1	No Impact

TOLERABLE / ACCEPTABLE CRITERIA - ECONOMIC

Severity	Level	Tolerable Freq.	Acceptable Freq.	Consequence
Extreme	7	0.000001	0.000001	> 1,000 MTHB
Massive	6	0.00001	0.00001	100 - 1,000 MTHB
Major	5	0.0001	0.0001	10 - 100 MTHB
Moderate	4	0.001	0.001	1 - 10 MTHB
Minor	3	0.01	0.01	100 k - 1 MTHB
Slight	2	0.1	0.1	< 100 kTHB
No Impact	1	1	1	No Impact

INITIATING CAUSES

	Freq /yr (Min)	Freq /yr (Max)	Data Source
Human Error (VSD Wiring)	0.0005	0.0005	Plant Exp
D-EF-F/M-01 Air Fan Failure	0.1	0.1	CCPS
H-F/M-01 Heater Filter Blockage	0.1	0.1	CCPS
Unsafe Operation (Start-Up)	1.56	1.56	Plant Exp

BARRIERS (IPL)

	PFDavg (Min)	PFDavg (Max)	Data Source
PT-1 High Pressure Alarm	0.1	0.1	CCPS
Specific Operating Procedure	0.1	0.1	CCPS

CONDITIONAL MODIFIERS

	Factor (Min)	Factor (Max)	Data Source
Operation Requirement (Time at Risk)	0.86	0.86	Plant Exp

Safety Requirements Specification (SRS) - SIF Verification

Project :	SIL Study	**Plant :**	ABC Plant
Client :	SaSI Innovation Company Limited	**Unit :**	1100
Description :	-	**Prepared By :**	Mario K.

SIL TABLE

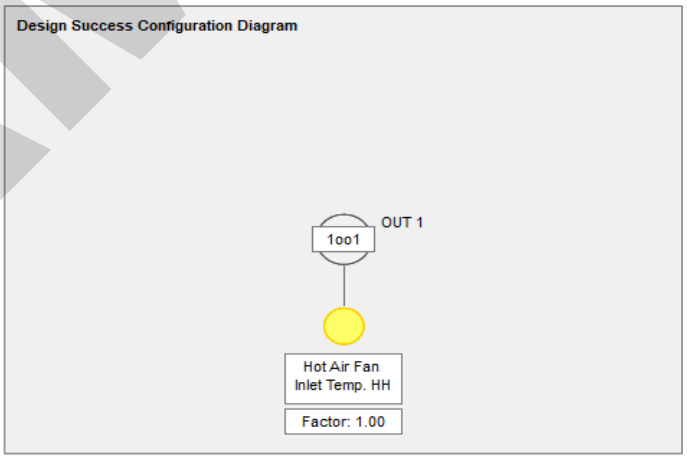
	PFDavg (Lower)	PFDavg (Upper)	Target PFDavg	RRF (Lower)	RRF (Upper)
SIL X	0.000001	0.00001	Redesign	100,000	1,000,000
SIL 4	0.00001	0.0001	0.00007	10,000	100,000
SIL 3	0.0001	0.001	0.0007	1,000	10,000
SIL 2	0.001	0.01	0.007	100	1,000
SIL 1	0.01	0.1	0.07	10	100
SIL a	0.1	1	0.7	1	10
SIL -	1	10	Not Required	0	1

RULES SET / DESIGN ASSUMPTION

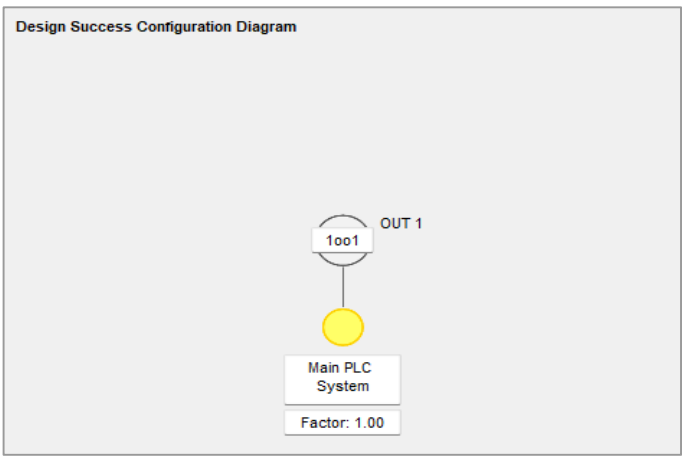
Equipment Life Time (Year) :	20
Beta-Factor or CCF across Subsystems :	0.005
Generic Subsystems MTTR (Hour) :	48
SE Subsystem Reliability Budget (%) :	35
LS Subsystem Reliability Budget (%) :	15
FE Subsystem Reliability Budget (%) :	50

SUBSYSTEMS DESIGN CONFIGURATION

SIF-ARS-001, Sensing Element Subsystem

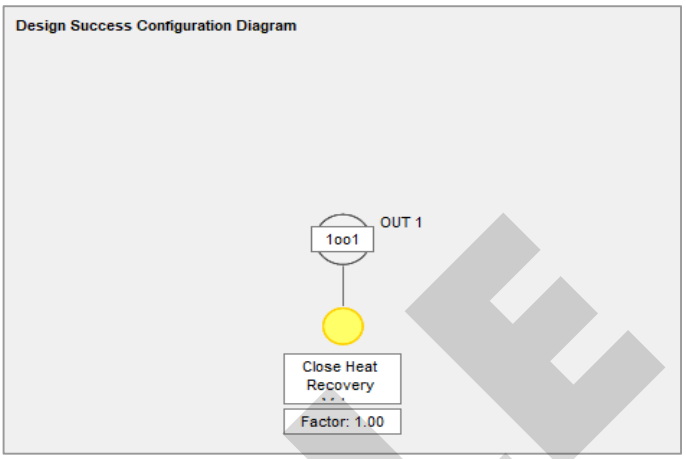


SIF-ARS-001, Logic Solver Subsystem

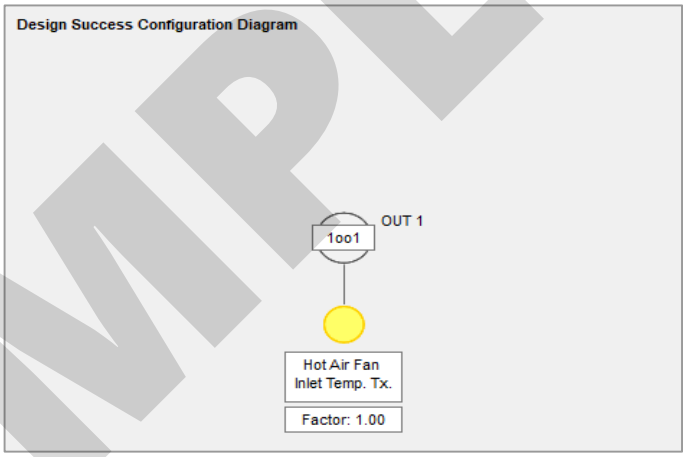


Project :	SIL Study	**Plant :**	ABC Plant
Client :	SaSI Innovation Company Limited	**Unit :**	1100
Description :	-	**Prepared By :**	Mario K.

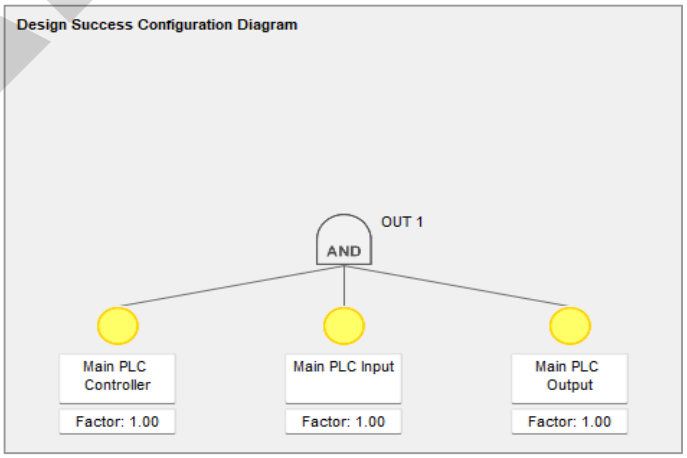
SIF-ARS-001, Final Element Subsystem



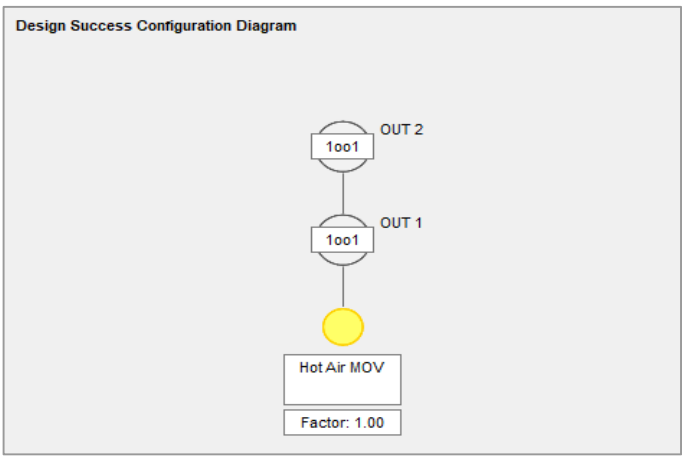
Hot Air Fan Inlet Temp. HH



Main PLC System



Close Heat Recovery Valve



Safety Requirements Specification (SRS) - Recommendation List

Project :	SIL Study	**Plant :**	ABC Plant
Client :	SaSI Innovation Company Limited	**Unit :**	1100
Description :	-	**Prepared By :**	Mario K.

ACTION CLASSIFICATION

Class Name	Description	Critical (Y/N)
Class A	Mandatory action, shall be implemented ASAP	Y
Class B	Recommended action, Operational purpose or Economic Risk	N
Class C	Recommended action, General purpose	N

SPECIFIC SIF ACTIONS LIST

SIF ID: SIF-ARS-001

Improve flow sensor to be higher reliability type	Class B

Improve flow sensor to be higher reliability type. Following options may be considered.
- DP flow transmitter with diagnostic capability (HART communication technology, smart type),
- Insertion Type Flowmeter (e.g. Thermal mass, Annubar or whichever practicable for the ducting conditions),
- SIL certified DP flow sensor,
- etc.

Project :	SIL Study	**Plant :**	ABC Plant
Client :	SaSI Innovation Company Limited	**Unit :**	1100
Description :	-	**Prepared By :**	Mario K.

SIF ID : SIF-ARS-001 Hot Air Fan, High Inlet Temperature (TT-4) **Status :** Pass

Function Group : Hot Air Fan **Process Safety Time (Sec) :** 5

Hazard Analysis

Hazard / Design Success Criteria :

This SIF is designed to prevent Hot Air Fan (D-EF-F/M-02) damage due to over-temperature.

PHA Ref: NODE-01, More Temperature

Demand / Risk Reduction Measures :

The hazard potential would occur when ....
IC1: D-EF-F/M-01 Air Fan Failure.
IC2: H-F/M-01 Heater Filter Blockage.
IC3: Unsafe Operation (Wrong start-up steps, Hot air flow through air-to-air heat exchanger while no return air flow).

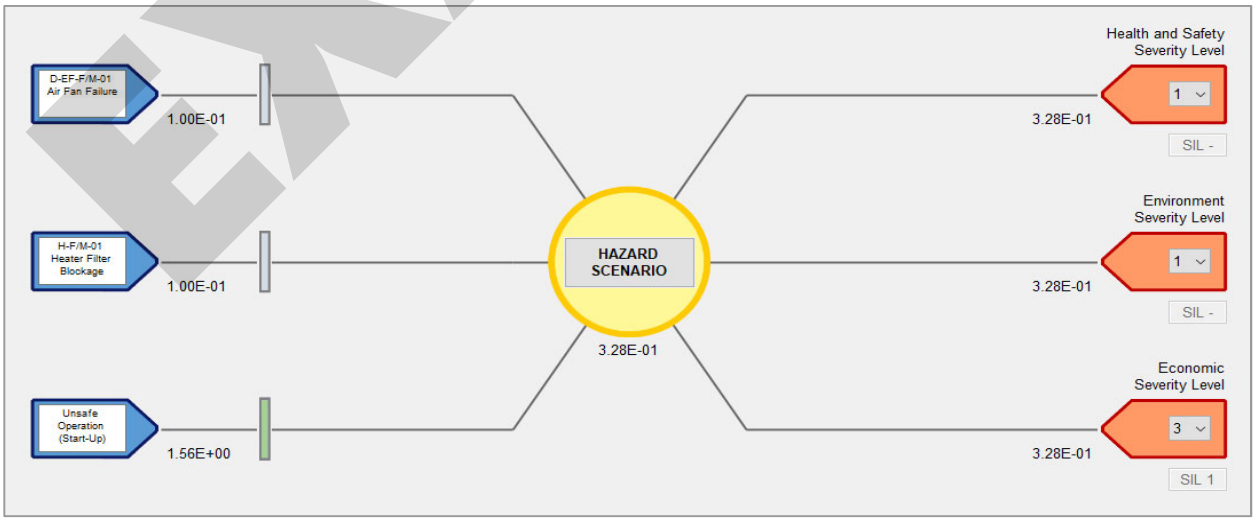
Note:
Start-up activity is required once a week.

Protection Layer:
IPL1: Specific Operating Procedure (Start-up).

Consequence :

Once the hazard occurs, it will lead to Hot Air Fan damage and resulting in ....
Health & Safety:
N/A
Environment:
N/A
Economic:
Loss of total < 1 MTHB for Hot Air Fan (D-EF-F/M-02) maintenance.

Note:
- Production opportunity loss (estimated 300 canister/mins) during the drying room is unavailable; however, another drying room could be utilized in emergency case.
- In case of Hot Air Fan (D-EF-F/M-02) is unavailable, the production could be continue operated via air-to-air heat exchanger bypass line with electric heater (H-F/M-01) instead of waste heat recovery system.



Initiating Cause #1	PFDavg / Factor	Frequency (/year)
D-EF-F/M-01 Air Fan Failure		1.00E-01
Initiating Cause #1 Barriers (IPL) and Conditional Modifiers		
Operation Requirement (Time at Risk)	0.86	8.60E-02

Safety Requirements Specification (SRS) - SIF Analysis and Design

Project :	SIL Study	**Plant :**	ABC Plant
Client :	SaSI Innovation Company Limited	**Unit :**	1100
Description :	-	**Prepared By :**	Mario K.

SIF ID : SIF-ARS-001 Hot Air Fan, High Inlet Temperature (TT-4) **Status :** Pass

Function Group : Hot Air Fan **Process Safety Time (Sec) :** 5

Initiating Cause #2	PFDavg / Factor	Frequency (/year)
H-F/M-01 Heater Filter Blockage		1.00E-01
Initiating Cause #2 Barriers (IPL) and Conditional Modifiers		
Operation Requirement (Time at Risk)	0.86	8.60E-02
Initiating Cause #3	PFDavg / Factor	Frequency (/year)
Unsafe Operation (Start-Up)		1.56E+00
Initiating Cause #3 Barriers (IPL) and Conditional Modifiers		
Specific Operating Procedure	1.00E-01	1.56E-01
Hazardous Event Release Frequency		**3.28E-01**
Health & Safety Consequence Barriers (IPL) and Conditional Modifiers	PFDavg / Factor	Frequency (/year)
N/A	N/A	3.28E-01
Environment Consequence Barriers (IPL) and Conditional Modifiers	PFDavg / Factor	Frequency (/year)
N/A	N/A	3.28E-01
Economic Consequence Barriers (IPL) and Conditional Modifiers	PFDavg / Factor	Frequency (/year)
N/A	N/A	3.28E-01

Hazard Analysis Result :

Severity Level		Frequency (/year)	SIL Level
Health and Safety	1	3.28E-01	SIL -
Environment	1	3.28E-01	SIL -
Economic	3	3.28E-01	SIL 1

ALARP Demonstration Required?

No

Target SIL Level	Target PFDavg	Required RRF
SIL 1	**3.03E-02**	**33**

Project :	SIL Study	**Plant :**	ABC Plant
Client :	SaSI Innovation Company Limited	**Unit :**	1100
Description :	-	**Prepared By :**	Mario K.

SIF ID : SIF-ARS-001 Hot Air Fan, High Inlet Temperature (TT-4) **Status :** Pass

Function Group : Hot Air Fan **Process Safety Time (Sec) :** 5

SIF Design : Low Demand Mode

Sensing Element Subsystem	HFT Requirement	Response Time	PFDavg (Min)	PFDavg (Max)
	Pass	**0.1**	**7.05E-03**	**8.49E-03**
Hot Air Fan Inlet Temp. HH		0.1	7.05E-03	8.49E-03
1oo1 Hot Air Fan Inlet Temp. Tx.		0.1	7.05E-03	8.49E-03
X degC TT-4		0.1	7.05E-03	8.49E-03
Logic Solver Subsystem	**HFT Requirement**	**Response Time**	**PFDavg (Min)**	**PFDavg (Max)**
	Not Evaluated	**0.1**	**4.72E-03**	**5.86E-03**
Main PLC System		0.1	4.72E-03	5.86E-03
Main PLC Controller		0.1	5.43E-05	6.45E-05
- Main PLC-02		0.1	5.43E-05	6.45E-05
Main PLC Input		0.01	4.34E-03	5.41E-03
- Main PLC-02-I		0.01	4.34E-03	5.41E-03
Main PLC Output		0.01	3.17E-04	3.83E-04
- Main PLC-02-O		0.01	3.17E-04	3.83E-04
Final Element Subsystem	**HFT Requirement**	**Response Time**	**PFDavg (Min)**	**PFDavg (Max)**
	Pass	**4**	**1.27E-02**	**1.30E-02**
Close Heat Recovery Valve		4	1.27E-02	1.30E-02
1oo1 Hot Air MOV		4	1.27E-02	1.30E-02
Close MV-1		4	1.27E-02	1.30E-02

Test Requirements :

Equipment Tag	Test Item	Mode	S/D	Interval - Hrs
TT-4	Sensor Function Test	Manual	No	8,760 (1Y)
Main PLC-02	PLC Diagnostic Test	Manual	No	8,760 (1Y)
Main PLC-02-I	PLC Diagnostic Test	Manual	No	8,760 (1Y)
Main PLC-02-O	PLC Diagnostic Test	Manual	No	8,760 (1Y)
MV-1	Full Test	Manual	Yes	8,760 (1Y)
	Overhaul and Test	Manual	Yes	43,800 (5Y)

Project :	SIL Study	**Plant :**	ABC Plant
Client :	SaSI Innovation Company Limited	**Unit :**	1100
Description :	-	**Prepared By :**	Mario K.

SIF ID : SIF-ARS-001 Hot Air Fan, High Inlet Temperature (TT-4) **Status :** Pass

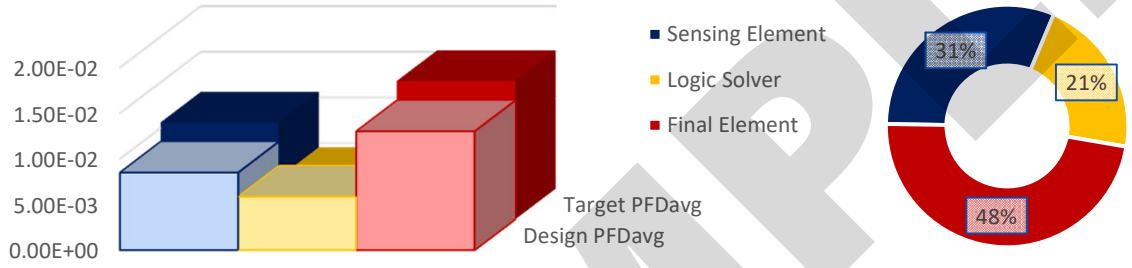
Function Group : Hot Air Fan **Process Safety Time (Sec) :** 5

SIF Design Result :

PFDavg (Min)	PFDavg (Max)	STR (Min)	STR (Max)
2.45E-02	2.74E-02	3.65E-02	4.46E-02
RRF (Min)	**RRF (Max)**	**Total Response Time**	
37	41	4.200 Sec	

Pass

Design HFT Requirement	Response Time	Relia. Allocation	Override Facility	Reset Method
Pass	Pass	AVERAGE	Required	Manual



Achieved SIL Level	Achieved PFDavg (Min)	Achieved RRF (Max)
SIL 1	**2.45E-02**	**41**

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