



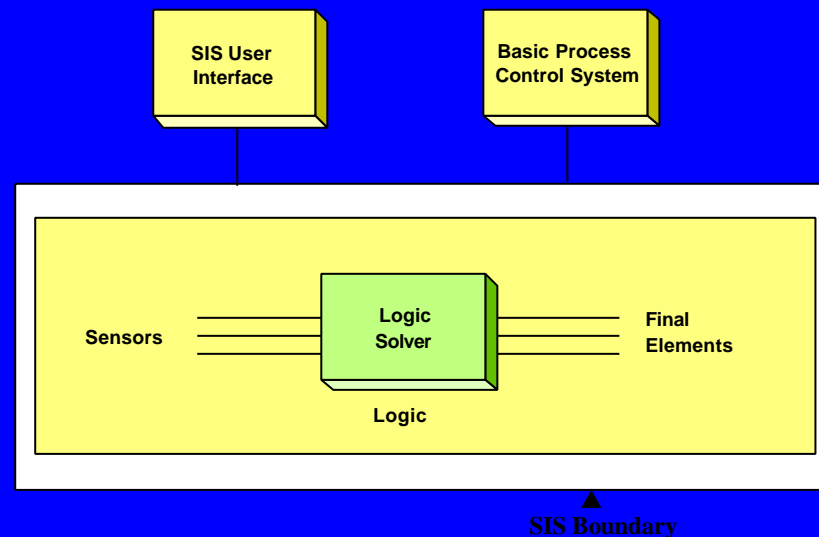
SEMINARIO

**SISTEMI DI SICUREZZA AD ALTA
AFFIDABILITÀ:
SAFETY INTEGRITY LEVELS (SIL)**

Applicazioni pratiche nella progettazione
Mosè Sinisi – Foster Wheeler Italiana

SIL STUDY - PRACTICAL ISSUES

- **FIELD OF APPLICATION**
 - SAFETY (ESD) FUNCTIONS
 - AUTOMATIC FIRE & GAS DETECTION SYSTEMS
 - MACHINERY PROTECTION FUNCTIONS
- **ENTIRE SAFETY FUNCTION LOOP**



SIL STUDY - PRACTICAL ISSUES

- ALL THE FUNCTIONS OF THE LOOP SHALL BE ADDRESSED

1.	US8001 Shutdown Sequence Gasification Unit Train 1	FS80023A	Oxygen	LL	Close XV80016	Downstream oxygen block valve
		FS80023B	Oxygen	LL	Close XV80015	Upstream oxygen block valve
					Close FV80023	Oxygen flow control valve
					Stop P-8004A/B/C	Feed oil pump
					Open HV80009	Grey water purge block valve
					Close 10 sec delay XV80012	Feed oil block valve
FS80023C	Oxygen	LL	Close HV80007	Small syngas block valve to downstream		
			Close HV80008	Scrubber overhead syngas valve to downstream		
			Close 10 sec delay XV80013	Steam block valve to mix tee		
			Open XV80017	Buffer N2 block valve		
				Activate UA80010	System trip to GT controller	

SIL STUDY - PRACTICAL ISSUES

- **SIL CLASSIFICATION**
- **SIL VERIFICATION**
- **SIL DESIGN**

SIL STUDY - PRACTICAL ISSUES



SIL STUDY - PRACTICAL ISSUES

- **SIL CLASSIFICATION**
 - **FREQUENCY OF DEMAND VS. CONSEQUENCES ASSOCIATED WITH A FAILURE**
 - SAFETY
 - ECONOMICAL
 - ENVIRONMENTAL

SIL STUDY - PRACTICAL ISSUES

- **SIL VERIFICATION**
 - Safety Function Configuration
 - Failure Mode / Failure Rate of the Components
 - Common Cause Failure
 - Maintainability (MTTR)
 - Testing Frequency
 - Diagnostic Coverage
- **SIL DESIGN**
 - Reliability
 - Fail Safe
 - Auto-Diagnostic
 - Maintainability

SIL STUDY - PRACTICAL ISSUES

SIL CLASSIFICATION

- **How often the Safety Function will be called ?**
 - **More than once per year:**
 - Failure of rotating machine
 - Human error (frequent operation / poor design)
 - **Once every 1 - 10 years**
 - Failure of a single DCS control loop
 - Human error (infrequent operation / good design)
 - **Less than one in 10 years**
 - Spurious closure / opening of a block valve
 - Erroneous closure of a isolation motorised valve

SIL STUDY - PRACTICAL ISSUES

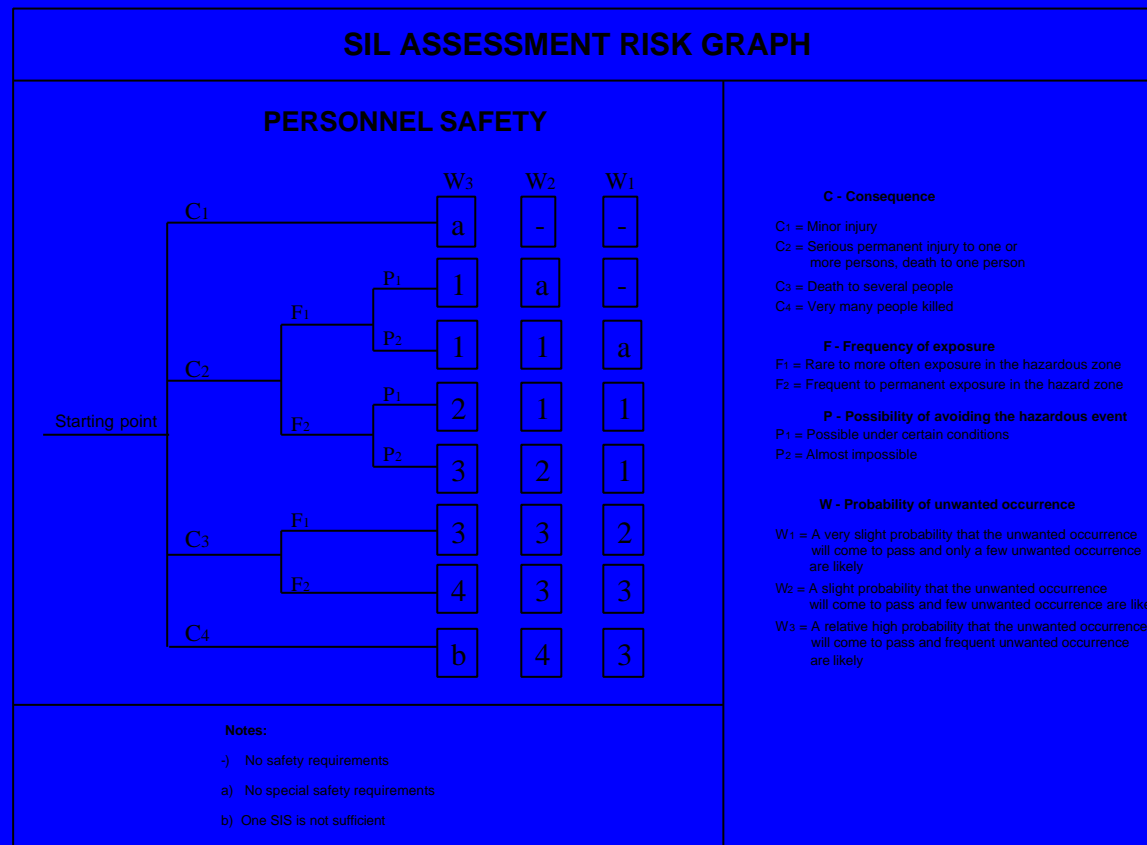
SIL CLASSIFICATION

- **Safety Consequences Risk Graph**
 - **Consequences Category**
 - **Frequency of Exposure**
 - **Possibility of Avoiding the Consequences**

SIL STUDY - PRACTICAL ISSUES

SIL CLASSIFICATION

- Safety Consequences Risk Graph

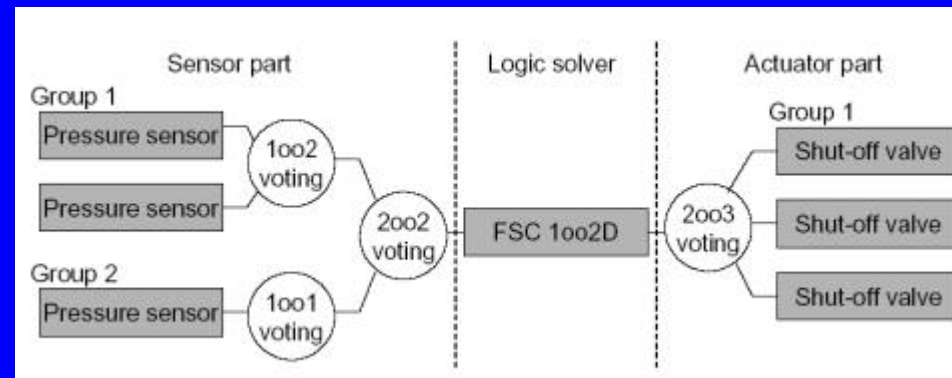


SIL STUDY - PRACTICAL ISSUES

SIL VERIFICATION

- **CONFIGURATION**

- 1 out of 1
- 1 out of 2.....



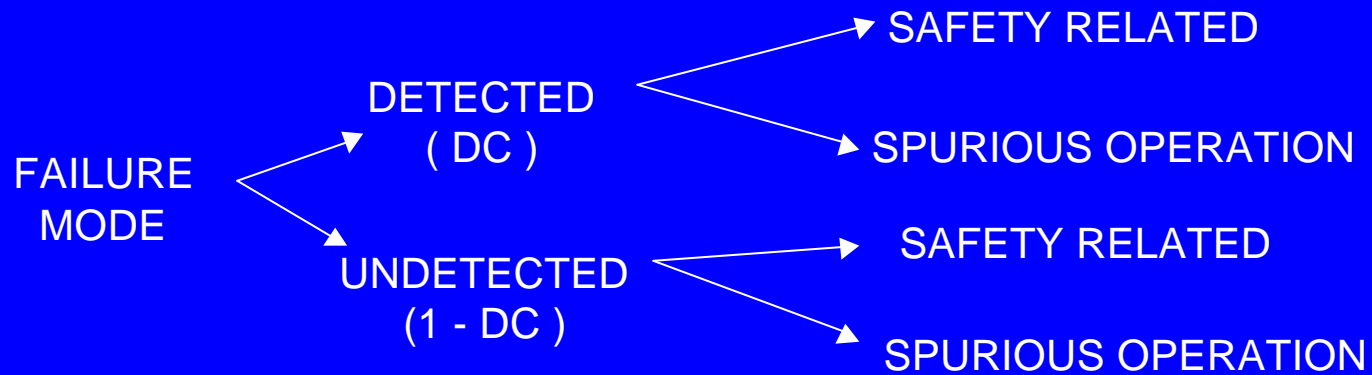
- **FAILURE MODE / FAILURE RATE**
- **COMMON CAUSE FAILURE**
- **MAINTAINABILITY (MTTR)**
 - Only slight effect on reliability

SIL STUDY - PRACTICAL ISSUES

SIL VERIFICATION

- **TESTING FREQUENCY / EFFECTIVENESS**
 - On line: check availability of facilities; test can be really carried out; etc.
 - When unit is shut-down: check T/A interval (min - max interval)
 - Clearly specify these requirement in the SIL report (in particular for not standard testing frequency)
- **DIAGNOSTIC COVERAGE**

SIL STUDY - PRACTICAL ISSUES



SIL STUDY - PRACTICAL ISSUES

- **Simplified Formulas (IEC 61508-6)**
 - **1 out of 1 configuration**

$$t_{CE} = \frac{I_{DU}}{I_D} \left(\frac{T_1}{2} + MTTR \right) + \frac{I_{DD}}{I_D} MTTR$$

$$PFD = (I_{DU} + I_{DD}) t_{CE}$$

t_{CE} = *Equivalent mean down time*

PFD = *Probability of Failure on Demand*

SIL STUDY - PRACTICAL ISSUES

SIL VERIFICATION

- **Low Operational Mode**
 - Probability of Failure on Demand (PFD)
- **High or Continuous Operational Mode**
 - Frequency of Failure (Failure Rate)

SIL STUDY - PRACTICAL ISSUES

SIL VERIFICATION

- **How can I improve reliability to meet SIL requirement?**
 - **Reducing Frequency of Demand of Safety Function (more reliable process control)**
 - **Improving Configuration of the Safety Function**
 - **Improving Maintainability**
 - **Reducing Testing Intervals**
 - **More Reliable Components**
 - **SIL Certified**
 - **Improved Auto-Diagnostic (“smart component”)**