



5th Chemical Process Safety Sharing (CPSS)

**Topic : *Improve Layer of Protection
in Fired Heater***

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5th Chemical Process Safety Sharing (CPSS)
3rd December 2019, Thailand



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- Standard and Existing Safeguarding
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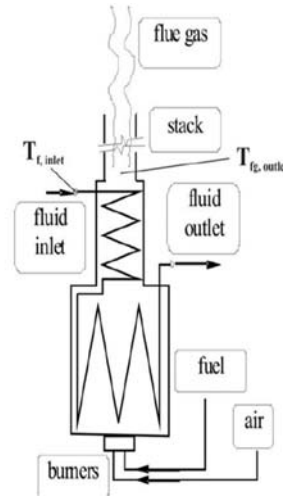
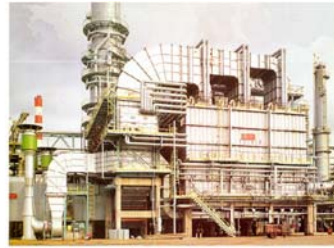
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Introduction to Fired Heater

The heater is really a large exchanger with a burner. The combustion process provides the heat to heat up the process steam. Most fired heaters absorb 80-90% of the combustion heat



- **Pre- Firing** : Prepares the fired equipment for the introduction of fuel and light-of of the burners. It includes prevention of fuel entering the fire chamber and purging the chamber to remove any residual hydrocarbon that may be present.
- **Ignition** : The light-off cycle is to safely introduce fuel to the burner and ignite it. After ignitions success, existence of stable flame is proven prior to move to the normal operation mode.
- **Normal Operation** : The normal operation phase occurs when a stable proven flame is used for process heating purpose.
- **Shutdown** : Slow down the heat supply to process until stop all burner.



Fired Heater : Unwanted



- ✓ Fuel has accumulated while burners are not operating and then ignited when a burner is lit. It can cause of explosion.
- ✓ Fuel accumulates after a burner goes out while operating, then subsequently finds a source of ignition.
- ✓ The process fluid is unable to remove sufficient heat which can cause of overheating the coil until damage and hydrocarbon release to fire.

Safeguarding System– Purpose

Primary Purpose

- To prevent the catastrophic combustion of accumulated fuel

Secondary Purpose

- To prevent overheating fired equipment and the catastrophic release of process streams that result



Review



Existing Safeguarding System Review

Case of Interest;

- Hazard Identification and Safety Analysis
- SIL Verification



Industry Standard



- ✓ API RP 556 : Instrumentation, Controls, and Protective Systems for Gas Fired Heaters and Steam Generator
- ✓ NFPA 85 : Boiler and Combustion Systems Hazards Code
- ✓ NFPA 87 : Standard for Fluid Heater
- ✓ ISA-TR84.00.05 : Guidance on the Identification of Safety Instrumented Functions (SIF) in Burner Management Systems(BMS)





Safeguarding Review : Permissive

Permissive	GC Site # 1	API RP 556	NFPA 85
Fuel Block Valve Prove Closed	X	X	X
Absence of flame prove	X	X	X
Pre-purge flow proved	X	X	X
Pre-purge timer complete	X	X	X
Pilot flame detected within time	X		X
Main flame detected within time			X
Adequate Process Flow	X	X	



Safeguarding Review : Interlock

Category	Interlock	GC Site # 1	Vender # 1	Vender # 2	API RP 556	NFPA 85	NFPA 87
Flame	Burner Flame Scan			X (Note 2)	X (Note-1)	X	X
	Pilot Flame Scan	X		X	X		
Fuel Gas	Fuel gas Pressure HH			X	X	X	X
	Fuel gas Pressure LL	X	X	X	X	X	X
	Pilot gas Pressure HH				X	X	X
	Pilot gas Pressure LL	X	X	X	X	X	X
Air	Combustion Air Pressure LL	X	X		Note 3		X
	Combustion Air Flow LL			X			Note 5
	Loss of Air (FD Fan)				X	X	X
	Air/Fuel ratio LL			X			
Other	KO Drum HH	X	X	X			
	Process Flow Coil LL	X	X	X	X	X	X
	Loss of ID Fan			X	Note 4		
	Firebox Pressure HH	X		X	X	X	X
	High Skin temperature HH				X		
	ID Fan suction temperature HH	X	X				

Note

- 1 The firing system should be designed to minimize possibility of flame failure. This best done by providing a reliability fuel system, pilot and burner pressure control.
- 2 Where not safeguarding by pilot
- 3 Low combustion air flow similar to loss of FD fan
- 4 Loss of ID fan or Low Draft or High Firebox Pressure
- 5 Combustion air minimum pressure or flow should be interlocked into combustion safety circuitry.



SIL Verification

ExSILentia Software was used for LOPA and SIL Verification



1. Calibrated PTTGC RAM Tolerable risk categories

In the SIL selection process the following risk receptor categories were considered.

- ✓ Personnel Safety
- ✓ Environmental Impact
- ✓ Asset Loss

	Minor	Serious	Severe	Extensive	Massive	Extreme	Catastrophic
Personnel Safety	Medical treatment	Loss time Injury	Single fatality or permanent total disabilities	More than one fatalities	N/A	N/A	N/A
Environmental Impact (I)	Minor Effect	Moderate Effect	Major Effect	Massive Effect	N/A	N/A	N/A
Asset Loss (THB)	Minor 0.3-3	Local 3-30 M	Major 30-300M	Massive > 300M	N/A	N/A	N/A
(I)	Minor impact	Moderate impact	Major impact	Massive impact	N/A	N/A	N/A
Tolerable Frequency (1/year)	≤ 1.00E-02	≤ 1.00E-03	≤ 1.00E-04	≤ 1.00E-05	≤ 1.00E-06	≤ 1.00E-06	≤ 1.00E-09

Consequence Category					
Personnel		Environment		Asset	
P0	--	E0	--	A0	--
P1	No injury or first aid	E1	No/slight Effect	A1	Slight = 0.3
P2	Medical treatment	E2	Minor Effect	A2	Minor 0.3-3
P3	Loss time Injury	E3	Moderate Effect	A3	Local 3 -30 M
P4	Single fatality or permanent total disabilities	E4	Major Effect	A4	Major 30-300M
P5	More than one fatalities	E5	Massive Effect	A5	Massive > 300M
P6	N/A	E6	N/A	A6	N/A



SIL Verification

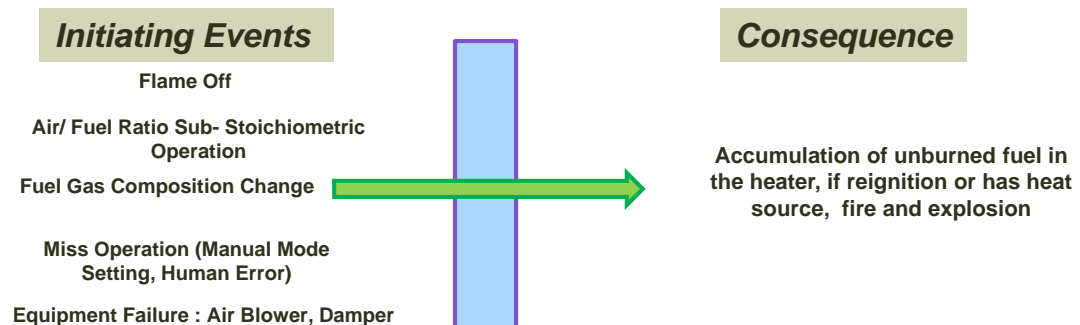


Hazard Identification



Hazard : Accumulation of unburned fuel in heater

Consequence : Re-ignition, fire and explosion, equipment damage and injure any personnel in the area of explosion



Safety Instrumented Function

Two safety function safeguards that are capability to stop the hazard demand

1. High Firebox Pressure Trip
2. Loss of Burner Flame Trip



SIL Verification



Severity Level Selections

The following Severity Levels and risk receptor-specific tolerable frequencies are associated with the hazard: Accumulation of unburned fuel in heater.



Risk Receptor	Severity	Level	Tolerable Frequencies [1/year]
Personnel Safety	Loss time Injury	Serious	1.00E-03
Environmental Impact ()	Minor Effect	Minor	1.00E-02
Asset Loss (THB)	Major 30-300M	Severe	1.00E-04

Initiative Event

All initiative events and independent protection layer. The sum of the initiating event frequencies, taking into account the Independent Protection Layer effectiveness, yields the total unmitigated event frequencies

Flame Off
Air/ Fuel Ratio Sub- Stoichiometric Operation
Fuel Gas Composition Change
Miss Operation (Manual Mode Setting, Human Error)
Equipment Failure : Air Blower, Damper

Risk Receptor	Sum Unmitigated Event Frequencies [1/year]
Personnel Safety	1.21E-02
Environmental Impact	1.21E-02
Asset Loss	1.21E-02



SIL Verification



Example : Initiating Event Air/Fuel ratio malfunction



Overview of the initiating event frequency, the enabling condition (if any), and associated Independent Protection Layer probabilities (if any). The resulting unmitigated event frequency for the Air/Fuel ratio malfunction

		Personnel PFD [RRF]	Environ. PFD [RRF]	Asset PFD [RRF]	PFD [RRF]	
Initiating Event	Air/Fuel ratio malfunction	0.1				[1/year]
Enabling Condition	Process Uptime	1				[-]
IPL 1	Operator observation	0.1 [10]	0.1 [10]	0.1 [10]	-	[-]
IPL 2	%Ignition	0.1 [10]	0.1 [10]	0.1 [10]	-	[-]
Resulting Unmitigated Event Frequency		1.00E-03	1.00E-03	1.00E-03	-	[1/year]



SIL Determination



Case : Hydrocarbon accumulated in firebox.



Hazard : Accumulation of unburned fuel in heater

Consequence : Re-ignition, fire and explosion, equipment damage and injure any personnel in the area of the explosion

	Required Risk Reduction	SIL
Personnel Safety	12	
Environmental Impact	1	
Asset Loss	121	
	--	
Overall Risk Reduction	121	
Target SIL		SIL 2



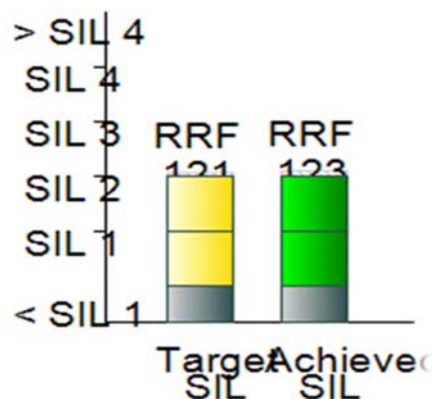
SIL Determination



✓ The target Safety Integrity Level determined for this Safety Instrumented Function is: **SIL 2 with RRF > 121**



✓ SIL verification determined that the Safety Integrity Level achieved by the Safety Instrumented Function is: **SIL 2 with RRF = 123**



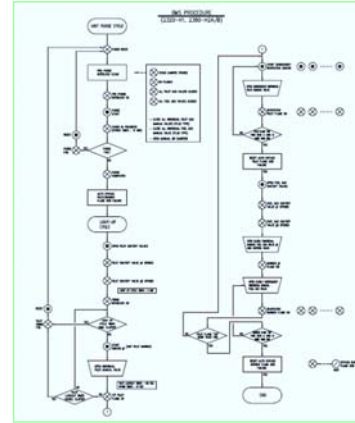
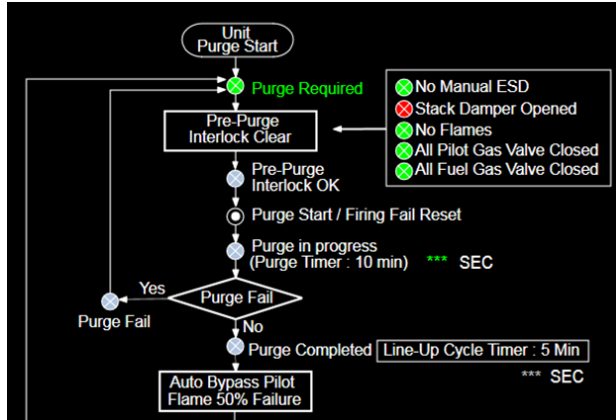


Actions



1. Pre-Firing

- ✓ Add interlock to ensure the stack was opened during purging.
- ✓ Add interlock to ensure the pilot and fuel gas shut-off valve were close during purge.
- ✓ Develop the existing graphic on DCS for fire heater startup flowchart to more clearly seen of each step and add guideline operator when interlock condition occur.



2. Ignition

- ✓ To add-in the interlock to not allow the fuel gas valve to open before complete lighting at least one pilot.

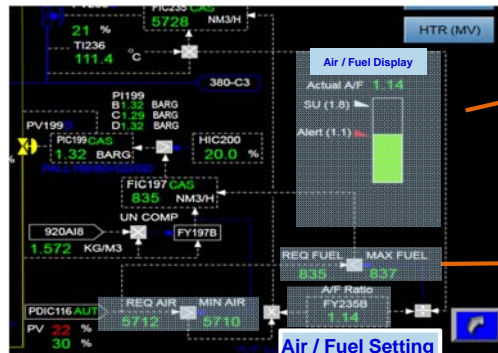


Actions



3. Normal Operation

- ✓ Change control scheme from fuel/air ratio to be air/fuel ratio.
- ✓ Modify base layer control to more safely control and provide more information to be guideline operator to properly control Air/Fuel Ratio during start up and normal condition.



4. Other

- ✓ Review fired heater start up procedure, the execution in the proper sequence prevents undesired outcomes. All of safeguarding system shall be activated and not allow to bypass or override all the time during heater start up and normal operation.
- ✓ Review operator training , work instruction and competency evaluation for the situation of fuel accumulation in firebox.



Thank you for your attention



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