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Pre-Startup Safety Review Performance and Close-Out Management for a New Licensed Petrochemical Plant

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During the development of a licensed petrochemical industrial plant project, the identification, review and proper addressing of hazards is carried out by the different project's stakeholders (Licensor, EPCC Contractor, Owner, etc.) since the early phases of feasibility study and basic engineering, up to detail design, procurement, construction and commissioning phases.
This results in multiple layers of HSE requirements whose proper and effective implementation needs to be checked before commencing operations, in order to prevent adverse HSE consequences that could affect other business aspects and success of the project.
A formal process to ensure that plants and facilities conform to HSE requirements, that relevant safety, operating, maintenance and emergency procedures are in place and that all process hazard analyses recommendations have been implemented, is the Pre-Startup Safety Review, or PSSR.
The PSSR shall be performed at site by a multidisciplinary team as close as possible, but prior to the mechanical completion, when fire protection systems, fire water network, fire and gas detection systems and emergency blow down systems are in place.
The PSSR team shall evaluate the overall review results and recommend whether the concerned unit/system is ready and safe to start-up.
This paper illustrates how different sessions of Pre-Startup Safety Review were performed and managed to close-out on a new petrochemical plant, to demonstrate that the facilities were ready and safe prior to the introduction of any hazardous materials.

1. Introduction

In March 2005, the BP Texas City refinery suffered a major disaster that killed 15 and injured 180 others. BP hadn't properly conducted safety critical checks. The CSB investigators found an inoperative pressure control valve, a defective high-level alarm and an uncalibrated sight-glass level transmitter as well as portable trailers with non-essential personnel located too close to the process (CSB, 2007), Properly performed PSSRs would have prevented this event (Broadribb M.P., Flynn S.A., 2009).
Effectively conducted PSSRs can prevent incidents and the resultant harm to personnel, equipment damage and loss of production and profits. PSSR is also a critical element of the process safety management (PSM) program mandated by the United States Occupational Safety and Health Administration (OSHA), which defines the need for a PSSR in 29 CFR (Code of Federal Regulations) 1910.119(i). According to OSHA, the ultimate responsibility lies with plant or facility management to ensure a PSSR is properly conducted before a covered process is started (Wincek, 2018).
The goal of the Pre-Startup Safety Review (PSSR) process is to provide a coherent, systematic, and as simple a strategy as possible to implement, in order to ensure that all prior identified hazards, loss exposures and other potential unidentified hazards associated with plant start-up and operation have been addressed to close-out before start-up.
According to the contractual requirements and to construction progress it may be decided to cover the PSSR in a single session or in two or even more sessions (Marucco D., 2015).

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2. Project Overview

Tecnimont S.p.A., international leader in the field of petrochemical plant engineering, in joint venture with a Chinese contractor, was appointed by the national oil & gas company as EPCC contractor of a 400,000 tons per year High Density Polyethylene (HDPE) licensed plant in Malaysia.
The HDPE Plant was a fundamental component of the overall 27 billion USD investment made for a world scale integrated refinery and petrochemicals complex, which covered an area of 80 km^2 and included:

- Refinery with 300,000 barrels per day capacity
- Naphtha Steam Cracker
- Petrochemical Derivatives Units
- Cogeneration Plant
- LNG Regasification Terminal
- Deep Water Terminal
- utilities, off site and jetty installations.

The complex was designed to meet both domestic and Asia's energy and chemicals demand, yielding an estimated annual production capacity of 3.6 million tons of petrochemical products.

Figure 1: HDPE Plant aerial view

The Pre-Startup Safety Review (PSSR) process for the HDPE Plant started in the second quarter of 2019, after the achievement of 80% mechanical completion and continued up to the end of the year, when the Ready for Start-Up (RFSU) certificate for Hydrocarbon-In was released.

3. Pre-Startup Safety Review Process

In compliance with contractual requirements, two different PSSR Reviews were performed in series, both managed by multidisciplinary Review Teams: the first one involved Licensor's representatives and Contractor's representatives, while the second one involved Owner's representatives and Contractor's representatives.
The reviews were covered in three sessions each, focused on the three macro-areas identified based on the planned start-up sequence of the different process units:

- Hexane Storage and Hexane Distillation Section
- Extrusion and Dry-end Section
- Polymerization and Polymer Drying Section

Table 1 summarizes the split of Plant's units by PSSR and the three macro areas superimposed to the Plant's plot plan are shown in Figure 2.*Figure **2**: PSSR macro areas*

Table 1: PSSR sessions

PSSR Session	Macro-area	Units involved
1	Hexane Storage and Hexane Distillation Section	Battery limit Hexane Unloading Hexane Storage Tanks Steam System Wastewater basin Substation & Field Auxiliary Room
2	Extrusion and Dry-end Section	Extruder Natural Extruder Black Intermediate Silos Blending Silos
3	Polymerization Section	Jacket Water Reactors and Outercoolers Polymer Drying TEAL unloading TEAL Transfer

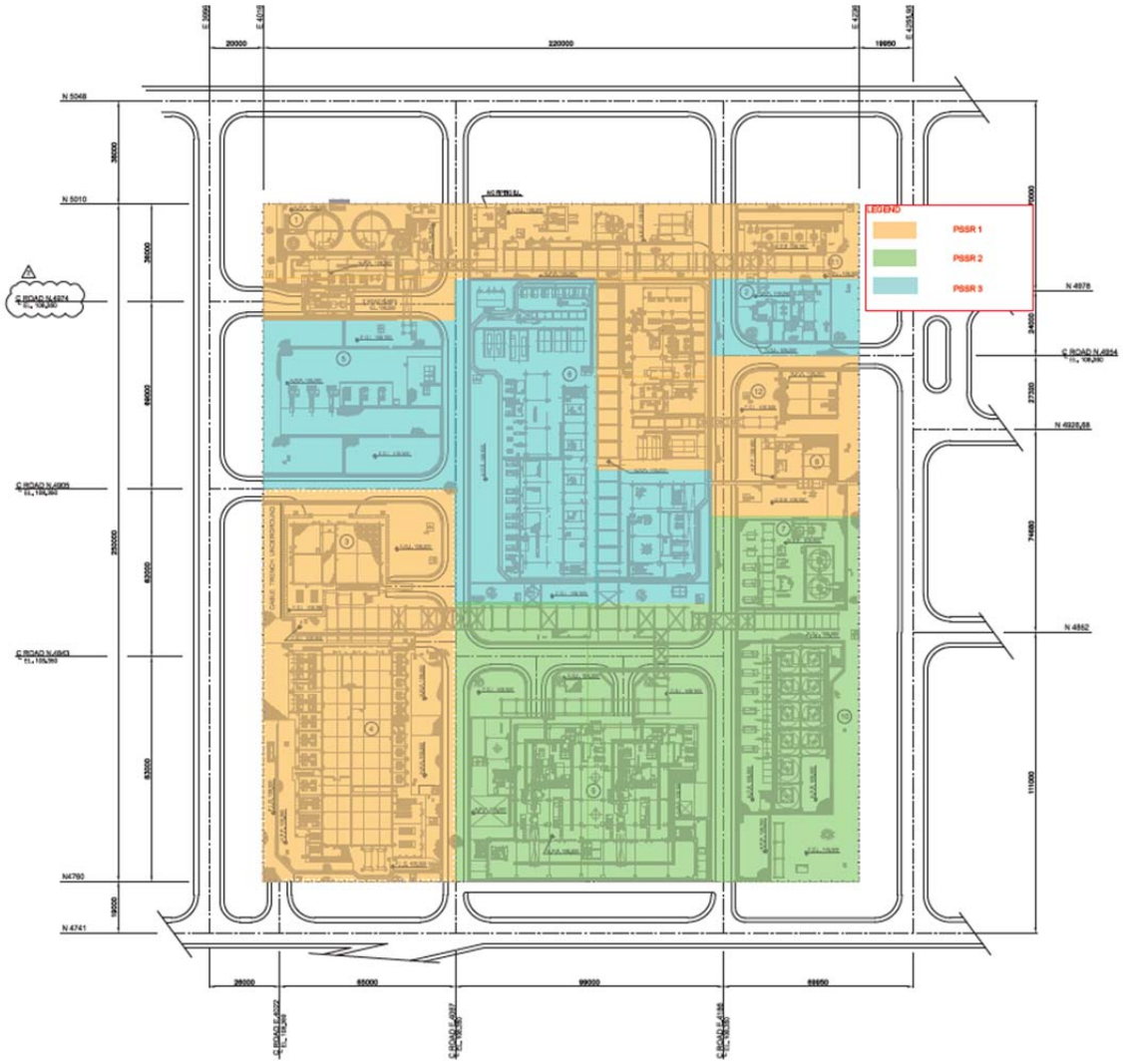

Figure 2: PSSR macro areas

3.1 Pre-Startup Safety Review Teams and Guidelines

The Licensor's PSSR was conducted by a Review Team including HSE, Design and Operation Specialists from both Contractor and Licensor, led by Licensor's Process Safety Manager. Licensor's General HSE Design Criteria and Criteria pertaining to the specific licensed HDPE technology were the reference guidelines according to which the Plant was designed and built, and Licensor's Pre-Startup Safety Review Sessions were conducted.

The Owner's PSSR was performed by a Review Team including HSE, Design and Operation Specialists from both Contractor and Owner, led by Owner's Central Directorate Operations Manager. A multidisciplinary PSSR checklists, shown in Figure 3, was developed by Owner, to help in guiding the discussions and focus the review effort in ensuring all process safety considerations were completed so that units being reviewed were ready for the start-up.

Each subject was covered by the Review Team through the assigned Specialist, according to experience and competences. Assistance to the Review Team was ensured by the Site personnel.

As a helpful support to the Review, the latest revision of: active and passive fire protection philosophies and layouts, Fire and Gas philosophy and layouts, Hazardous Area Classification philosophy and layouts, Quantitative Risk Assessment, P&IDs, Management of Change log, risk assessments action items close-out final documentation of other disciplines involved, e.g. Process, Civil, Instrumentation/Telecommunication, Electrical, etc., were made available.

Pre-Start up Safety Review Checklist

Package/Unit	
Date :	

No	PSSR Questions	Check?		
		No	Yes	NA
A	**FIRE SAFETY**			
1	Has BOMBA inspection been conducted? Has the CCC been approved and issued?			
2	Have the fire protection systems been provided and tested at site? These includes smoke, fire and gas detection, manual call point, fire alarm panel, fire damper, beacon light and sounder.			
3	Have manual deluge valves, hydrant isolation valves, and hydrant nozzle valves been opened and closed under operating pressure?			
4	Has the hydrant pressure-regulating devices been calibrated and tested?			
5	Have firefighting equipment, manual call points, abort switches, fire and gas detectors been labelled correctly?			
6	Have bund walls, dikes and remote impounding basins been isolated? All rainwater drain valves are in CLOSED position?			
7	Have access to Fire Alarm Panel, INERGEN Panel, INERGEN cylinders and Fire & Gas controls been restricted / locked?			
8	Are certified fire doors provided as per the required rating?			
9	Have the fire extinguishing systems been provided and tested at site? These includes portable fire extinguishers, wheeled DP extinguishers, hose reels, water curtains, INERGEN, dry powder, monitors, deluge/spray/sprinkler systems, and foam systems.			
10	Have access to all fire extinguishing systems been cleared of obstruction e.g. scaffolding, plastic cover, construction debris?			
11	Have high risk rooms such as battery room, electrical room and ENMC room been cleared of combustible material? Are these still being used as temporary storage?			
12	Have traffic barricades and security gates been installed to control vehicle access into Hazardous Classified Areas?			
13	Have escape routes (including exit doors, staircase and landing area) been cleared of obstruction, illuminated and marked?			
14	Has the inventory inside fire hose boxes and fire extinguisher cabinets been checked against its equipment list and its door sealed against theft and abuse?			
15	Are portable fire extinguishers provided with valid certificate of inspection?			
16	Have all roadside hydrants and monitors been provided with traffic bollard and paved grade for CEFS PIC accessibility?			
17	Has a joint site inspection been conducted with CEFS for occupied buildings and high risk buildings e.g. substation?			
18	Have all plastic cover for smoke, gas or flame detectors been removed? These plastic covers were used to protect against damage and debris during construction.			
19	Has KELUAR/EXIT signs and other safety signage been installed? If these were lighted, has emergency power supply been tested?			
20	Has the foam inventory been provided in the right amount and concentration? Has it been sighted and acknowledged by CEFS?			
21	Has hydrants and firewater ring mains been hydrotested?			
22	Has the surface drainage and oily sewers been cleared of debris?			
23	Has fireproofing coating/concrete been inspected and is intact?			
24	Has the fire truck and dry riser connections been tested by CEFS?			
25	Has an emergency assembly area or a muster point been designated? Can it be accessed directly by fire truck and ambulance?			
26	Are sufficient escape set or SCBA provided as per design?			

Figure 3: Owner's PSSR sample checklist

3.2 PSSR Execution

The PSSR sessions started with a tabletop discussion, aimed at the clear identification of session's scope, the review of related design documents and the planning of site visit. The site visit focused on actual implementation at site of items discussed tabletop and on verification of physical readiness of the units in terms of, but not limited to:

- availability and adequateness of escape routes throughout the Plant
- review of fire protection and fire detection systems installation

- review of safety equipment installation i.e., safety showers, eye washes, first aid boxes, escape packs, self-breathing apparatus, fire suits etc.
- check of other critical installations, such as process safety devices discharging to atmosphere, sampling points, air intakes, Public Address General Alarm system, etc.
- check of housekeeping

For each item the Review Team determined implementation adequateness to allow the unit to be safely started-up.

3.3 PSSR Findings, Tracking and Close-out

When substandard conditions were identified during the PSSR, the Review Teams proposed corrective actions, called recommendations, to be properly addressed to ensure that all potential hazards were eliminated.

For each session, reports were prepared by the Review Team Leader and issued with the photographic evidence reference of the items not in compliance with guidelines i.e., findings, and the indication of the recommendations to be applied. All PSSR recommendations were categorized based on Severity as per Risk Assessment Matrix (RAM) in Figure 4.

Consequence		SEVERITY	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
		People	Slight Injury	Minor Injury	Major Injury	Single Fatality	Multiple Fatalities
					Major Health Effects*	Permanent Total Disability*	Permanent Total Disability*
		Environment	Slight Impact	Minor Impact	Moderate Impact	Major Impact	Massive Impact
		Asset	Slight Damage	Minor Damage	Local Damage	Major Damage	Extensive Damage
		Reputation	Slight Impact	Limited Impact	Considerable Impact	Major National Impact	Major International Impact
LIKELIHOOD	E Almost Certain	Incident has occurred several times per year	E1	E2	E3	E4	E5
	D Likely	Incident has occurred more than once per year	D1	D2	D3	D4	D5
	C Possible	Incident has occurred more than once per year in industry world wide	C1	C2	C3	C4	C5
	B Unlikely	Incident has occurred in industry, world-wide	B1	B2	B3	B4	B5
	A Remotely likely to happen	Never heard of in industry world-wide but could occur	A1	A2	A3	A4	A5

VERY HIGH
HIGH
MEDIUM
LOW

* For chronic health effects

Figure 4: Risk Assessment Matrix

Recommendations were prioritized by assigning risk ranking in accordance to the following criteria:

- all PSSR recommendations under Severity Rating 3, 4 or 5 were categorized as PS1 i.e., to be closed before start-up
- all PSSR recommendations under Severity Rating 1 or 2 were categorized as PS2 i.e., to be closed after start- up.

After the two PSSR Reviews were completed, a total of 832 recommendations were identified for the HDPE Plant, categorized as shown in Table 2 and Table 3:

Table 2: Licensor's PSSR recommendations summary

PSSR	Number of recommendations PS1	Number of recommendations PS2
Licensor's Session 1	23	-
Licensor's Session 2	26	-
Licensor's Session 3	35	10

Table 3: Owner's PSSR recommendations summary

PSSR	Number of recommendations PS1	Number of recommendations PS2
Owner's Session 1	189	58
Owner's Session 2	144	42
Owner's Session 3	228	77

All PSSR recommendations were tracked and monitored internally through Contractor's mechanical completion database management system, using the existing punch-list template, and through a dedicated register (refer Figure 5) reporting PSSR findings – "Requirement " column – and related close-out action – "Agreed Resolution" column. Status of all PSSR recommendations, PS1 and PS2, was updated on weekly basis. Licensor and Owner respectively confirmed closure of recommendations upon provision of relevant evidence.
The PSSR was officially closed out once all findings were closed out through specific agreed resolution.

ITEM	REQUIREMENT	OBSERVATIONS	PRIORITY	AGREED RESOLUTION	STATUS
1.	**General – Piping** Primary content shall be granted on all lines of process and utility fluids	PSSR 1: Blinds on flanges are missing or flanges are not plugged that can generate hydrocarbon release to the atmosphere. Moreover contamination of lines (water, sand, dust, etc.) can be expected even before hydrocarbon intake	A	PSSR 2: Situation improved. Plastic foil is in use where blinds are missing (refer to appendix 2)	CLOSED
2.	**General - Battery room** Gen.10.2.13...• Safety shower and eye wash station if batteries are not sealed.	2.F.1 Safety shower is missing on FAR battery room	A	Batteries in FAR are sealed type. Emergency eye wash will remain.	CLOSED
		2.F.2 Safety shower is missing on Substation battery room	A	Batteries in Substation are NiCd, unsealed. Eye wash replaced with safety shower + eye wash configuration (refer to appendix 2)	CLOSED

Figure 5: Sample close-out register from Licensor's PSSR

4. Conclusions

The Pre-Startup Safety Reviews carried out for the HDPE licensed Plant allowed for the proper identification of gaps between the various HSE requirement acknowledged during the development of the Project and their effective implementation before commencing operations. After the two PSSR Reviews were completed, a total of 832 recommendations were identified for the HDPE Plant and the performance and close-out of the PSSRs required the effort of the overall Project's Team, including Engineering Specialists, Site personnel, Project Management and Site Management from Contractor's, Licensor's and Owner's side.
The HDPE Plant RFSU certificate for Hydrocarbon-In was achieved once all PS1 were closed-out and the Hydrocarbon-In was safely performed with no incidents and no equipment damage on 31st December 2019.

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