FIPI

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From the Desk of the

Director General

Greetings from Federation of Indian Petroleum Industry (FIPI)!

The year 2023 was marked by extraordinary heat, devastating storms and weather-related disasters that not only posed a direct threat to human health and wildlife but also led to severe droughts, water shortages, and stressed agricultural systems. There is no doubt that climate change was the driving force behind the numerous climate events this year. The extreme weather events of 2023 serve as a stark reminder for all of us that climate change is not a distant threat but a current and pressing reality.

In this regard, the annual UN Climate Change Conference (COP28) hosted by the United Arab Emirates in Dubai this year, provided the opportunity for world leaders to discuss and agree on a global response to address the challenges posed by extreme weather events.

Against the backdrop of this challenging global environment, India is poised to become the new growth engine of the world backed by its strong domestic macroeconomic fundamentals. With India's GDP projected to grow at robust 6.5% by RBI for FY 2023-24, its energy demand is bound to rise which will pose significant challenges to climate change.

To help India strengthen its climate resilience, the Honourable Indian Prime Minister Shri Narendra Modi on behalf of India committed to bring down the carbon intensity of India by more than 45% by 2030 and achieve the target of net zero carbon emissions by 2070. Further, Indian Government has called for making "Lifestyle for the Environment" (LiFE) a global mission to tackle the adverse effects of climate change.

To achieve net zero, India has also incorporated green energy and energy efficiency significantly in its mode of operating systems- whether it be through the Saubhagya scheme (household electrification), Ujjwala scheme (to provide LPG cylinders), or its ambitious green hydrogen mission.

Further, India's launch of the Carbon Credit Trading Scheme (CCTS) in FY 2023-24, a form of domestic emissions trading scheme, is another significant step forward in incentivising emission reductions across industrial and power sectors. CCTS will help meet country's near-term Nationally Determined Contributions (NDC) goals and long-term target of achieving net-zero emissions by 2070. With such groundbreaking regulation, India will not only reduce its own carbon emissions, but also carve out a low-carbon, sustainable pathway for high levels of economic development, that the rest of the nations can follow.

In addition to the above, as natural gas is an environment friendly clean fossil fuel, and has huge potential in providing solutions to environmental challenges, the Honourable Minister of Petroleum & Natural Gas and Housing & Urban Affairs, Shri Hardeep Singh Puri launched the 12th City Gas Distribution (CGD) Bidding Round of PNGRB in Delhi in November 2023. The 12th CGD bidding round aims to achieve 100 per cent coverage of the country by expanding the reach of natural gas to households, industrial and commercial facilities as well as fuel transportation, thereby marking a giant leap towards achieving a gas-based economy.

Further in the EV segment, the Honourable Union Minister for Power and New & Renewable Energy, Shri R. K. Singh launched a digital platform focused on near real-time Electric Vehicle adoption and forecasts, associated battery demand, charging density, and market growth trends. The platform seeks to address the need for macroeconomic data and analysis on India's growing electric mobility segment. The EV-Ready India dashboard has forecast a 45.5% CAGR in electric vehicles between CY 2022 and CY 2030, increasing from annual sales of 6.9 lakhs electric two-wheelers (E2Ws) in 2022 to 1.4 crores E2Ws in 2030.

In a major step towards enhancing the use and adoption of CBG, the National Biofuels Coordination Committee (NBCC), chaired by the Honourable Minister of Petroleum & Natural Gas and Housing & Urban Affairs, Shri Hardeep Singh Puri announced the introduction of phase wise mandatory blending of CBG in CNG (Transport) & PNG (Domestic) segments of CGD sector. This step will help to stimulate demand for CBG in CGD sector, import substitution for LNG, saving in forex, promoting circular economy and assist in achieving the target of net zero emissions. In addition, Sustainable Aviation Fuel (SAF/Bio- ATF) initial indicative blending percentage targets were also set by the committee.

In the downstream segment, the consumption of petroleum products during April-November 2023, with a volume of 152.3 MMT, reported a growth of 4.9 % compared to the volume of 145.10 MMT during the same period of the previous year. This growth was led by 6.5% growth in MS, 5.4% in HSD, 12.9% in ATF & 12.4% in Naphtha consumption. For natural gas, the consumption for the month of November 2023 was 5328 MMSCM which was 6.6% higher than the corresponding month of the previous year. Thus, robust economic growth has led to an upbeat in the fuel demand outlook in FY 2023-24.

Various Events organized by FIPI during the quarter

Let me now provide you with a glimpse of the work undertaken by FIPI in the current quarter FY 2023-24. During the current quarter (October-December 2023), FIPI has been active in organising various knowledge sharing events and webinars covering aspects related to the oil and gas industry.

FIPI in knowledge partnership with S&P Global, organised a webinar on 'Carbon Markets' in October, 2023. The webinar was conducted to delve into the fundamentals of carbon markets, exploring carbon credits and allowances while distinguishing between voluntary and compliance markets. The webinar witnessed an overwhelming response with the participation of more than 200 professionals working across the oil and gas value chain.

The Abu Dhabi International Petroleum Exhibition & Conference (ADIPEC) 2023 was held from 2nd October to 5th October 2023 at Abu Dhabi, UAE under the patronage of the UAE. FIPI under the aegis of MoP&NG co-ordinated to set-up the India Pavilion on behalf of the Indian Oil & Gas industry in ADIPEC 2023. Eleven major oil & gas companies participated and displayed their technologies & facilities to the global organizations during the event. The theme for this year's India Pavilion was "Innovation & Collaboration - Driving India's Energy Transformation." FIPI stall was inaugurated by the Honourable Minister of Petroleum & Natural Gas and Housing & Urban Affairs, Shri Hardeep Singh Puri on 2nd October 2023.

On November 17th 2023, FIPI, along with HDFC Bank Limited as the knowledge partner organized a half-day seminar on "Overseas Direct Investment (ODI) Regulations and its Compliance'' at New Delhi. The seminar showcased the key changes in ODI regulations and its compliance mechanism. It was attended by senior finance officials of the oil and gas industry.

On 5th December 2023, FIPI in association with EY as knowledge partner, organised a webinar on 'Digital Personal Data Protection Act, 2023'. The webinar was conducted to shed light on the Act that provides processing of digital personal data in a manner which recognizes both the right of individuals to protect their personal data and the need to process such personal data for lawful purposes.

Further, I am happy to share that this time, India Energy Week 2024 is being organized at Goa from February 6 -9, 2024. The IEW 2024 is envisaging participation of 30,000+ attendees, 1000+ exhibitors, 15 International Exhibiting Country pavilions, 8,000+ Conference Delegates, 500+ speakers and 80+ Ministerial, Keynote, Strategic and Technical Conference Sessions. The Conference cum Exhibition will include participation from NOCs, NECS, IOCs and IECS, International Service Providers, EPC Contractors, Technology, Service Companies, Utility Companies and Financial Organizations from across the Oil, gas, and energy sector. I urge you and your organization to participate at IEW 2024 and make this event a resounding success.

Ongoing FIPI Studies

FIPI, on behalf of its members, is carrying out a study on "Role of CCUS in India's Energy Sector" with the objective to assess the role & importance of CCUS, in India's energy sector. Eight industry members namely, IOCL, BPCL, HPCL, GAIL, HMEL, ONGC, OIL and Nayara Energy have agreed to partner and share the cost for this study. EY has been engaged as the knowledge partner for the study who has submitted the interim report in

November, 2023 and subsequently a meeting has been conducted to discuss the inputs of study partners.

Another major work initiated by FIPI is carrying out a study with BCG for developing the Global Biofuel Alliance (GBA) under India's G20 Presidency. The objective of the study is to analyse and support alignment and broader adoption of GBA.

FIPI, in collaboration with its five partner organizations, namely GAIL, ONGC, Pipeline Infrastructure Ltd., Shell and ExxonMobil launched a comprehensive study on the "Role and Potential of Natural Gas in Mitigating Industrial Air Pollution." The Energy and Resources Institute (TERI) was appointed as the research partner for this study, which focuses on three key industrial clusters: Gurgaon (Haryana), Varanasi (Uttar Pradesh), and Sangareddy (Telangana). TERI has submitted the final report to study partners.

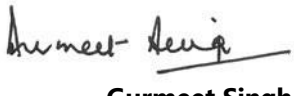
Last but not the least, FIPI conducts regular Committee meetings with its members to discuss their matters relevant to oil and gas industry and subsequently represent their issues at various levels of regulatory authorities.

Conclusion

Just like other emerging economies, India is also undergoing a phase of energy transition. The country is gaining universal access to modern, reliable, and affordable energy services on one hand while transitioning to a low-carbon energy mix on the other. With new and emerging energy options, India can only move ahead towards cleaner and more sustainable environment.

As we continue this journey together, I assure you that FIPI will always be at the forefront in advocating the industry issues while working closely with all its stakeholders in scripting the growth story of the Indian oil and gas industry.

I wish you all the best and a very happy new year 2024!



Gurmeet Singh

FEDERATION OF INDIAN PETROLEUM INDUSTRY

CORE PURPOSE STATEMENT

To be the credible voice of Indian hydrocarbon industry enabling its sustained growth and global competitiveness.

SHARED VISION

- A progressive and credible energy advisory body stimulating growth of Indian hydrocarbon sector with global linkages.
- A healthy and strong interface with Government, legislative agencies and regulatory bodies.
- Create value for stakeholders in all our actions.
- Enablers of collaborative research and technology adoption in the domain of energy and environment.
- A vibrant, adaptive and trustworthy team of professionals with domain expertise.
- A financially self-sustaining, not-for-profit organization.

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Retrofitting Dry Gas Seal (DGS) in Process Gas Centrifugal Compressor having Wet Seal System

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Abstract:

Process Gas Centrifugal Compressor is one of the most critical equipment of refinery process units. In Diesel Hydro-Treating Unit (DHDT), Diesel Hydro-Desulphurization Unit (DHDS), Hydro-Cracker Unit (HCU) & Catalytic Reforming Unit (CRU), it is named as *Recycle Gas Compressor (RGC)* and in Fluid Catalytic Cracking Unit (FCC) & LPG Recovery Unit (LPG), it is named as *Wet Gas Compressor (WGC*). Process gas Centrifugal compressors have seals on the rotating shafts that prevent the high-pressure gas from escaping the compressor casing. These seals can be high-pressure oil ("wet") seals or mechanical gas ("dry") seals, which act as barriers against escaping gas. We will, in this article, comprehend these Wet Seal & Dry Seal systems. Working Principle, that helps in understanding the main difference between Wet & Dry Gas Seal systems. Dry Gas Seal Retrofits - Existing compressors can be upgraded from their current wet seals to dry gas seals - Feasibility Considerations. Dry Gas Seal, as cost-effective, offer advantages over wet seal. Understanding - economic benefits of Dry Gas Seal Over Wet Seal.

Introduction

Process gas Centrifugal compressors have seals on the rotating shafts that prevent the high-pressure gas from escaping the compressor casing. These seals can be high-pressure oil wet seals or mechanical gas dry seals, which act as barriers against escaping gas. The floating wet (Oil) seal system is obsolete design. In wet seal centrifugal compressors, seal oil is circulated under high pressure between rings around the compressor shaft, forming a barrier against the compressed gas to prevent its escape to the atmosphere. Seal oil, which is circulated under high pressure between three rings around the compressor shaft (Figure-I), forming a barrier against the compressed gas leakage. The centre ring is attached to the rotating shaft, while the two rings (HP/LP) on each side are stationary in the seal housing, pressed against a thin film of oil flowing between the rings to both lubricate and act as a leak barrier. O-ring rubber seals prevent leakage around the stationary rings.

Figure-I (Source[2]: Wet Seal, EPA, USA-2003, DOC.)

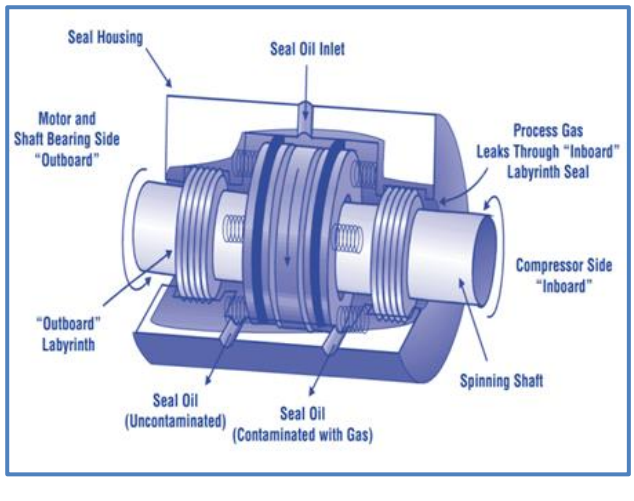
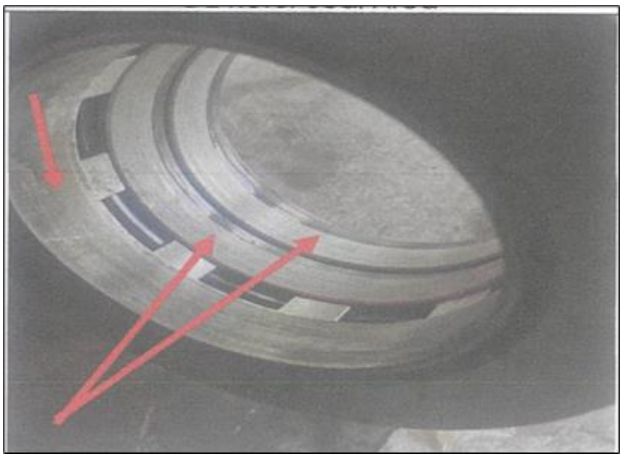


Figure-I (A) (DE HP/LP Seal Faces)



Dry gas seals are an integral part of modern centrifugal compressors. Today more than 90% of newly manufactured centrifugal gas compressors are equipped with dry gas seals. Dry gas seals operate with clearances measured in microns, much less than the thickness of a human hair![1] Such small clearances are unheard in the rotating equipment industry. Dry gas seal system does not use any circulating seal oil. Dry seals operate mechanically under the opposing force created by hydrodynamic grooves and static pressure.

Hydrodynamic grooves are engraved into the surface of the rotating ring fastened to the compressor shaft (Figure-II).

The tandem style gas seal is the style most commonly applied in process gas service (Figure-III). Tandem gas seals are essentially two dry gas seals—a primary seal and a secondary seal—positioned in series, and contained within a single cartridge.

Figure-II (Source[2]: Dry Seal, EPA, USA-2003, DOC.)

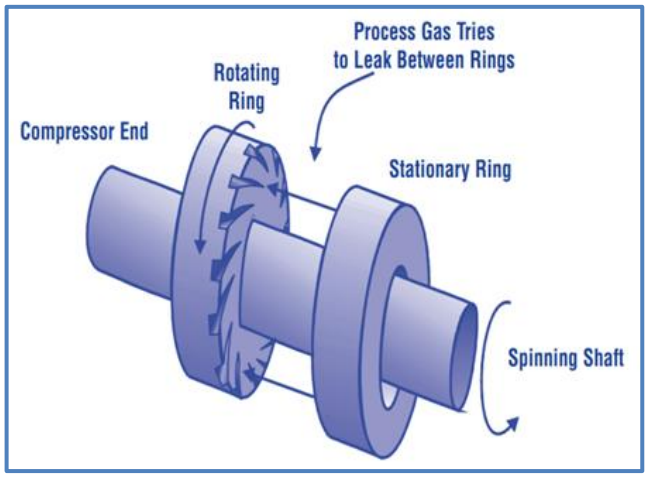


Figure-III (Source[2]: Dry Seal, EPA, USA-2003, DOC.)

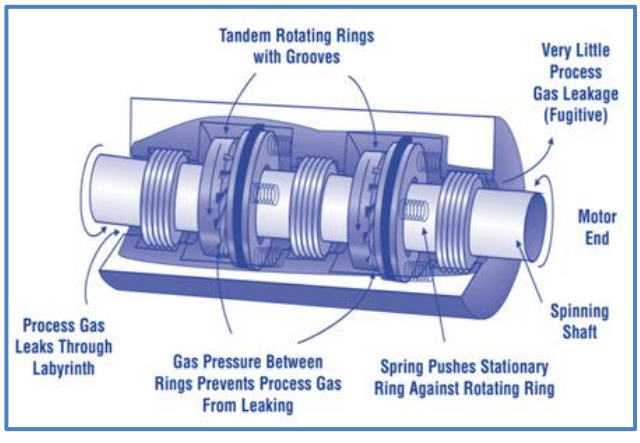


Figure-III (A) (Dry Seal Cartridge)

Seal Systems

- ***Wet (Oil) Seal***
- ***Dry Gas Seal (DGS)***

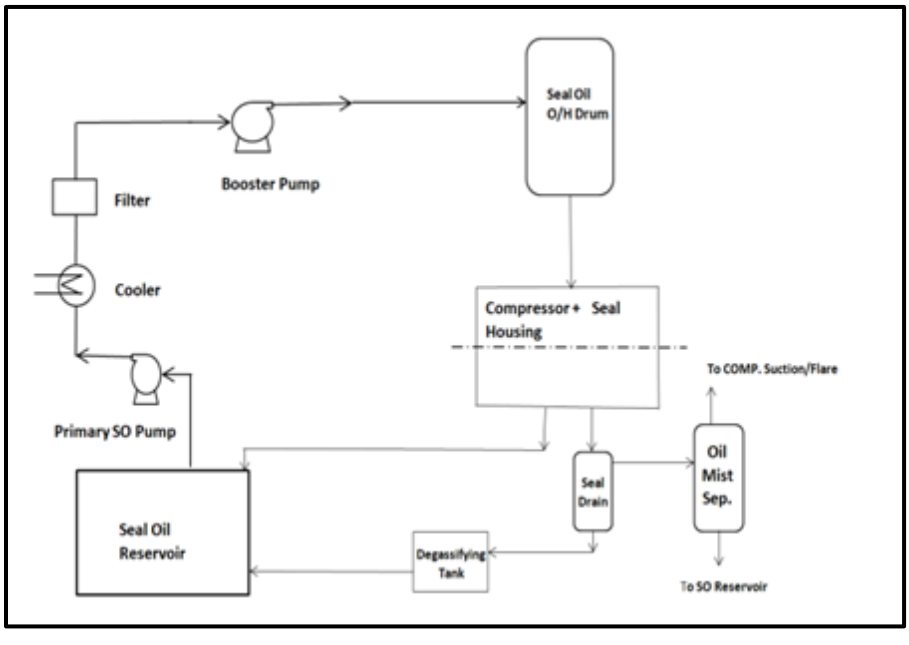
Wet seal is requires a supply of seal oil at a pressure higher than the required sealing pressure. Seal oil pressure is generated by seal oil primary pump and seal oil booster pump. The gas reference pressure is provided at top of the seal oil overhead day tank mounted a level of 15 feet above the compressor to set up the differential pressure of seal oil above reference gas pressure. The seal oil flow between seal rings on compressor shaft, forming a barrier against the process gas. Most of the seal oil flows outboard, through the outer seal ring (LP) to a sweet drain back to the reservoir. Some of the oil flows inboard, through the inner seal ring (HP), making contact with the process gas. A small amount of process gas mixes with the oil flowing through the inner seal ring. The oil-gas mixture is drained to a trap system. In the traps, the seal oil absorbs a considerable amount of process gas.

This sour oil is routed to a sour oil drain and either reclaimed or disposed of. If the sour oil is reclaimed, it is generally circulated and purged of entrained process gas oil using heaters and/or degassing tanks (Figure-IV). The recovered process gas is typically routed to the flare system. However, in some cases, may route to compressor suction. Some of the injected seal oil flows into the compressor casing and is lost into the process.

Wet seal oil system requires following main auxiliaries:

I. Seal Oil Reservoir tank
II. Seal Oil Over-head tank
III. Seal Oil Primary pump & driver
IV. Seal Oil Booster pump & driver
V. Seal Oil Drain tank (Traps)
VI. Seal Oil Mist Separator
VII. Seal Oil De-Gasifying tank
VIII. Associated Utility & Instrumentation

Figure-IV (Typical Schematic of Compressor Wet Seal System)



Dry gas seal technology is quite interesting. A totally dry seal operates at high speeds and pressures at a relatively small clearance and gas leakage rate. Some gas seal configurations can even operate with zero hydrocarbon gas emissions, which may provide an environmental benefit to us all.

Dry gas seals are gas-lubricated, mechanical, non-contacting, end-face seals, consisting of a rotating ring and a primary ring.

In Dry Seal, injected sealing gas (N2 during start-up/Process gas during operation) flows from the outside diameter of the rotating ring into the rotating ring's grooves. Gas enters the grooves and is compressed because of the volume reduction at the tips, creating area of slightly higher gas pressure. This area developed at the grooves causes separation of the stationary and rotating rings by the desired gap. This gap is very small, typically in the range of 3 to 10 µm. The gas flows from high pressure area to the low pressure side of the seal, creating a controlled seal leakage, and the rings operate on a thin film of gas as a non-contacting seal.

When the compressor is not rotating, the stationary ring in the seal housing is pressed against the rotating ring by springs. When the compressor shaft rotates at high speed, compressed gas has only one pathway to leak down the shaft, and that is between the rotating and stationary rings. This gas is pumped between the rings by grooves in the rotating ring. The opposing force of high-pressure gas pumped between the rings and springs trying to push the rings together creates a very thin gap between the rings through which little gas can leak. While the compressor is operating, the rings are not in contact with each other, and therefore, do not wear or need lubrication. O-rings seal the stationary rings in the seal case.

During operation, gap between the two rings is self-adjusting. Ideally, a dry gas seal operates at a minimum gap to minimize the leakage rate. However, a centrifugal compressor rotor is subject to axial movement during operation, which is restricted by a thrust bearing. If the gap between the stationary

and rotating seal rings increases during operation because of axial rotor movement, the pressure at the rotating ring groove tips will be reduced as the volume increases. The gas forces acting on each side of the stationary and rotating seal rings will force the rings toward each other, thereby restoring the running gap to the desired value. In other words, if the clearance between the seal rings decreases because of axial rotor movement, the pressure at the rotating ring groove tips will increase as the volume decreases, overcoming the gas forces acting on the outside of the two rings, thereby increasing the gap to the desired value. The minimum gas seal leakage resulting from gap between rotating and stationary rings of dry gas seal is trade-off with highest possible gas film stiffness. Very low gap presents increase risk of seal damage. Inboard of the dry gas seal is an inner labyrinth seal, which separates the process gas from the gas seal. A clean and dry sealing gas is injected between the inner labyrinth seal and the gas seal, providing the working fluid for the seal gap. The vast majority of this injected gas flows across the inner labyrinth seal and into the compressor, or process side of the gas seal. A very small amount of the sealing gas, the seal leakage, passes through the primary seal and out the primary vent, which is normally connected to the user's flare system.

Outboard of the dry gas seal is a barrier seal, which separates the gas seal from the compressor shaft bearings. A *separation gas* (typically nitrogen or instrument air) is injected into the barrier seals. Around 50% of the separation gas flows inboard and combines with the seal gas leakage out the vent. The remaining 50% of the separation gas flows outboard, into the bearing chamber. The primary function of the barrier seal is the prevention of lube oil migration into the gas seal.

Dry gas Seal requires seal gas *filtration system* which is normally installed at RGC/WGC platform & much simpler in design.

Main Difference between Wet & Dry Gas Seal Systems:

Both wet and dry gas seals are mechanical seals used to prevent gaseous substances from escaping a pressurized system, each with advantages and disadvantages Typically, a dry gas seal consists of two metal rings that fit together closely and are held together by a spring. The rings within dry gas seals are made up of silicon, tungsten carbide, or another substance. Selection of material of construction (MOC) for dry gas seal rings is very crucial and must have specific precise properties. Conversely, wet gas seals use a liquid film to help prevent leakage, typically delivered by a pressurized system that helps keep the space between the two sealing surfaces lubricated. This reduces wear from friction and acts as a sealant barrier to prevent leaking.

Dry Gas Seal Retrofits:

Many Centrifugal compressors were manufactured before the development of dry gas sealing technology. Most of these compressors are equipped with oil film seals. Existing compressors can be upgraded from their current wet seals to dry gas seals. A dry gas seal retrofit also requires decommissioning and replacement of the existing oil seal system with a new dry gas seal support system in addition to replacing the compressor seals. If it is commercially evaluated & decided that existing compressor seal system to be retrofitted with dry gas seal, detailed technical study to be done before proceeding with the retrofit:

-Gas to be used in dry gas seal: it's pressure, quality & composition.
-Sufficient space for proposed Dry gas seals in compressor.
-Sufficient number of gas seal ports on compressor heads.
Based on above & other required compressor modification, seal upgradation to be considered.

Benefits/Incentives of Dry Gas Seal Over Wet Seal:

S. N.	Comparison	Wet (Oil) Seal	Dry Gas Seal
1.	Seal Oil Cost	Top-up cost, Handling cost, Clean-up cost (if Process Contamination occur)	Eliminated
2.	Process Gas Leakage/Emission	High	Low
3.	Maintenance cost	High	Low
4.	Operating Cost	High	Low
5.	Simplicity	Low (Seal Oil system auxiliaries)	High
6.	Reliability	Low	High

Since dry gas seals don't require pumps and systems to circulate oil, they require, about 5-10 percent of what wet seal systems need. With the highest proportion of a compressor's downtime resulting from issues within their seal systems when utilizing wet seals, the fact that dry gas seals have fewer parts to support makes them more reliable and means the compressor is less likely to experience downtime. Dry gas seals require less maintenance than wet ones because they have fewer moving components, such as control valves, pumps, and relief valves. Dry gas seals don't need a complex support system for circulating oil to components. Wet seals leak oil into process gas, may cause reactor catalyst performance to degrade; dry gas seals prevent this process contamination. Dry gas seals are safer to operate, as high-pressure oil systems aren't needed.

Conclusion:

Through present article, an attempt is made to present the simplified view of seal systems which is vital component of process gas centrifugal compressors. Wet seal is an obsolete system and has inherent limitation. Today more than 90% of newly manufactured centrifugal gas compressors are equipped with dry gas seals. Even, exiting process gas centrifugal compressors are being upgraded from wet seal to dry seal system considering its simplicity, durability, reliability, safety, cost-effectiveness. Interested reader, having further curiosity and keen to know about dry gas seal system may consider references.

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1) *Dry Gas Seal Handbook, First Edition, John S. Stahley.*
2) *CCAC OGMP – Technical Guidance Document Number 3: Centrifugal Compressors with "Wet" (Oil) Seals Modified: April 2017.*
3) *Lessons Learned from Natural Gas STAR Partners, Replacing Wet Seals with Dry Seals in Centrifugal Compressors, EPA.USA- 2003.*
4) *Centrifugal Compressor Wet Seals Seal Oil De-gassing & Control, BGE–An Exelon Company, 2014 Natural Gas STAR, May-2014*

Laboratory Investigation for Flow Assurance in Wells of Western Onshore Field: Mitigating Organic Formation Damage

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Abstract

Problems associated with asphaltene and paraffin deposition have been identified in petroleum literature for large part of last century. These deposition can significantly reduce well productivity and profitability, causing operational issues, damaging formations, and decreasing production. Heavy oil producers in Western Onshore Oilfields of ONGC encounter frequent flow assurance issues. Highly waxy nature of crude oil in this region further aggravates the issues in winters. Asphaltene precipitation and deposition in reservoir results in organic formation damage in near wellbore region. This often occurs as a result of pressure depletion during the course of production lifecycle. This leads to wettability alteration and permeability impairment in the reservoir resulting in poor influx and productivity decline. Laboratory studies have been carried out to ascertain the crude oil parameters for representative surface crude oil samples from two candidate wells in the field. Various crude stability indicators relying on compositional analysis of crude oil indicated asphaltene precipitation tendency in both oils. Wells in the region are producing with high drawdown (>100 kg/cm^2) which is a strong indicator of formation damage. Originally water-wet fines show alteration in wettability due to asphaltene deposition in reservoir pore throats. Wax deposition tendency was also established in both surface crude samples. Wax content in dosed surface sample was found to be ~14%, whereas its un-dosed counterpart exhibited only 8.8% wax content in lab studies illustrating the efficacy of current PPD dosing formulation. Suitable remedial strategies for mitigation of asphaltene deposition in the near wellbore region of candidate wells have been designed. Multiple formulations with varying organic solvent compositions were tested with the crude samples at both ambient and reservoir temperatures. Aromatic solvent based formulation is recommended to address organic formation damage along with 10% EGMBE for restoring wettability. PPD dosage was optimized via Pour point

and rheological assessment. Given the lowest temperatures in summer (April-October) lie in the range of 28-30 ºC in the region, dosage of 1000ppm PPD may suffice the flow assurance requirements instead of the currently practiced 3000ppm. Reduced PPD dosing in summer can lead to an estimated annual chemical reduction of ~4060 kg PPD. This translates to estimated annual cost savings of nearly 8 lacs.

Keywords: Productivity decline, Formation damage, Permeability Impairment, Asphaltene, PPD dose optimization.

Introduction

Asphaltenes are very intriguing molecules for both academia and the oil industry. They have been studied for decades and there are still many research projects ongoing to determine their structures and behaviour and bring new insights and knowledge to flow assurance management. Fully understanding the behaviour of asphaltenes is challenging due to their complexity. Petroleum industry has been plagued with organic formation damage problem arising from Asphaltene precipitation and deposition for decades, with wettability alteration and permeability impairment being the most devastating effects to occur simultaneously. Asphaltene precipitation and deposition in the reservoir can significantly affect productivity. The implication of the asphaltene problem results from the adsorption of asphaltene on the pore surface and the blockage of the flow path due to precipitation of asphaltene. This results in permeability reductions and alteration of the wetting state of the rock. (Mohammed et al). Models have been developed to simulate formation damage due to precipitation and multiple factors have been narrowed down signalling their effect on this thermodynamic phenomenon. Asphaltene precipitation is reported to be a function of pressure, temperature, live crude oil composition, and, to a lesser extent, oil/water interactions. Asphaltenes possess a tendency to precipitate as the pressure is reduced, especially near the bubble point. In cases where reduction of pressure occurs inside the reservoir, for example near the wellbore, it may result in asphaltene precipitation within the effective pore space. This may lead to an increase in skin and, subsequently, more precipitation and deposition. Ultimately, this often results in the reduction of oil rates and leads to the death of well.

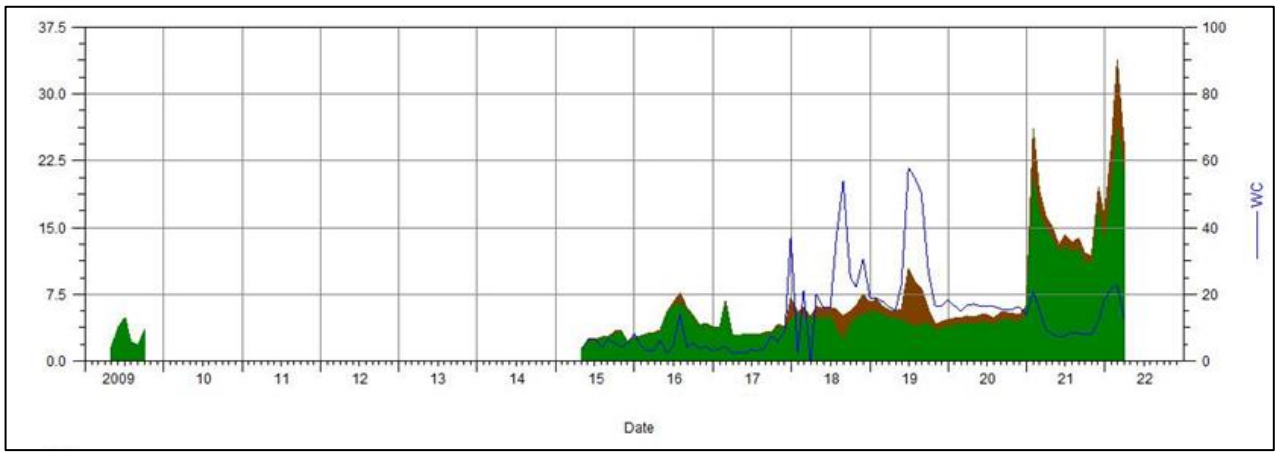
Field & Reservoir Description

The field chosen for this study falls under Cambay Asset of ONGC which was put on production in May 2015. The field has 2 major hydrocarbon bearing sands, with Oil Initially In Place (OIIP) valued at 2.8225 & 1.1125 MMT with envisaged Recovery Factor (RF) of 2.7% and 10% respectively. Of the 10 wells drilled in the chosen field, 07 wells are on production, producing 150 m^3/d of liquid with average water cut of 7%. Wells in the area are currently producing with very high drawdown.

Figure 1.0 depicts the Production Performance of Cambay Asset since the discovery in May 2009 and commencement of production operations in May 2015. GOR lies in the range of 300-350 v/v.

Status of the 10 wells drilled in this field as of Nov-2022 is as follows: 07 flowing wells and 03 non-flowing. Presently the field is producing 180 m^3/day of liquid and 157 m^3/day of oil.

Figure 1.0. Production Performance of Cambay Asset



The status of reserves in Nadiad field as on 01.04.2022 with sand wise distribution is placed in Table 1.0 as under. Young Cambay Shale, i.e. YCS and Chhatral pays are the identified pays in the field.

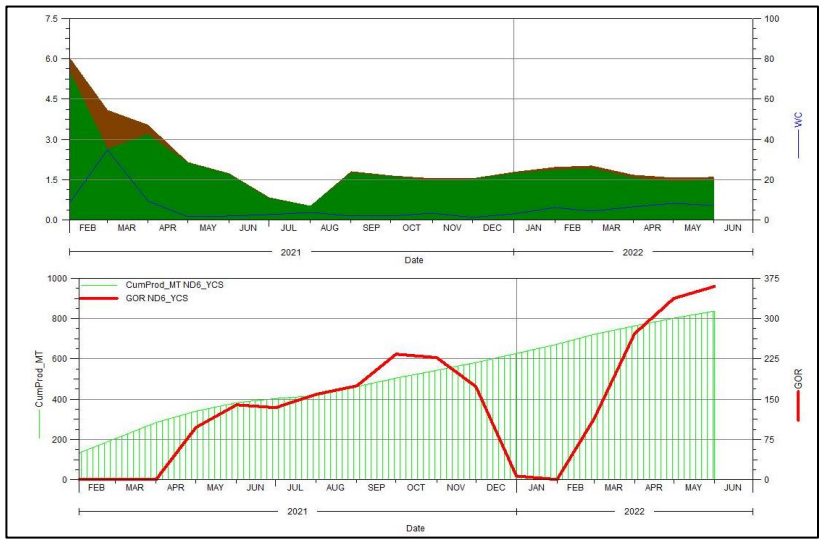
Table 1.0. Reserves Status of Cambay Asset

Sand	OIIP	RF	EUR	Np (As on 01.04. 2022)	Reserves	R/P	Current oil Recovery	Envisaged Oil Recovery due to addnl. inputs
	(MMt)	(%)	(MMt)	(MMt)	(MMt)	(Years)	(%)	(%)
Sand-1	2.8225	2.7	0.0754	0.0083	0.0294	22.8	0.3	1.5 (RFDP)
Sand-2	1.1125	10	0.112	0.0045	0.1067	32.9	0.4	7.6 (RFDP)
Total	3.9350	4.75	0.1867	0.0128	0.1362	30	0.3	2.6 (RFDP)

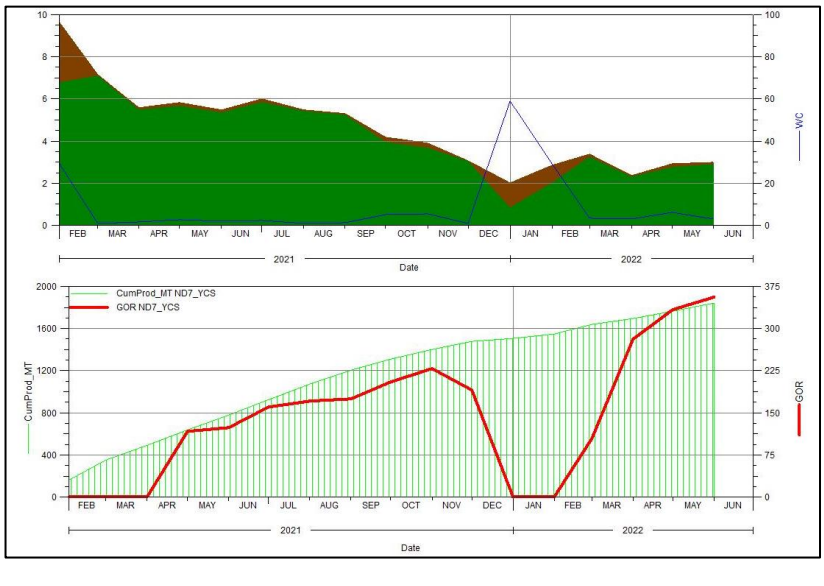
Candidate wells selection

Based on the production performance, 02 nos. of candidate wells viz. A and B were identified to ascertain possible causes of flow hindrance and thereafter suggest suitable stimulation strategies for production enhancement. The liquid and oil production history of the identified wells is given in figure 2.0.

Figure 2.0. Production performance of identified wells A and B.



A



B

Other major details of candidate well details are placed in table 2.0.

Parameter	A	B
Pay Zone	Sand-1	
Mode	SRP	
Average Permeability (mD)	3-9	
Reservoir Pressure (kg/cm^2)	195	
Reservoir Temperature (^{o} C)	100ºC	
Perforation Interval (m)	1460-1465.5	1594-1599 m
Q_L (BLPD)	18.9	18.5
Q_O (BOPD)	17.9	18.3
GOR (v/v)	300-350	

Crude Oil Analysis

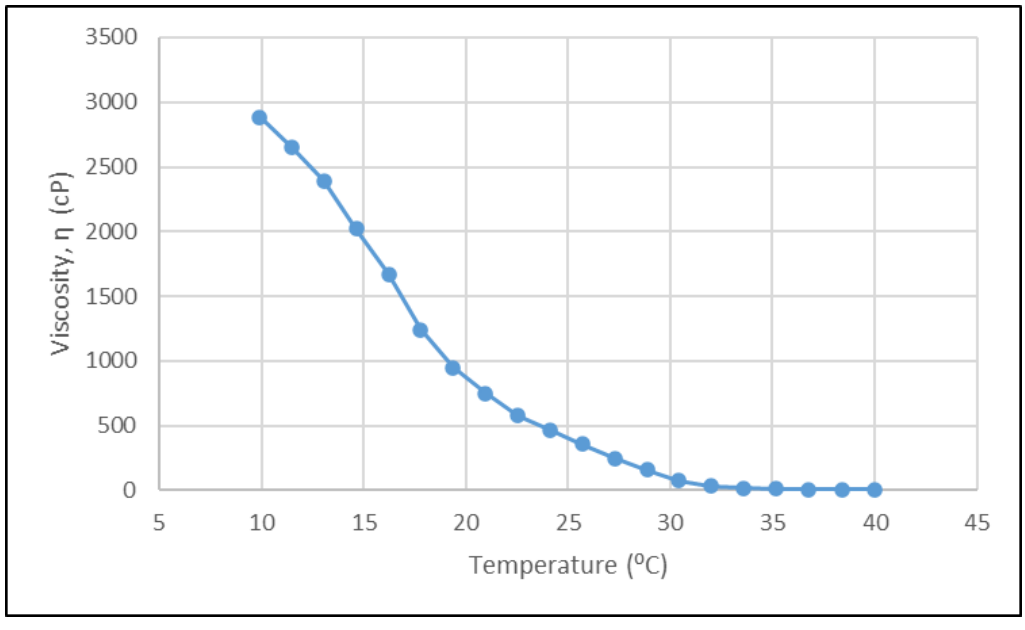
Representative crude oil samples were Crude oil samples pertaining to wells A and B were received. Various laboratory studies viz. SARA analysis, pour point, water content, BS&W, wax content estimation and rheological studies were carried for determination of different oil parameters for crude oil analysis of samples received from well nos. A and B. The corresponding results have been tabulated below.

Table 3.0. Dehydrated oil parameters for crude oil of A and B

	Test name	Undosed Crude Oil	Crude Oil Dosed with 3000 ppm PPD
1.	Specific gravity (15ºC)	0.8112	
2.	API	42.93	
3.	Free water	Traces	Traces
4.	BS&W	Trace sediments	Trace sediments
5.	Water content (%)	Traces	Traces
6.	Pour Point (ºC)	27	15
7.	Wax (%w/w)	8.8	14.1
8.	Saturates (% w/w)	80.60	
9.	Aromatics (%w/w)	13.82	
10.	Resin (%w/w)	5.32	
11.	Asphaltenes (% w/w)	0.25	
12.	WAT	Not available	24

Rheological study on undosed surface crude oil sample of well B was carried out with inflexion points recorded in the range of 27-30ºC at atmospheric pressure conditions marking steep increase in η viscosity at lower temperatures. The viscosity variation with temperature was recorded at shear rate of 10/s and the data has been plotted as under.

Figure 3.0. Rheological profile of Undosed B crude oil

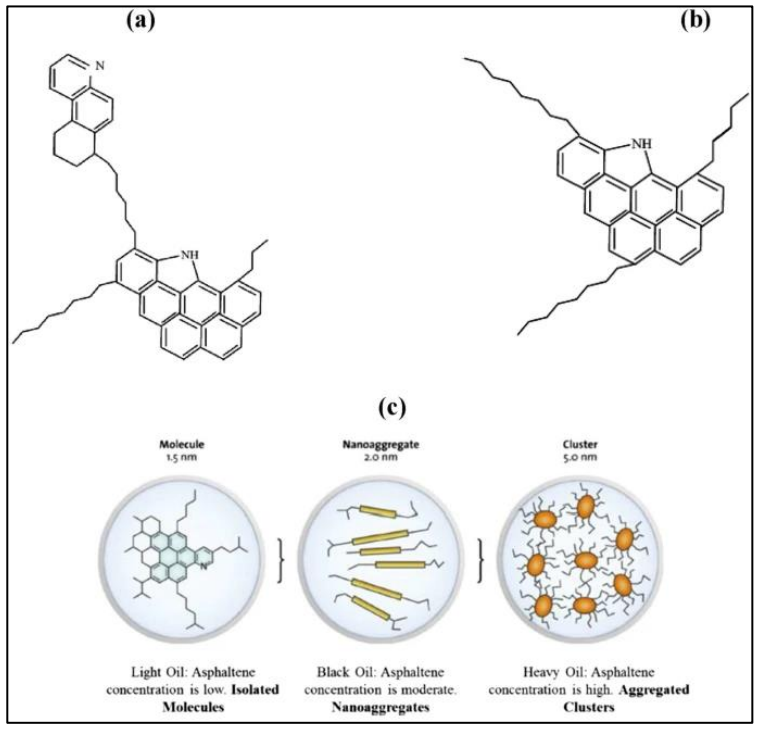


The viscosity variation with temperature shows that the inflexion point is around 30ºC for undosed crude oil.

Establishing Asphaltene Precipitation and Deposition

Asphaltenes are a solubility class typically defined as the heptane-insoluble, toluene-soluble fraction of petroleum. Asphaltenes possess a high degree of polynuclear aromatic rings that have alkyl side chains and incorporate heteroatoms (such as O, N and S). The heteroatomic polar functional groups confer a limited molecular solubility of asphaltenes in hydrocarbon solvents that are partially or fully aliphatic. In organic solvents, asphaltenes associate to form discoidal aggregates 3-15 nm in diameter. In petroleum, these aggregates are solvated by resins. Oxygen and nitrogen functional groups are likely the major cause of the interfacial activity of asphaltenes. These polar moieties, along with p-bonding among aromatic moieties, are also probably responsible for the aggregation of asphaltenes (Amiri et al).

Figure 4.0. (a) Archipelago asphaltene structure, (b) Continental asphaltene structure, and (c) Yen–Mullins asphaltene model.



With respect to structural architecture, asphaltene does not have a definite structure. Continental, archipelago, and Yen–Mullins models are some of the most accepted structural models of asphaltene. According to Figure 4.0, the archipelago model possesses several aromatic rings joined together through various aliphatic branches. According to several researchers, there are four governing factors which play a vital role in the precipitation of

asphaltene from crude oil. These include the changes in oil composition, variation in temperature and pressure, and electrokinetic effect (Gharbi et al. 2017). Though, alterations in oil composition occur through depressurization process and blending of oils; however, during production of hydrocarbon, the changes in pressure is considered to be the foremost factors among all other affecting factors. The deposition problem could cause emergence of numerous challenges to operators in the form of pore throats clogging in reservoir, wettability alteration of reservoir rock from water wet to oil wet, increase in the oil viscosity, wells, downhole and surface equipment and facilities choking or blocking; thus, causing net hydrocarbon recovery reduction and requirement of the deployment of expensive treatment methods for mitigation. These treatment techniques may include chemical, mechanical, thermal, biological, and ultrasonic methods. Among all these mentioned methods, mechanical and chemical approaches are mostly employed.

There are various prevention strategies that were reported over the years. Among all of them, SARA based relationships models (Saturates, Aromatics, Resins, Asphaltenes) are quite popular and common. These relationships are developed based on the fact that crude oil is characterized on the basis of SARA fractions and each fraction affects the asphaltene stability in crude oil (Ali et al. 2021). Resins and aromatics promote asphaltene stability in oils, thus ceasing asphaltene precipitation. Aromatics dissolve asphaltene molecules, while resins are polar components which interact with asphaltene molecules to provide shielding effect against other asphaltene molecules preventing their flocculation. Alternatively, saturates and asphaltenes components in crude oil favor asphaltene precipitation mechanism. The resins are miscible in saturates thus high saturate contents dissolve more resins letting asphaltene molecules free to combine and deposit (Mansoori 2010).

In order to investigate whether the Laboratory studies were conducted to provide experimental data so as to infer the petroleum (SARA) fractions in obtained crude oil. Different SARA based asphaltene stability predicting models including Resin- Asphaltene ratio, Colloidal Instability Index, Colloidal Stability Index and Refractive Index indicated in literature have been used in this study.

Colloidal Stability Index (CSI)

CSI index was proposed on the concept that the asphaltene present in unstable crude oils are likely to be more polar than those contained by stable oils. CSI can be computed by using Eq. (Mohammed et al. 2021; Guzmán et al. 2017).

Figure 5.0. Empirical formula for colloidal stability index.

$$CSI = \frac{(\varepsilon^{asph})\,(Asphaltenes\ in\ wt\%) + (\varepsilon^{sat})\,(Saturates\ in\ wt\%)}{(\varepsilon^{res})\,(Resins\ in\ wt\%) + (\varepsilon^{arom})\,(Aromatics\ in\ wt\%)}$$

where (ε) represents a dielectric constant and its values for SARA components for stable and unstable oils are following (Hascakir 2017)

Table 4.0. Dielectric constant values of SARA components for stable and unstable oils.

	Unstable Crude	Stable Crude
ε_{asph}	18.4	5.5
ε_{res}	3.8	4.7
ε_{sat}	1.921	
ε_{arom}	2.379	

Table 5.0. Colloidal Stability Index (CSI) criteria for predicting Asphaltene stability.

CSI	Asphaltene stability
<0.95	Stable
>0.95	Unstable

If CSI comes greater than 0.95, then oil is considered as unstable else it is categorized as stable.

Table 6.0. Asphaltene stability in B as per Resin- Asphaltene ratio, Colloidal Instability Index & Refractive Index criteria

Well No.	Res/Asp	CII	CSI	ΔRI	Asphaltene Precipitation Potential		
B	21.3	4.22	3.00	0.024		✓	

It can be conclusively inferred that crude oil of the well completed in Sand-1 pay of the field possess asphaltene precipitation potential on the basis of colloidal instability index, colloidal stability index and refractive index criteria (Refer Table 6.0).

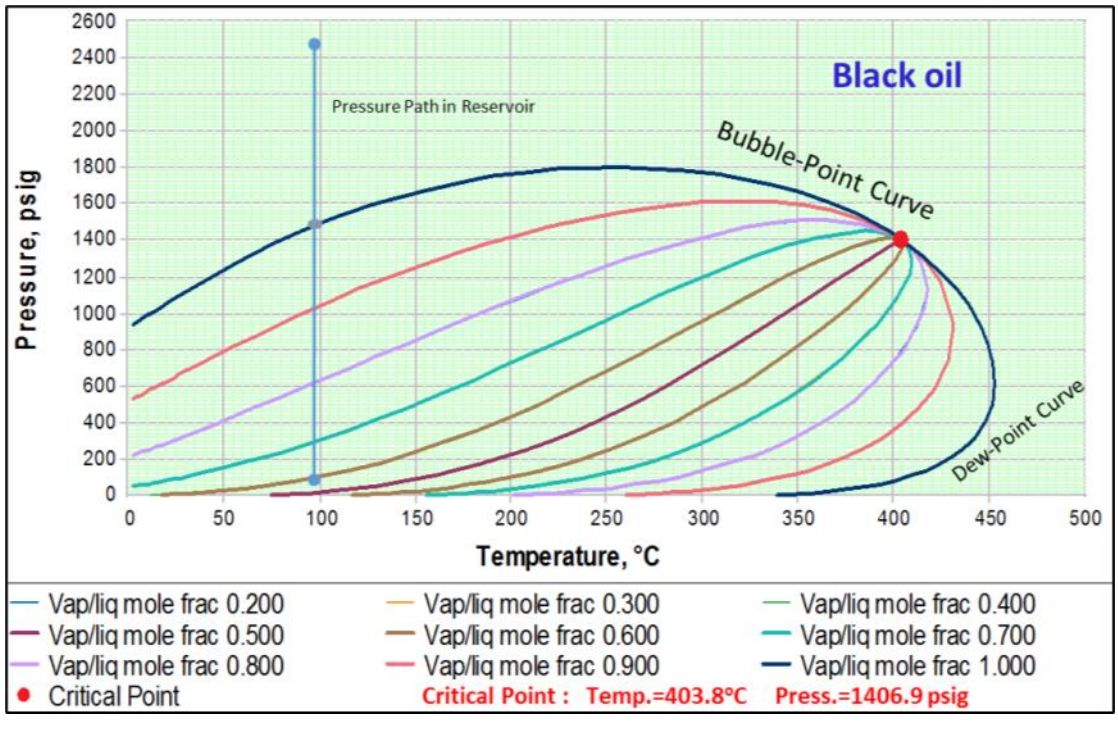
Both of the candidate wells are likely to have organic formation damage arising from asphaltene precipitation and deposition in the near wellbore region. Therefore, both wells have potential for skin reduction on account of organic deposits in near wellbore.

Validation of Asphaltene Deposition Phenomenon

Reservoir pressure for Sand-1 has been recorded to be 195 kg/cm^2 via build-up study. Latest Flowing Bottom Hole Survey (BHS) data showed the pressure survey for B well (dated 07.12.2021). At well depth of 1575m (perforation interval 1594-1595m), flowing pressure was recorded to be 82.13 kg/cm^2 at reservoir temperature (102.5^{o}C).

Only 0.4% of hydrocarbons in Sand-1 have been recovered so far, hence any significant pressure drop reflecting in production decline from reservoir is not envisaged. Therefore the wells in the region are producing with high drawdown (>100 kg/cm^2) and indicate formation damage in the near wellbore region. Laboratory studies indicate towards organic formation damage arising from asphaltene precipitation and deposition.

Figure 6.0. Phase diagram of Reservoir Fluid.



Wang and Civan (2005) emphasized that the maximum asphaltene precipitation and the lowest solubility conditions occur when the bubble point is reached and the reverse conditions are observed as the pressure declines to below or increases to above the bubble-point pressure.

Bubble point pressure (Pb) for Reservoir Fluid for well completed in Sand-1 in same fieldis reported to be 104.51 kg/cm^2 (1486.5 psig) at reservoir temperature (98.8 ^{o}C). This data sets forth the likelihood of asphaltene deposition in wells currently producing with high drawdown in the field.

Production gains can be envisaged from reduction in skin developed in wells as a consequence of organic formation damage arising from Asphaltene deposition. Therefore suitable stimulation strategy to remediate organic formation damage can provide encouraging results in both wells.

Phase diagram of Reservoir Fluid for well completed in Sand-1 of Cambay Asset is placed in figure 6.0.

Reversal in Wettability

Wettability alteration has been largely attributed to changes in the pore system (adsorption), which may be due to rock–fluid interaction, fluid–fluid interactions, rock mineralogy, and brine chemistry. At the reservoir scale, a reservoir can be compartmentalized due to asphaltene, while at the pore scale asphaltene can create barriers to flow, change relative permeability and wettability of the rock, and, consequently, impact ultimate recovery. Asphaltenes mostly precipitate on rock surfaces non-uniformly, depending on the pore shape, surface roughness, and mineralogy. These may lead to either complete or partial changes in the wettability of the rock. The wettability of a reservoir is a result of a strong interfacial boundary condition that exists within the rock system which makes a fluid preferentially mobile in the presence of other fluids. Thus, it is predominantly due to the adherence or coating of the pore structure with a fluid that is either hydrophobic or hydrophilic.

Asphaltene adsorbs on the pore surface, coating the surface and changing the wettability due to electrochemical interactions. Polar components in crude oil are said to be the most susceptible to adsorption. It has been reported that the rate of adsorption by the polar compounds is linearly related to the wettability alteration.

Flocculated asphaltene behave as cationic surfactants. Positive charge of asphaltenes facilitates their penetration of connate water to attach to the negatively charged water-wet mineral surfaces and thereby convert the rock surfaces from water-wet to oil-wet. When the asphaltenes precipitate and deposit in the reservoirs, they lead to alteration of rock surface wettability and thus lower the relative oil permeability (Mohammed et al. 2021).

Paraffin Deposition Tendency

Waxes are a mixture of linear, branched, and cyclic aliphatic hydrocarbons isolated from petroleum. Most crude oils contain 1-30 wt % high-molecular-weight paraffin and microcrystalline waxes, which, at low temperatures, precipitate as a component in organic deposits.

The crystallization of wax occurs when the flowing fluid's temperature is less than or equal to the cloud point temperature or wax appearance temperature (WAT). In contrast, deposition is a term used to describe the formation and growth of a layer of the precipitated wax crystal on a surface. The main mechanisms responsible for wax precipitation include nucleation, growth and agglomeration. These processes usually occur individually or concurrently, with one stage always being predominant at a time. During the later process, the interlock of wax crystals causes strong network formation in the system (Yang et al., 2015).

Based on the 04 major oil components e.g., Saturates, Aromatics, Resin, Asphaltene, wax deposition index (WDI) was calculated to establish the waxy nature of crude and the degree of waxiness in the crude sample.

The expression for WDI and criteria for degree of waxiness is given in figure 7.0.

Figure 7.0. WDI and criterion of waxy crude oil.

$$WDI = \frac{(S + 0.95As)}{(0.18r + Ar)}$$

WDI > 1 Waxy Crude
WDI < 1 Non Waxy Crude

The table 7.0 below summarizes the WDI based on the crude oil composition. WDI depends upon the composition of basic components of crude e.g., Saturates, Aromatic, Asphaltene and Resin. It indicates that, an oil sample with lower wax may have higher WDI with in comparison with crude sample having higher wax content. In this study, it is found that all the crude samples having high degree of waxiness and may pose problem related to wax deposition.

Table 7.0. Wax content and WDI for crude oil of B

Well No.	Wax Content (%)	WDI	Wax Deposition Possibility
B	14.1	5.47	✓

Wax content and WDI has indicated that crude oil of B possesses potential for wax deposition on encountering lower temperatures at shallower depths. This is also substantiated by wax deposits found in upper parts of production tubing.

Laboratory studies

Laboratory studies were designed to identify suitable remedial strategies for asphaltene deposition, water wettability restoration and investigation for further optimization of PPD dosing. Organic solvent job would be the suitable stimulation treatment to address the formation damage due to asphaltene precipitation. EGMBE has been added for conversion of oil-wet formation to water-wet for increased oil permeability.

Methodology adopted:

- ✓ *Solubility studies for Design and Optimization of Organic Solvent Formulation for Organic Deposition Remediation*
- ✓ *Water wettability restoration agent*
- ✓ *PPD Dosage Optimization Studies*

Design of Organic Solvent Formulation for Organic Deposition Remediation

Chemical methods for asphaltene remediation are one of the most widely used approaches. Conventional benzene, toluene and xylene (BTX) solvents have been successfully applied for remediation of asphaltene problems during crude oil production and processing (Elochukwu et al).

Along these lines, solubility studies were carried out to determine the most appropriate combination of organic solvent compatible with the crude oil of the field.

Crude extract of crude oil samples received from B was prepared to mimic the heavy organic deposits for the concerned wells. The solubility of extract was measured with various solvent formulation for 4 hours at ambient temperatures (26ºC) and higher wellbore temperatures (70ºC). The detailed results are displayed in table 8 below.

Table 8.0. Results of Solubility studies with various solvent formulations on crude extract of B

Solvent system	B	
	70ºC	26ºC
50% Diesel + 25% Toluene + 25% Xylene	89	82
50% Diesel + 30% Toluene + 20% Xylene	90	83
40% Diesel + 30% Toluene + 30% Xylene	92	85
60% Diesel + 20% Toluene + 20% Xylene	89	82
100% Xylene	92	86
100% Toluene	94	87
45% Diesel + 25% Toluene + 25% Xylene + 5% NMP	86	82
40% Diesel + 20% Toluene + 20% Xylene + 10% NMP	88	86
95% Diesel + 5% NMP	79	No visible solubility*
90% Diesel + 10% NMP	82	No visible solubility*

Different formulation consisting of xylene, toluene, diesel and NMP (N-Methyl-2-pyrrolidone) were formulated and tested for solubility of representative crude extract samples of B. Conventional aromatic solvent based formulation containing 20% Toluene + 20% Xylene in Diesel has shown remarkable solubility for crude extract at both temperatures.

*: Crude extract sample was found to be majorly undissolved after observation period and could not pass through the filter paper during filtration stage;

Mutual Solvent for Water wettability reversal

The objective of adding another chemical is to alter the wettability of rocks from oil-wetting (as a result of asphaltene deposition on formation) to water-wetting using a suitable chemical agent. This is expected to increase the water relative permeability & reduce the residual oil saturation of formation and leading to increase in the productivity of identified wells. The most important surfactant characteristics required for a successful treatment are as follows:

- ✓ *Strong interaction between the water wettability restoration agent and minerals on the rock surface. This is necessary for durability of the treatment.*
- ✓ *The chemicals should provide both water and oil repellency to make rock surfaces water-wetting.*
- ✓ *Chemicals should not cause formation damage resulting from undesired reactions, precipitation, emulsions, plugging, or other adverse phenomena.*
- ✓ *Chemicals should be soluble in a non-aqueous solvent, preferably an organic solvent.*

Addition of wettability restoration agent in the suggested solvent job design was proposed to achieve following targets:

- ✓ *Conversion of oil-wet formation to water-wet for increased oil permeability*
- ✓ *Effective destabilization of in situ emulsion*

Ethylene glycol monobutyl ether (EGMBE) has been adopted as a suitable solution on the basis of literature survey and previous IOGPT reports. EGMBE has been reported as a mutual solvent which offers broad-spectrum effectiveness in attaining water wettability in sandstone reservoirs. EGMBE is also reported as an effective water-wetting agent and a good solvent for many oil-wetting materials.

Current Wax Mitigation Strategy

The asset currently relies on various strategies for organic deposit remediation and mitigation such as hot oil circulation, scrapping and annulus dosing/ bottom hole dosing in few wells.
The field is dosing Pour Point Depressant (PPD) to the tune of 3000 ppm daily in 4 of its producing wells. The detailed dosing strategy is placed in Table 9.0.

Table 9.0. Currently dosed PPD Formulation in the field

S.No.	Well No.	Dose of PPD (kg)	70% "HaLaLp" Crude oil (L)	30% Xylene (L)	Total volume (L)	Total volume (L) /day
1	C	10	43.30	18.56	61.86	75
2	A	5	20.88	8.95	29.83	40
3	B	9	40.52	17.37	57.89	75
4	D	5	19.81	8.49	28.30	45

"HaLaLp" Crude oil (High Aromatic, Low Asphaltene and Light Paraffinic)

Deposit sample analysis

A deposit sample collected from well head during cleaning of bean/choke was also sent along with the crude oil for laboratory investigation. The sample was analyzed to ascertain the organic and inorganic components, which were recorded as follows:

Inorganic content	:	61%
Organic content	:	39%

The high amount of sandy/silty nature is indicative of sand incursion. However, field experience has confirmed that the wells are facing no issue pertaining to sand control/ production.

Efficacy of Current Wax Mitigation Strategy

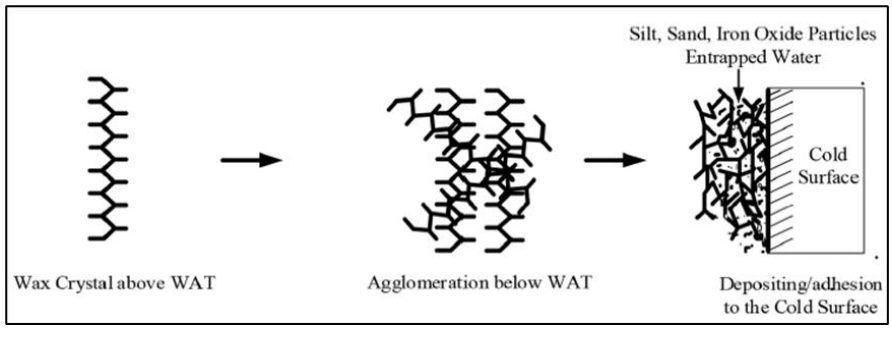
The field is dosing ~3000 ppm of Pour Point Depressant (PPD) daily in 4 wells. Wax deposition index indicates high wax deposition tendency in crude oil sample. Wax content in dosed surface sample was found to be ~14%, whereas its un-dosed counterpart exhibited only 8.8% wax content in lab studies illustrating the efficacy of current PPD dosing formulation.

Table 10.0. Results of Solubility studies.

Well No.	Wax Content (%)
B (Dosed)	14.1
B (Undosed)	8.8

Undosed crude showed lower wax content which is indicative of the precipitation and deposition of paraffins/ saturates as they encounter lower temperatures; the reported value is estimated to be a conservative figure as some paraffins might have precipitated out of solution phase on experiencing lower temperatures.

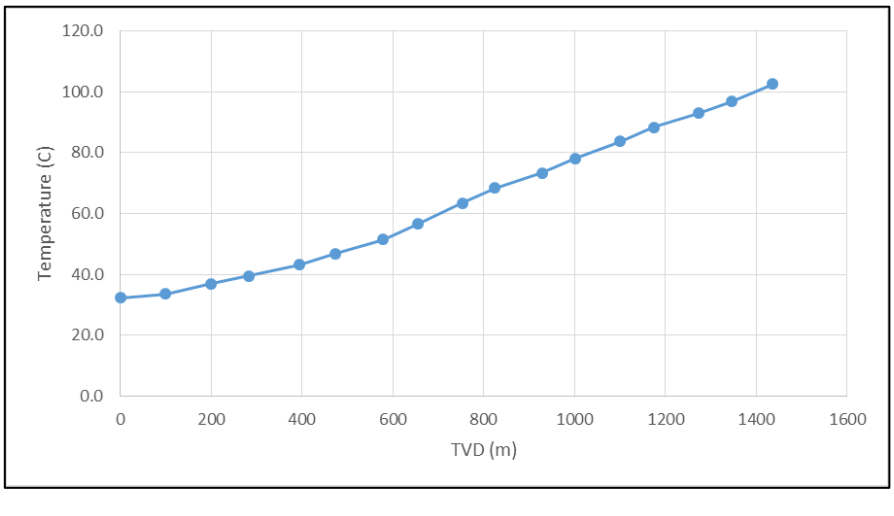
Figure 8.0. Interaction mechanisms with wax crystals



Looking at the thermal profile of well B (refer figure 9.0) as per the data supplemented via latest flowing bottomhole gradient survey (December 2021), well head temperature is recorded at 32.3ºC.

Comparing the registered pour point data of undosed crude oil (27ºC) vis-à-vis its dosed counterpart (15ºC), wax deposition is not envisaged at current operating conditions based on temperature profile of B.

Figure 9.0. Thermal profile of well B



Current PPD dosing is highly effective in effective reduction in Wax Appearance Temperature and Pour Point resulting in aversion of paraffin deposition at shallower well depths. However, the presence of organic deposits during cleaning of choke indicates that other factors might be responsible for the deposition such as;

i. Sand particles may act as nucleating sites for wax deposition facilitating deposition in upper parts of tubing and choke
ii. A higher fraction of flocculated asphaltenes provides active sites for wax crystallization.

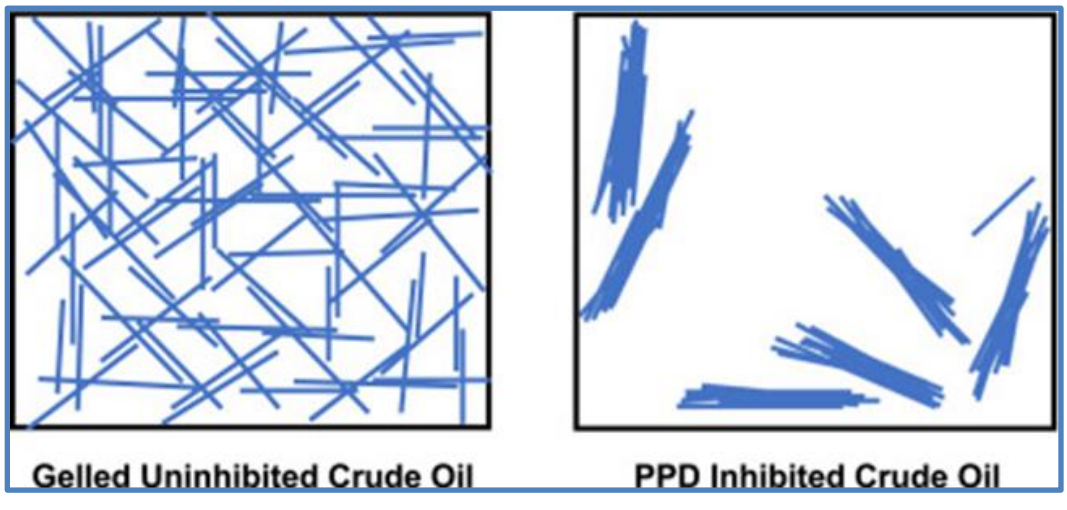
Mechanism of PPD functioning

Pour point depressants are high molecular weight polymers which primarily function by inhibiting the formation of a wax crystal structure that would prevent oil flow at low temperatures. In field applications, two general types of pour point depressants are used.

(i) Alkylaromatic polymers adsorb on the wax crystals as they form, preventing them from growing and adhering to each other.
(ii) Polymethacrylates co-crystallize with wax to prevent crystal growth.

The additives do not entirely prevent wax crystal growth, but rather lower the temperature at which a rigid structure is formed.

Figure 11.0. PPD alteration of wax crystal network lattices



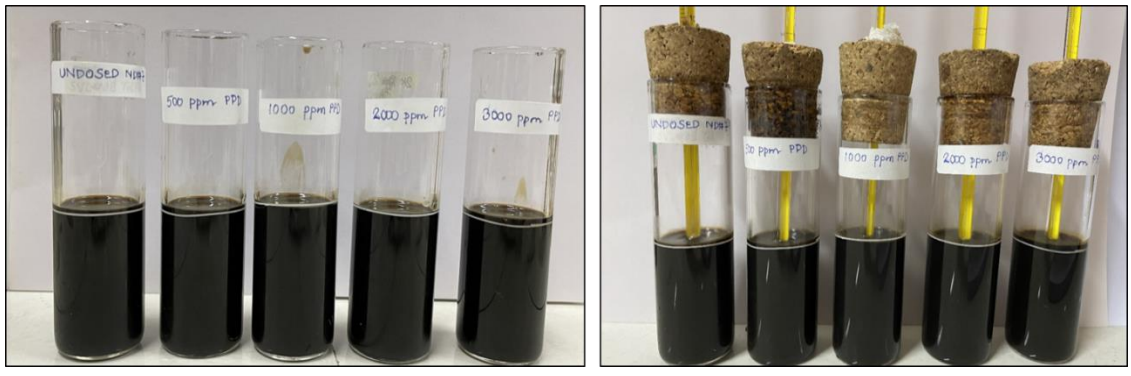
The mechanism by which most PPDs function is by incorporating into the newly forming wax network thereby causing a reduction in network branching and growth. A weakened network structure of paraffins also occurs from the incorporation of the PPD. This renders the network more easily broken by shear forces. Both these effects synergistically lead to improved flow properties with reduced viscosity and reduced pour point (gelation temperature). And even if gelation occurs, the yield strength of the gel is weakened.

PPD Dosage Optimization Studies

Various doses of PPD-1 were investigated to explore further opportunities in current PPD dosing strategy. Investigation comprised of recording of inflexion points in viscosity profiling via rheological studies on Anton Paar rheometer at constant shear rates.

The inhibition performance improvement is indicated by the decrease of viscosity and delay in inflexion points (indicative of delay in wax appearance temperature and pour point in dosed samples).

Figure 12.0. PPD dose optimization studies.



PPD-1 was dosed in surface crude oil samples of B at various concentration varying from zero ppm (control sample) to 3000ppm.

Depression in Pour point

The oil is doped with PPD at four different concentrations (500, 1000, 2000 and 3000 ppm) and each dosed oil was screened by measuring the efficacy to delay Pour Point. Results were recorded by adopting the ASTM D97 and have been tabulated as under. According to ASTM D-97, the actual pour point is 3ºC higher than the reading observed. So 3ºC is added to the thermometer reading as the Pour Point of the sample.

Pour point for control sample and 500 ppm dosed were observed at 27ºC. Depression in pour point by 6ºC was observed at doping concentration of 1000 ppm wherein pour point of 21ºC was recorded. It further dropped to 12ºC at 2000 ppm PPD dosing. No further delay in pour point was observed on increasing the concentration of PPD to 3000 ppm.

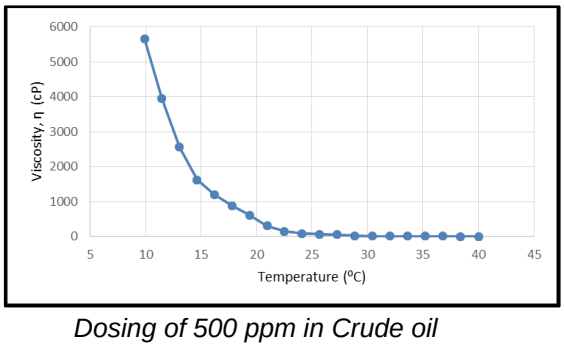
Table 14.0. Pour points recorded in incremental PPD dosing

S. No.	PPD (ppm)	Pour point (ºC)
1.	0	27
2.	500	27
3.	1000	21
4.	2000	12
5.	3000	12

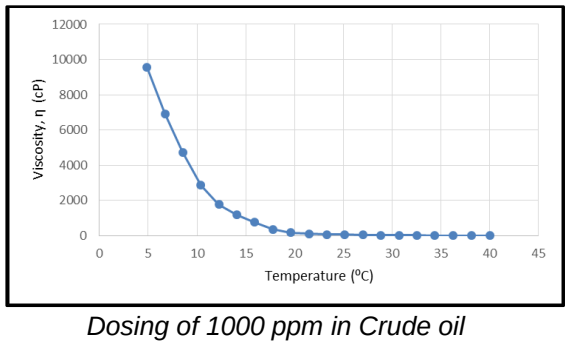
Reduction in viscosity

The rheological study was performed using Anton Paar shear controlled Rheometer to measure the crude oil viscosity. Initially, the oil sample is heated above the estimated wax crystallization temperature (~50ºC) to eliminate the entire non-Newtonian characteristic.

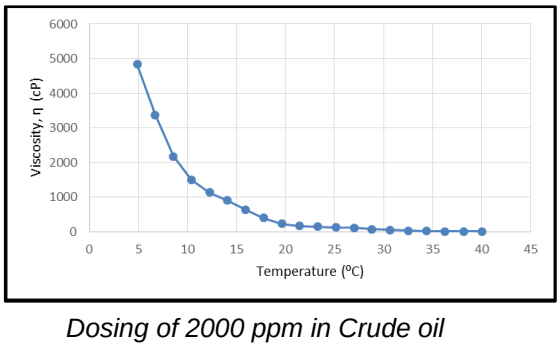
Figure 13.0. Analysis of Crude Oil Rheological Properties



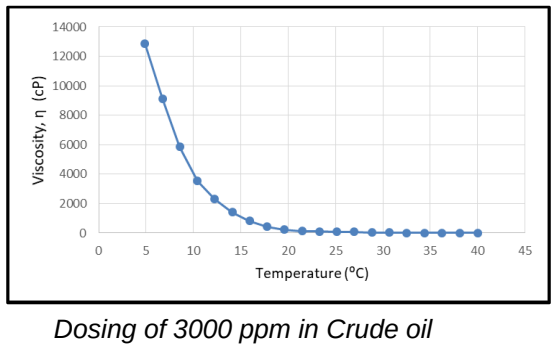
Dosing of 500 ppm in Crude oil



Dosing of 1000 ppm in Crude oil



Dosing of 2000 ppm in Crude oil



Dosing of 3000 ppm in Crude oil

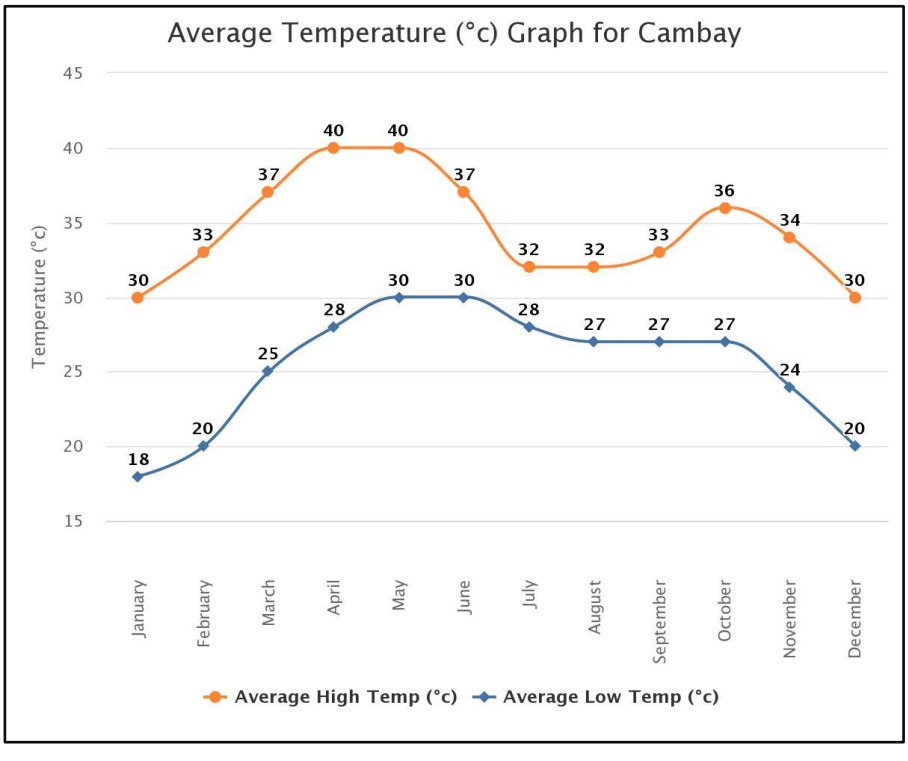
Figure 13.0 shows that the oil viscosity increases as a result of the precipitated crystals in the bulk fluid due to the drop in temperature the fluid flow gradually changes from Newtonian to non-Newtonian behaviour. This implies that the crude oils exhibit non-Newtonian behaviour as the temperature continues to drops close to its pour point. Effect of PPD on crude oil rheological properties corroborates the results of section 6.6.1 as the performance of the PPD reduces as its concentration decreases.

Comparing the results against control (refer figure 3.0), viscosity in doped oil shows inflexion points only below 25ºC, whereas in un-doped counterpart, the inflexion point is around 30ºC. The inflexion points shift further below 20ºC as the concentration of PPD is increased.

Economics of Dosage Reduction

Average surface temperatures for Cambay Region were ascertained using digital resources. Figure 12.0 shows the annual temperature profile of Cambay region.

Figure 14.0. Annual temperature profile of Cambay



The average surface temperatures in the region can be clubbed as per 2 weathers accommodating the range of thermal variation. Lowest temperatures in summer (April-October) lie in the range 28-30 ºC whereas lowest temperatures in winter (November-March) oscillate around 18-20 ºC.

Based on laboratory studies, temperatures in summer provide an opportunity for reduction of PPD dosing in summer from the current parameters of 3000ppm to 1000 ppm.

Given that the cost of PPD/MT as per latest procurement details available with asset is 1.97 lacs and 29 kg/day PPD is consumed daily as per data received from the surface chemistry team; reduced PPD dosing in summer can lead to an estimated annual chemical reduction of ~4060 kg PPD. This translates to estimated annual cost savings ~8 lacs

Designing of formulation

Based on reservoir properties & production performance, candidate wells viz. A and B were identified for treatment by the asset. BTX (benzene, toluene and xylene) based solvent job is recommended with soaking time of 4-6 hours before flow back. Suggested formulation is given as below:

Solvent Formulation: 49% Diesel + 20% Xylene +20% Toluene +10% EGMBE + 1% Surfactant

Conclusion

On the basis of literature survey and crude oil analysis of representative crude oil samples of A and B, following factors have been found to be major causes for flow hindrance in selected wells of Nadiad field, Cambay Asset:

- ✓ *Asphaltene: Precipitation & Deposition*
- ✓ *Wax deposition tendency*

Multiple formulations with varying organic solvent compositions were tested with the crude samples at reservoir and ambient temperature conditions. 20 % Toluene + 20% Xylene based organic solvent formulation job is recommended to address formation damage due to asphaltene precipitation along with EGMBE for restoring wettability.

Pour point was optimized with varying dosage of PPD-1used in field. Optimization studies were carried out with concentration ranging from zero (0) ppm to 3000 ppm (currently used in field). Efficacy of the system was measured on two parameters; viz Pour point depression and viscosity reduction. Based on average lowest surface temperature in summer in Cambay region, dosage of 1000ppm PPD may suffice the flow assurance requirements in warmer weather.

Recommended Solvent Formulation for organic deposit remediation based on laboratory investigation is as follows:

49% Diesel + 20% Xylene +20% Toluene +10%EGMBE + 1% Surfactant

Acknowledgment

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Driving Process Safety Performance through Intelligent Dashboard

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Abstract

Performance measurement to improve work processes or systems is a well-recognized technique in almost all of the industries throughout the world. This is because, only by measuring something, we can determine how well it is performing. The processing industries like petroleum refineries, gas processing facilities, petrochemical manufacturing units etc. uses various work processes and procedures to safely produce/ handle hazardous chemicals. The use of these work processes and procedures are driven by safety management systems under the widely recognized OSHA's or CCPS "Process Safety Management framework". Incessant monitoring and evaluation of work processes and procedures through prudently selected indicators or metrics is essential to prevent or mitigate catastrophic incidents which have detrimental impact on People, Environment, Asset & Reputation of the company (PEAR).

Experts in the field, statutory auditors, and leadership teams often agree that measuring process safety performance is essential for identifying the strengths and weaknesses of safety management systems in order to achieve continual improvement. CCPS and regulatory bodies such as OSHA and HSE UK have offered substantial guidance on the creation of process safety performance indicators for organizations. However, the accomplishments of organizations that have implemented systems for monitoring and evaluating process safety performance indicators are frequently not publicized or accessible on public platforms. As a result, safety professionals who wish to implement (or) intend to improve (or) wish to derive intelligent insights from these systems within their organizations frequently encounter difficulties in communicating the necessary resources and practical obstacles to top management. Therefore, in order to bridge this divide and disseminate the success story of HPCL-Mittal Energy Limited (HMEL), which manages the Guru Gobind Singh Refinery in Bathinda, Punjab, India, this paper emphasizes the key aspects in development of a digitalized dashboard for monitoring process safety performance indicators. Furthermore, it highlights HMEL's remarkable transformation of this dashboard into an intelligent tool that effectively identifies areas of concern within its safety management systems, facilitating proactive improvements.

Keywords: *Process Safety; Performance Measurement, Indicators, Data Analytics, Dashboard, Continuous Improvement, Safety Management Systems, Case Study, Intelligent Insights, Permit Audit, Management of Change, Operator Safety Round, Near Miss Analysis*

1. Introduction

Process safety management (PSM) entails the implementation of a methodical and rigorous framework designed to oversee processes that encompass the handling and storage of hazardous chemicals. This framework is guided by established and widely accepted best practices in engineering, operations, and maintenance, as outlined by prominent international organizations like OSHA, CCPS, HSE UK, and others. The primary goal of PSM is to proactively avert loss of primary containment incidents (LOPC) that carry the potential to release hazardous chemicals or energy, which in turn could lead to fatalities, environmental harm, asset impairment, and production setbacks.

Process safety incidents often arise from the failure of multiple protective barriers, which are installed to effectively contain and mitigate hazards. These failures manifest as weaknesses or gaps within these barriers. These protective barriers are commonly referred to as layers of protection or integral components within process safety management systems. The vulnerabilities within them serve as openings through which initiating events can escalate into full-fledged process safety incidents. These protective barriers encompass a range of measures, including engineering design controls and people-centered administrative controls.

When an initiating event manages to breach the gaps or weaknesses in the protective barriers—leading to events like loss of containment or process safety incidents at various tiers (tier-1/2/3)—and subsequently results in an incident, these incidents are classified as lagging indicators. Conversely, instances where the deterioration of protective barriers is detected through specific indicators, such as routine preventive maintenance programs, before an incident occurs, these indicators are deemed as leading indicators.

In essence, the combined set of leading and lagging indicators are collectively known as process safety performance indicators.

Process safety performance indicators play a pivotal role within every process industry, serving as indispensable tools for proactively assessing the state of process safety within their facilities. These indicators establish a mechanism to gauge performance in relation to set requirements and objectives. Evaluating the performance of process safety systems stands as a cornerstone for attaining and upholding exceptional operational excellence. The act of measuring performance to enhance the implementation of work systems is a well-established and triumphant practice across various process industries.

Strategically chosen metrics that align with the precise process safety objectives of an organization serve to unveil achievements while highlighting areas of vulnerability within safety management systems. In essence, process safety performance indicators not only facilitate a proactive approach to safety assessment but also contribute significantly to refining overall operational efficacy.

CCPS, API along with regulatory bodies like OSHA and HSE UK have provided extensive guidance regarding the establishment of process safety performance indicators in the realm of process industries. Nevertheless, the achievements of organizations that have successfully integrated monitoring and evaluation systems for these indicators often remain undisclosed or inaccessible through public channels. Consequently, process safety professionals aiming to implement such systems within their own entities frequently encounter challenges when it comes to communicating essential resources and practical hurdles to upper management.

In certain industries, where data analytics-based performance dashboards have been implemented, there exists an untapped potential—a treasure trove of intelligent insights that remain underutilized. While these organizations have taken a commendable step towards enhancing their process safety performance, there is room for further exploration and exploitation of the power inherent in data analytics.

The deployment of a performance dashboard is often seen as a significant milestone, symbolizing an organization's commitment to process safety and operational excellence. However, the full extent of what these dashboards can offer in terms of insightful, data-driven decision-making is not always realized. In some cases, organizations may use these dashboards primarily as monitoring tools,

focusing on tracking historical performance or compliance with safety regulations. While these functions are undoubtedly valuable, the true potential of data analytics often lies dormant.

Hence, to bridge this informational gap and to share the success story of HPCL-Mittal Energy Limited (HMEL), the entity overseeing the operations of the Guru Gobind Singh Refinery & Petrochemical Complex in Bathinda, Punjab, India, this paper centers on the creation of a technologically advanced intelligent dashboard designed for the real-time monitoring of process safety performance indicators.

2. Methodology

HPCL Mittal Energy Limited (HMEL), a public private partnership joint venture formed in 2007. HMEL operates Guru Gobind Singh Refinery and Petrochemical Complex in the state of Punjab, India and is committed to deliver superior petroleum and petrochemical products to the Indian/ overseas market. HMEL has implemented a robust Process Safety Management program in its process plants. The PSM program of HMEL is a collection of 16 elements organized under 4 foundation blocks based on the cumulative guidance from “CCPS Risk Based Process Safety Management”, “UK Energy Institute PSM framework” and OSHA’s “Process safety management of highly hazardous chemicals”. At the outset of its Process Safety Management (PSM) journey, HMEL recognized the importance of measuring process safety performance to enhance its operational processes and management systems. In the early stages, process safety performance indicators were documented using Microsoft Excel spreadsheets. These Excel-based dashboards were then employed in safety committee meetings to facilitate discussions on the strengths and weaknesses of their safety management systems.

As technology evolved, HMEL transitioned from using Excel sheets to employing advanced data analytics tools. This new approach involves capturing real-time, plant-specific data derived from operational processes. The collected data is then presented in customized real-time dashboards. This sophisticated process safety dashboard is accessible to a wide range of stakeholders, from the company's board of directors down to frontline workers. This real-time accessibility empowers them to assess the efficiency of plant processes and the effectiveness of safety management systems promptly and effectively.

The remaining section of this paper addresses the step-by-step approach in development of digitalized dashboard and how HMEL is driving its process safety performance through intelligent aspects of data analytics.

2.1 Selection of Process Safety Leading and Lagging Indicators:

Effective process safety performance measurement requires the identification of suitable leading and lagging indicators. Leading indicators are predictive metrics that provide insights into the potential for future incidents or accidents, while lagging indicators, on the other hand, are reactive metrics that reflect historical data related to incidents or accidents that have already occurred. A vast amount of guidance is published on selection of performance indicators by organizations such as CCPS, American Petroleum Institute (API) etc. One such example guidance is: CCPS publication “Process Safety Lagging and Leading Metrics”. Table 1 lists down some of the performance indicators (not a full list) for reference of the reader.

Table 1: Examples of Performance Indicators

Lagging indicators	Leading indicators
• No. of Tier-1 process safety incidents • No. of Tier-2 process safety incidents • No. of Tier-3 process safety incidents • No. of online clamps on hazardous service lines/ equipment	• No. of PHA recommendations pending/ overdue for closure • No. of external/ internal audit recommendations pending/ overdue for closure • Number of operating/ maintenance procedures pending/ overdue for revision

2.2 Identification of Source Systems for Work Processes & Procedures

Understanding the source systems of various work processes and procedures is fundamental. This involves pinpointing the data origins, systems, and processes that contribute to the safety management framework. Below are some of the examples of work processes in which plant operational/ maintenance data gets recorded.

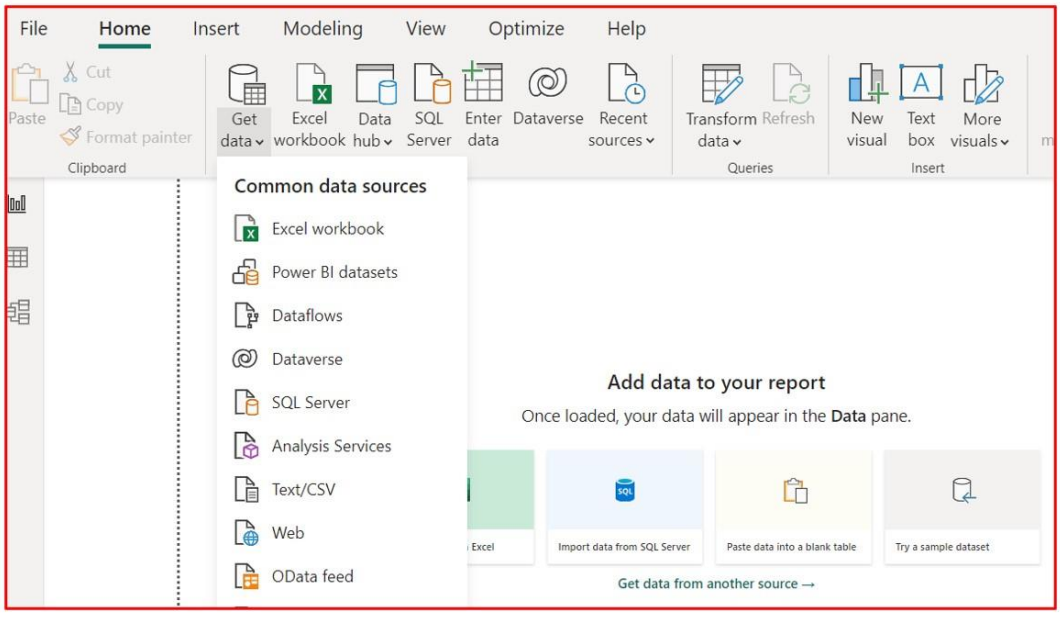
Table 2: Work processes data recording tools

Plant data	Example business software tools where data gets recorded
Occupational/ process safety incident data	SAP BI
Occupational/ process safety near miss data	SAP BI
Online clamps on piping/ equipment data	SAP BI
Management of change workflow	SSIS/SQL
Operating/ Maint. procedures workflow	SSIS/SQL
Employee participation	SharePoint
Work permit audit workflow	SSIS/SQL
Internal/ external audit action tracker	SSIS/SQL
PHA action tracker	SSIS/SQL
PSSR action tracker	SSIS/SQL
Incident Recommendations tracker	SAP BI
Training tracker	SAP BI

2.3 Utilization of Data Analytics Tool for Mapping and Importing Data

Leveraging data analytics tools, such as advanced data mapping techniques, facilitates the integration and importation of data from diverse sources. This step ensures that relevant data streams are included for analysis. One such example data analytics tool is PowerBI developed by Microsoft. Power BI allows users to connect to a wide range of data sources, both on-premises and in the cloud. It supports seamless integration with popular data platforms like Excel, SQL Server, SAP BI, SharePoint, and more.

Figure 1: PowerBi user interface showing data import options from wide range of data sources



2.4 Data Transformation and Process Safety Key Performance Indicator (KPI) Generation

Data transformation processes are crucial for converting raw data into actionable insights. It is a critical step in the data analytics process. It involves cleaning, shaping, and organizing raw data into a format that is suitable for analysis. Power BI offers a powerful tool called Power Query Editor for performing data transformation tasks. Power BI allows you to create KPIs by combining measures and setting target values and thresholds. A KPI typically includes a target value, an actual value based on data, and indicators (such as icons) to represent performance against the target.

2.5 Data Visualization for Monitoring and Performance Evaluation

Visual representation is essential for conveying complex information effectively. PowerBi allows users to generate customizable visualizations tailored to process safety performance indicators. Gauges, charts, tables, cards and heat maps convey critical information at a glance, aiding in quick decision-making.

2.6 Trend Analysis of KPIs

Trend analysis involves examining the historical performance of performance indicators to identify patterns, deviations, and potential areas of safety concerns. Trend analysis in Power BI allows safety professionals to access historical data and compare current performance against past periods. This historical context aids in identifying long-term trends and evaluating the effectiveness of safety initiatives.

2.7 Leveraging Intuitive Features of Visualization Tool

Power BI's intuitive features make it accessible to both technical and non-technical users. Process safety professionals can easily navigate through the tool, select data sources, design visualizations, and create insightful dashboards without the need for extensive technical training. The drag-and-drop functionality in Power BI simplifies the creation of visualizations. Process safety indicators, such as incident rates, near-miss occurrences, or compliance metrics, can be visually represented through charts, graphs, and gauges.

2.8 Slicing and Dicing of Data for Insights

Utilizing Power BI's capabilities for slicing and dicing data offers a powerful approach to gaining insights and improving process safety management. Slicing and dicing refer to the ability to segment and analyze data from different angles, which is particularly valuable in industries prioritizing safety. Power BI enables multi-dimensional analysis by allowing users to slice data along various dimensions. For process safety management, this means dissecting safety data by factors such as time periods, locations, equipment, departments, or incident types. Each dimension provides a unique perspective on safety performance.

3. HMEL's Process Safety Performance Intelligent Dashboard

In accordance with the methodology outlined in Section 2, HMEL has successfully developed an advanced process safety management performance dashboard. This innovative dashboard serves as a dynamic tool that enables the continuous monitoring of all work processes, procedures, and safety management systems in real time. Its primary purpose is to provide valuable insights into the functioning of these systems at a grass root level, offering a comprehensive understanding of their efficiency and effectiveness in preventing incidents. The use of PowerBI tool for the data analytics has helped the organization in seamless integration with real time data source platforms. Figure 2 & Figure 3 shows the snapshots of HMEL's digitalized dashboard visualization.

Figure 2: Overview of dashboard

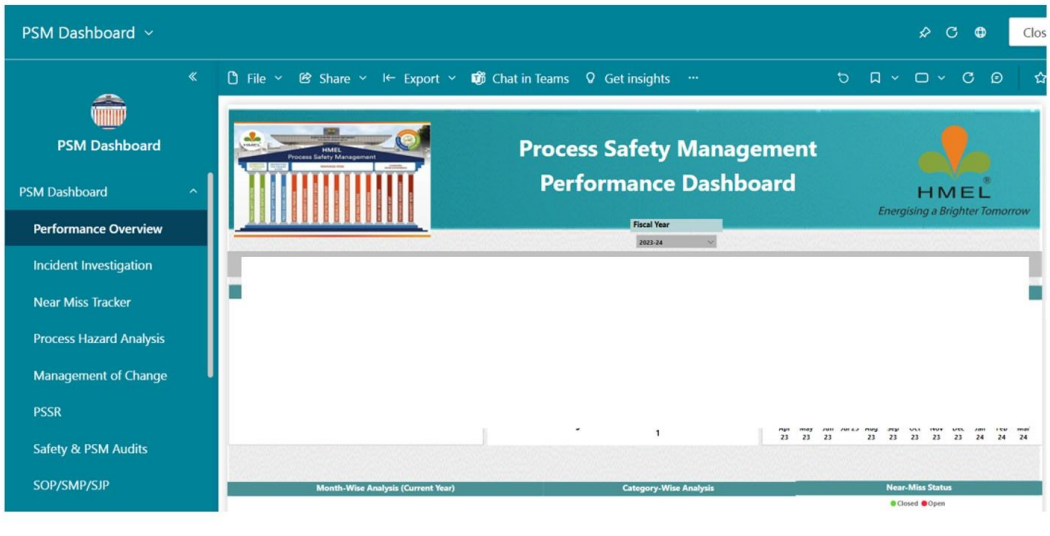
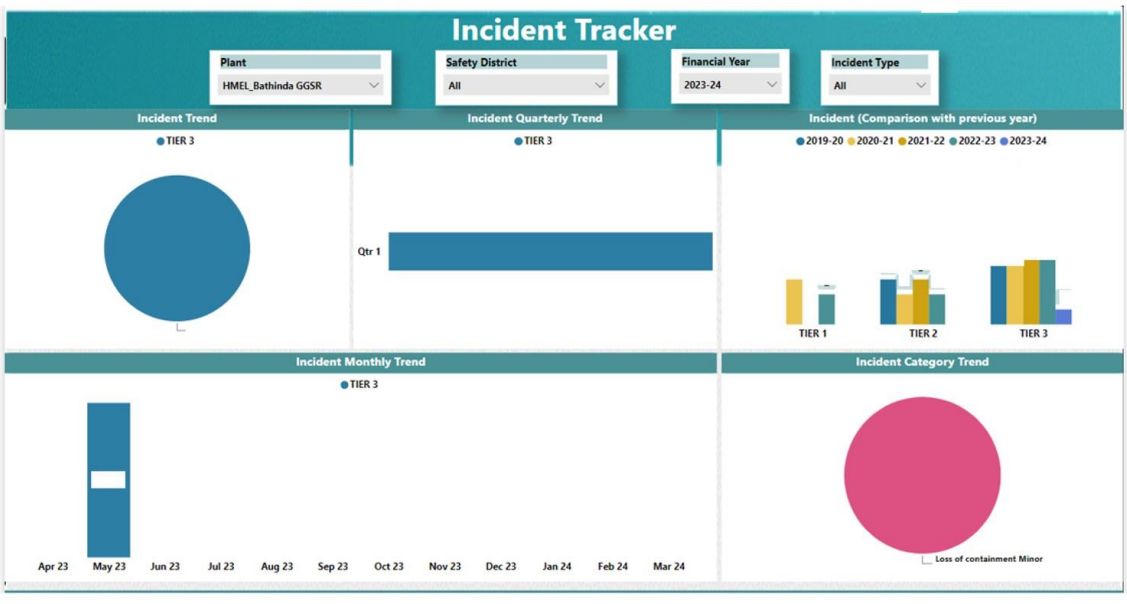


Figure 3: Incident tracker page of dashboard



In the realm of process industries that deal with hazardous chemicals, the development of process safety performance dashboards has become a common practice. These dashboards serve as invaluable tools for monitoring leading and lagging indicators, providing a snapshot of an organization's safety performance at any given point in time. **However, despite their potential to drive proactive safety measures, many organizations inadvertently limit their dashboards to serving as mere trackers of completion deadlines**.

A similar narrative unfolded at HMEL, where the initial emphasis was on diligently addressing pending items within the timeframes set by the organization. This approach was rooted in the belief that by efficiently closing out tasks indicated by leading indicators—such as SOP/SMP reviews and PHA recommendations—a safer operational environment would naturally follow. However, the reality proved to be more nuanced.

The dashboard's display of promptly resolved tasks did not translate into a corresponding reduction in process safety incidents. This incongruence led to a pivotal realization: the dashboard's potential extended beyond task completion. **Instead of fixating on reactive responses to pending items, HMEL recognized the importance of leveraging the dashboard's analytical capabilities to uncover the deeper insights concealed within the data**.

In response, HMEL enhanced the dashboard's functionality to spotlight areas of concern, thereby shifting the focus from an emphasis on closing tasks to a proactive approach centered on incident prevention. This modification enabled the organization to identify potential risk factors and take preemptive action. The true significance of this shift became evident as the graph representing process safety incidents began to display a discernible downward trend over time.

The transformation was driven by the dashboard's newfound role as an intelligent informant, reliably pinpointing areas warranting attention. This allowed HMEL to intervene before issues escalated into incidents. The dashboard, once a static repository of data, evolved into a dynamic tool that guided decision-making and facilitated proactive safety measures.

4. Analysis and Results

This section focuses on HMEL's pursuit of process safety excellence, where a shift from conventional practices to a data-driven approach yielded profound results. As explored in the preceding discussions, HMEL's proactive efforts in addressing pending items were initially met with a disparity between task completion and actual process safety improvement. This disconnect prompted a pivotal transition in strategy—an evolution catalyzed by an in-depth analysis of the data presented through the process safety performance dashboard.

By harnessing the latent potential of the performance dashboard, HMEL's process safety landscape was redefined. The results achieved not only signify a reduction in process safety incidents but also underscore the broader impact of insightful data utilization on organizational safety culture and performance.

4.1 Unveiling the Power of Process Safety Near Miss Analysis Through the Dashboard Intelligent Algorithm.

Within the array of features that underscore the dashboard's effectiveness, the analysis of process safety near misses shines as a prime exemplar of its intelligent capabilities. At HMEL, our approach to process safety near misses is bolstered by an algorithm integrated within our data analytics software. This algorithm performs a crucial role in segregating near misses into two distinct categories: those of occupational nature and those pertaining to process safety. Moreover, it harnesses the inputs provided by the near miss reporter to further classify process safety-related near misses into various subcategories, thus enhancing its discerning capabilities. These intelligent classification functionalities are aptly depicted in Figure 4 to Figure 7.

To provide a tangible illustration, Figure 5 accentuates the growing trend of process safety near misses linked to improper labeling and signage. Simultaneously, Figure 7 spotlights an escalating number of near misses attributed to the loss of containment—an issue primarily rooted in challenges associated with small bore connections.

The progressive evolution of this near miss classification system has emerged as an invaluable asset for HMEL. It serves as a dynamic compass, enabling us to pinpoint areas of concern with precision. This newfound clarity, in turn, empowers us to promptly initiate corrective actions. By continually monitoring and responding to these near miss trends, we strive to enhance our overall process safety and cultivate a culture of proactive risk mitigation.

Figure 4: Near miss primary classification

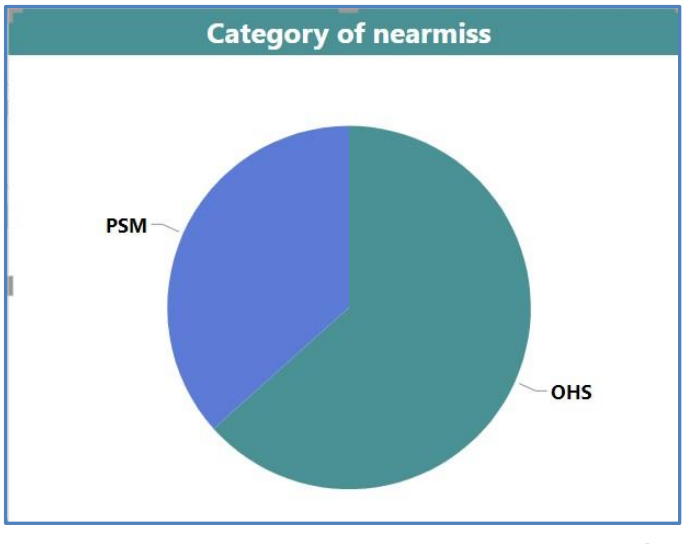


Figure 4 shows the out of total reported near misses in HMEL, how many are process safety related and how many are OHS related.

Figure 5: Near miss category wise classification

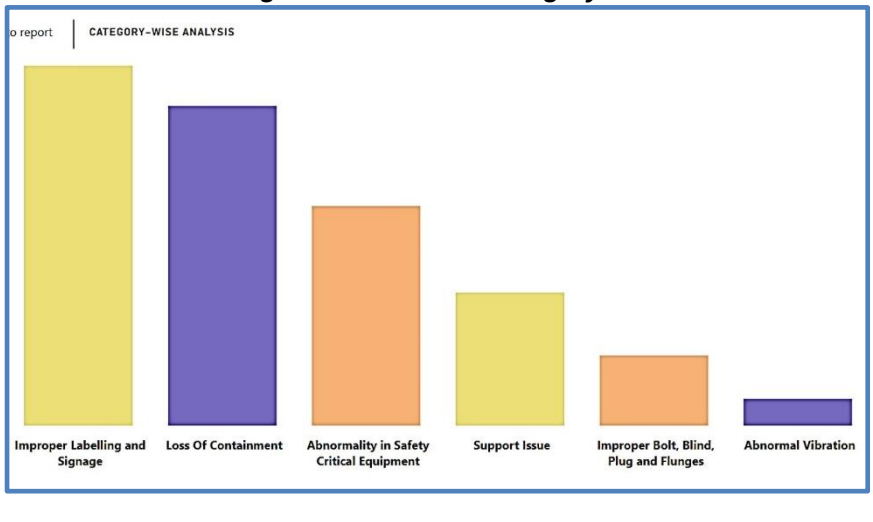


Figure 5 shows out of total reported process safety related near misses what is their category wise classification

Figure 6: Type of chemical released in case of LOC

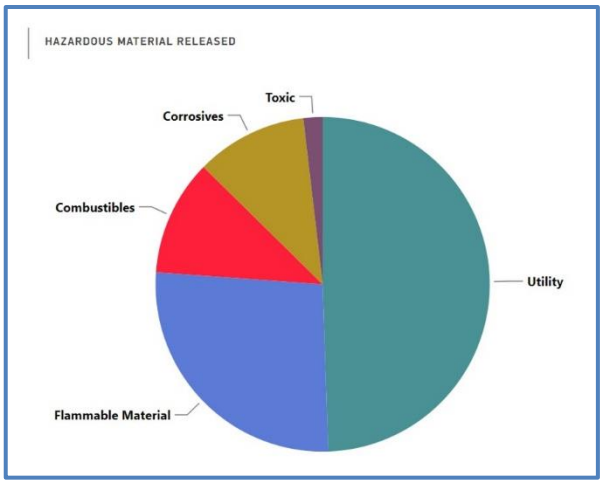


Figure 6 shows the out of total reported loss of containment related near misses in HMEL, what is the count of different released materials.

Figure 7: Point of release of chemical in case of LOC

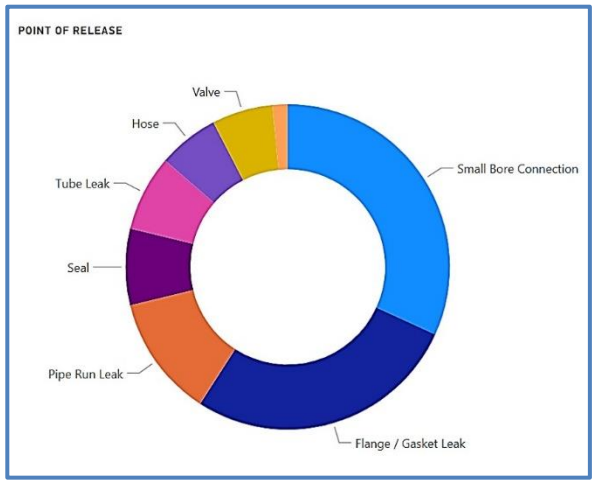


Figure 7 shows the out of total reported loss of containment related near misses in HMEL, what are the point of releases.

4.2 Harnessing Intelligence Through the PASS Tracker: Insights from Permit Audit Analysis:

An integral facet of our dashboard's intelligence lies in the "Permit Audit and Suraksha Samwad (Safety Conversation)" tracker, known as PASS. This innovative inspection system, operational within our process plants, transcends the conventional permit audit process. At HMEL, it serves as a dynamic platform where individuals not only audit permits but engage in meaningful dialogues with job executors, delving into the drivers behind unsafe behaviors. This amalgamation of audit and conversation culminates in an electronic record system that meticulously captures the nuances of each permit audit and safety conversation.

This recorded data serves as a reservoir of actionable insights. It enables us to dissect the primary areas of permit deviation and identify the behavioral barriers that contribute to these deviations during permit activities. Armed with this data, we effectively target our areas of concern, shaping a comprehensive action plan to enhance organizational parameters and address behavior gaps.

The real-time big data analysis of PASS through our Power BI dashboard serves as a beacon of transformation within our permit-to-work system. The data gleaned from PASS undergoes intricate analysis, unveiling trends, patterns, and areas ripe for improvement. These analytical insights offer a panoramic view of potential permit deviations, key behavioral issues, and avenues for process optimization. They, in essence, empower us to make informed decisions and take proactive measures aimed at incident prevention and refining our refinery's overall performance. Figure 8 to Figure 10 encapsulate the intelligent insights emanating from our dashboard.

Figure 9, for instance, provides a vivid depiction of areas where permit deviations have occurred. It lays bare the instances where workers, executing their tasks, may not have been adequately aware of the associated hazards. This figure also highlights deficiencies in job safety analysis and toolbox talks for specific issued permits.

Furthermore, Figure 7 spotlights a notable increase in permit deviations related to personal perception and permit planning. Personal perception probes into the subjective beliefs and assumptions of workers that may lead them to bypass safety precautions. Whether rooted in the perception of low risk, discomfort with safety measures, or time constraints discouraging protocol adherence, understanding these perceptions provides invaluable insights. These insights, in turn, inform our targeted training and communication strategies, fostering a culture of heightened safety consciousness within our organization.

In conclusion, the PASS tracker and the dashboard's intelligent analysis collectively guide us towards a safer and more optimized operational environment. The insights harnessed from these systems enable us to bridge gaps, reinforce safety measures, and drive continual improvement, thereby elevating our commitment to operational excellence and incident prevention.

Figure 8: Work permits where deviation observed vs no deviation.

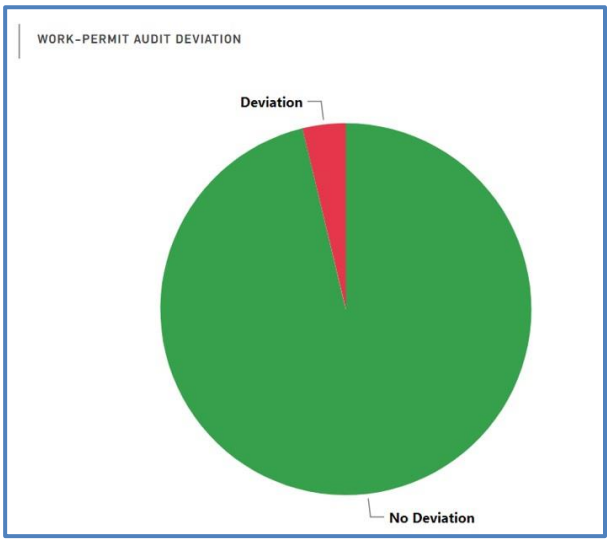


Figure 9: Parameters wise classification where deviation is observed in work permits

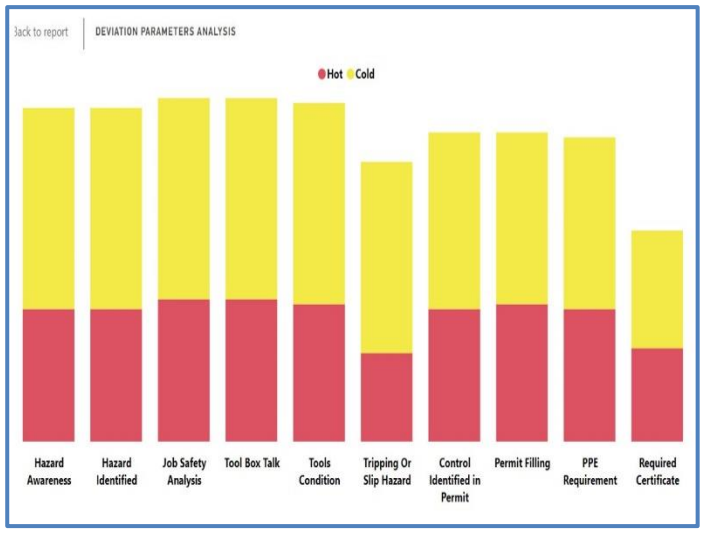


Figure 10: Work permits where short cuts are observed

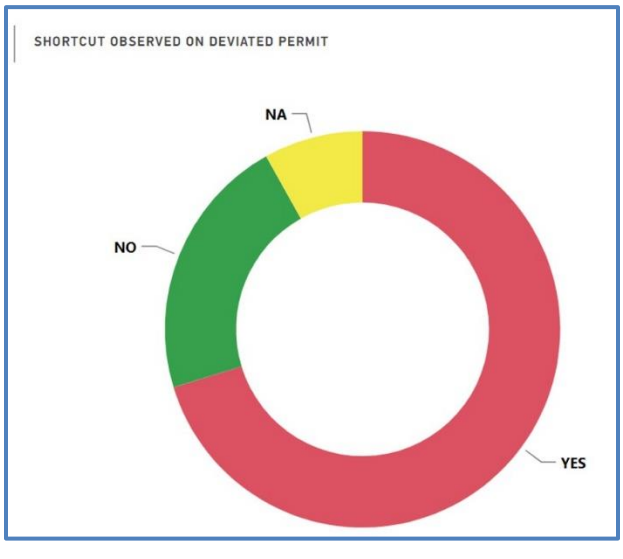


Figure 11: Work permits where person worked in line of fire

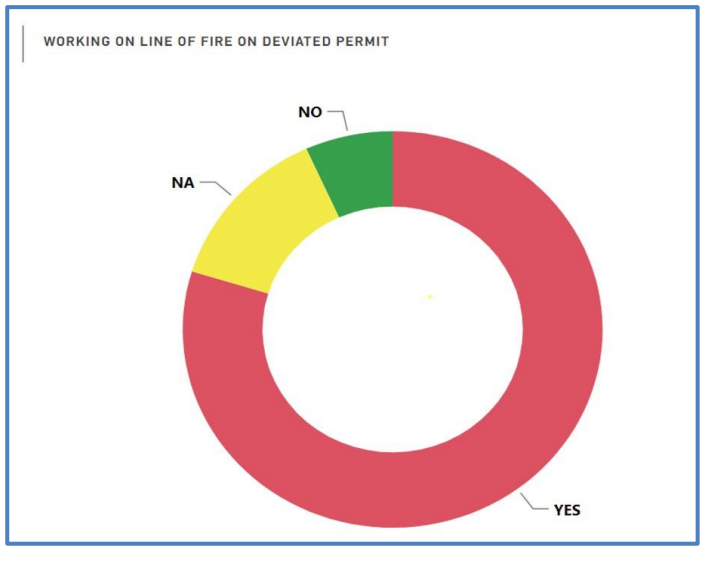


Figure 12: Work permits where behavior gaps are found.

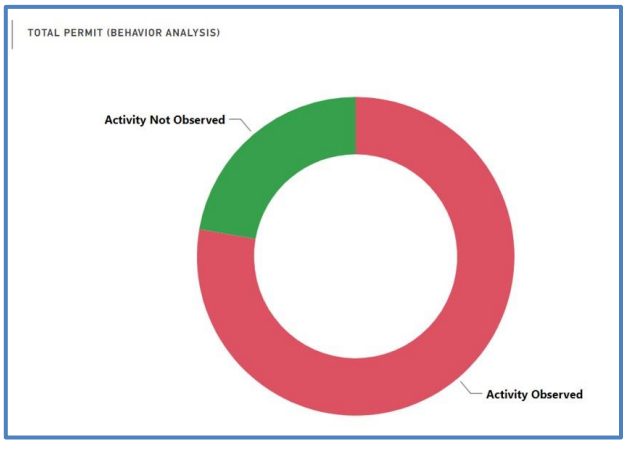
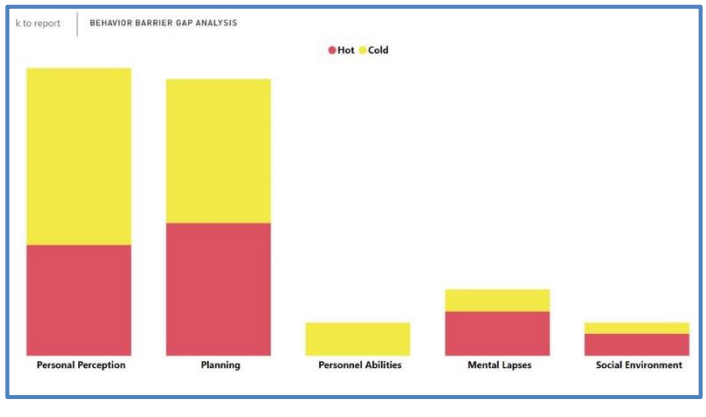


Figure 13: Behavior barrier gap classification



4.3 Leveraging Intelligence Through the Operator Safety Round (OSR) Tracker: Enhancing Plant Safety Systems.

The process safety performance dashboard continues to reveal intelligent insights, this time stemming from the Operator Safety Round (OSR) tracker. At HMEL, we've pioneered a digital OSR platform designed to efficiently assign checklist-based inspection tasks to individuals. These tasks revolve around evaluating the condition and integrity of a wide array of plant-specific safety systems. These encompass critical components such as pressure and temperature safety valves, insulation, fireproofing, shutdown valves, short and long bolting, safety showers, machine guards, stenciling, and more. These inspections occur on a scheduled periodic basis.

Upon completion of an assigned inspection task, the individual responsible for the assessment is required to submit their observations and action items through the OSR digital platform. This platform not only facilitates the recording of data but also serves as a conduit for improvement. If any deficiencies or damage are identified during the inspection, the system enables the individual to outline necessary actions to rectify these issues.

The beauty of the Operator Safety Round (OSR) digital platform lies in its real-time communication with the Power BI data analytics tool. This integration allows for the immediate assessment of checklist completion compliance at an individual level. Furthermore, it brings to the forefront areas where emerging action items require attention during inspections. Figure 14 and Figure 15 within the dashboard encapsulate the intelligent insights derived from this system.

Figure 15, for instance, offers a vivid visualization of areas where a significant number of action items are generated during Operator Safety Rounds, signaling a clear need for improvement. This not only streamlines our response to identified issues but also enhances our proactive approach to maintaining and upgrading critical safety systems.

Figure 14: Operator Safety Round - Refinery Wide Compliance Status

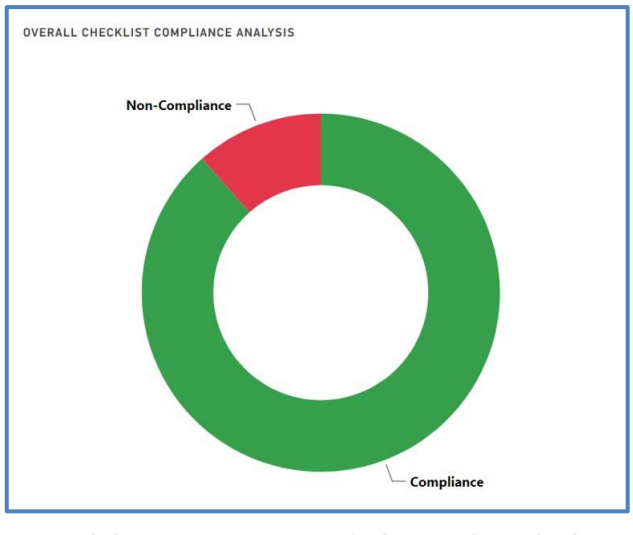
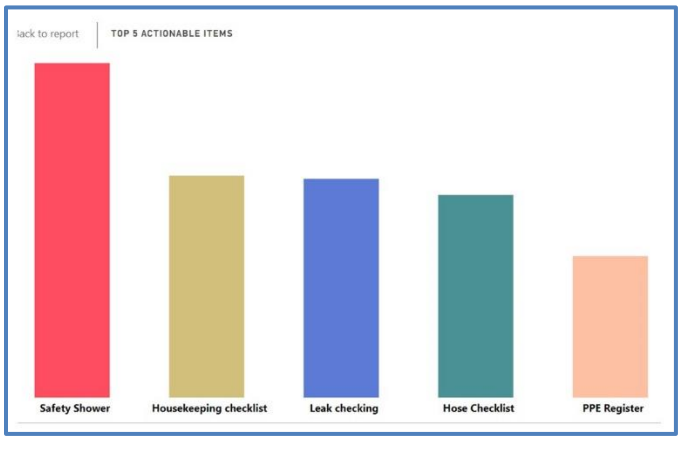


Figure 15: Top 5 Action Items from Operator Safety Rounds



4.4 Driving Management of Change (MOC) Through Dashboard Intelligent Insights

The process safety performance dashboard continues to deliver invaluable insights, with the Management of Change (MOC) Tracker page emerging as a pivotal source of intelligence. Within the domain of process safety management, MOC is a cornerstone element, addressing the critical need to prevent the inadvertent introduction of new hazards or the escalation of existing risks when modifications are made to processes. This intricate element encompasses a structured review and authorization process that assesses proposed adjustments to facility design, operations, organization, or activities before they are executed.

At HMEL, we've implemented a digitalized change management system, aptly named the "TDMS-MOC workflow," to comprehensively manage all changes to our existing facilities. This system seamlessly integrates with our Power BI dashboard, offering real-time insights encapsulated in Figure 16 to Figure 19.

Figure 18, for instance, draws attention to a significant revelation. It sheds light on instances where changes proposed through MOCs were indeed implemented at the field level. However, the closure process was not completed within the TDMS-MOC digital platform. This visual provides a transparent overview of the stages at which the workflow of these MOCs encountered delays. It's evident that despite field-level implementation, the as-built P&IDs (Process and Instrumentation Diagrams) or PSI (Process Safety Information) were not updated in the system.

Moreover, Figure 19 offers a comprehensive visualization of the status of temporary MOCs, highlighting those that have been converted back to normal, those that remain active in the plant, and those that have been transitioned to permanent changes. Notably, this visual reveals an essential aspect—the number of temporary MOCs still active even after surpassing their scheduled removal date, indicating changes initiated using temporary MOCs that may pose unaddressed risks if left to operate.

These intelligent insights gleaned from the dashboard serve a vital role in ensuring the effective closure of all MOCs raised by various departments, including operations and maintenance. This concerted effort is a cornerstone in our commitment to creating a reduced-risk process safety environment within our process plants. By embracing data-driven decision-making, we bolster our capacity to manage changes effectively and maintain the utmost safety and operational standards.

Figure 16: MOC creation requests over the years

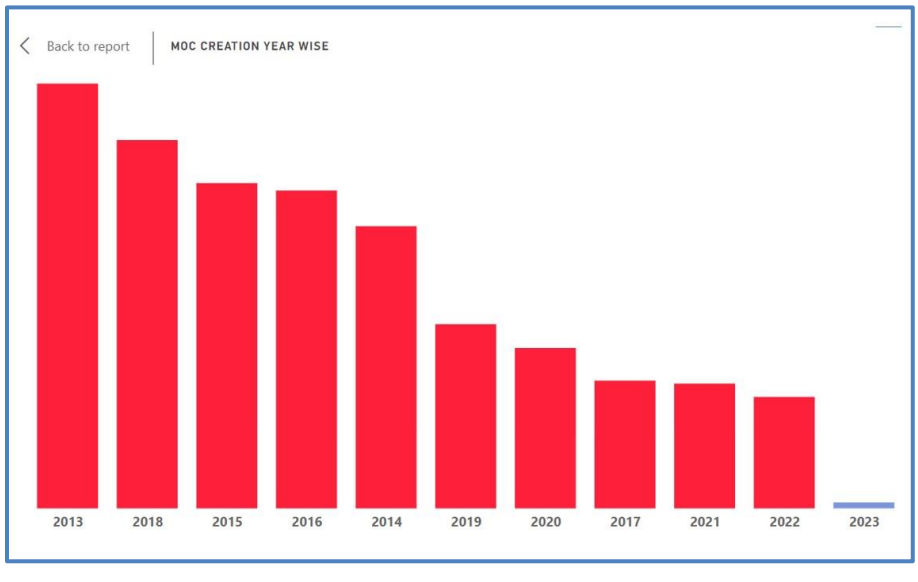


Figure 17: Executed MOC pending for closure

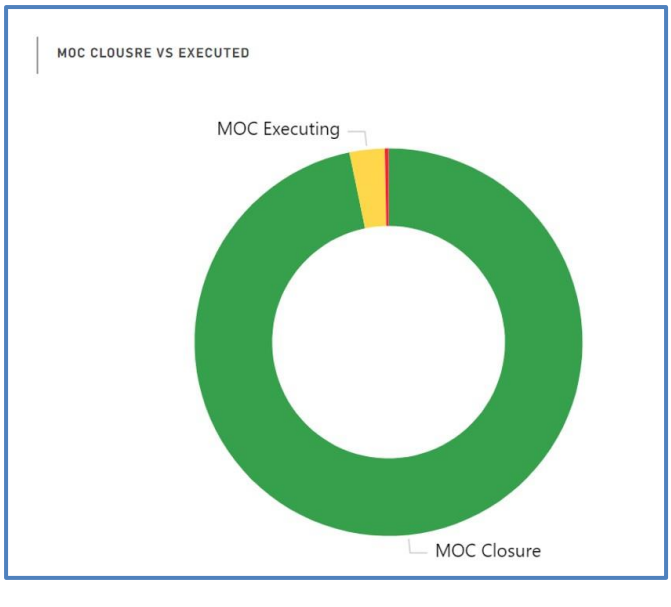
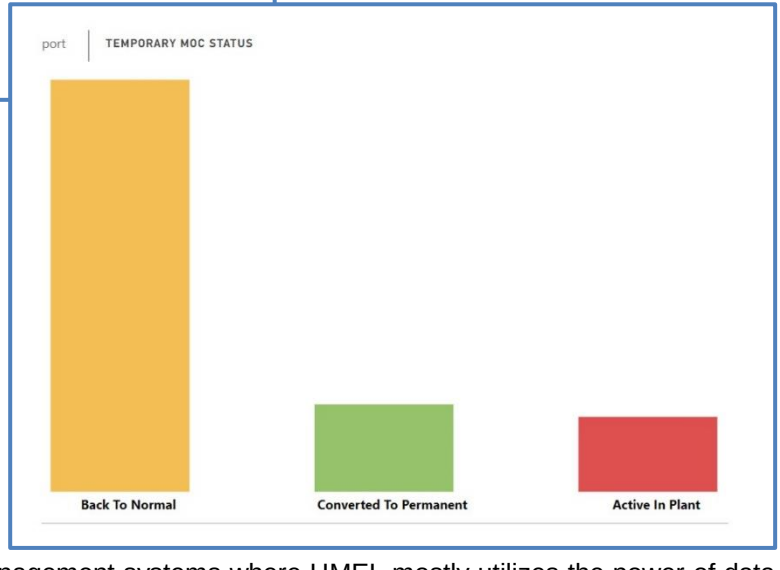


Figure 18: Executed MOC pending at different stages in system

Figure 19: Temporary MOC overall status



In summary, these are some of the safety management systems where HMEL mostly utilizes the power of data analytics to derive useful insights. While the implementation of data analytics-based performance dashboards is a commendable step towards enhancing process safety, many organizations might not be fully harnessing the power of data analytics to derive intelligent insights. These dashboards have the potential to revolutionize how organizations approach process safety, shifting from a reactive stance to a proactive one, and continuously driving improvements. Therefore, it is essential for organizations to explore and unlock the full capabilities of these tools to realize the highest levels of safety and operational excellence.

5. Conclusion

In conclusion, the evolution of HMEL's approach to utilizing its process safety performance dashboard underscores a broader lesson for organizations. A dashboard should not be confined to a retrospective view of completed tasks; it should serve as a catalyst for informed and proactive decision-making. By delving into the data, identifying trends, and responding proactively, organizations can reshape their safety landscapes. HMEL's journey serves as a testament to the potential transformation that awaits when organizations harness the full analytical power of their safety performance dashboards.

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Leveraging Experience of Domestic Consumer Metering of the Power Sector in the City Gas Distribution (CGD) Sector

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1. Background

The Petroleum and Natural Gas Regulatory Board (PNGRB) has authorised about 295 Geographical Areas (GAs) spread over 630 districts in 28 states / UTs, including all cities under these GAs, for the establishment of the city gas distribution (CGD) network. This covers about 98% of the population and 88% of the country's total geographical area under the CGD network. The CGD network in India has witnessed rapid growth in terms of infrastructure development. The government aims to increase the share of natural gas in the primary energy mix from 6.7% in 2021 to 15% by 2030. As the country transitions towards a gas-based economy, the demand for gas is expected to increase.

Currently, total domestic connections in India are about 1.2 Cr in the gas sector compared to 26 Cr in the electricity sector. Based on commitments given by various CGDs in the 9th – 11th round of bidding, around 12.2 Cr domestic PNG connections are proposed to be released in the next 7-8 years. Given this, PNG connections are expected to increase rapidly during this period.

Most domestic connections are currently released with conventional postpaid / credit meters in the gas sector. Conventional credit type metering has a monthly recurring revenue cycle of physical meter reading, bill processing, bill preparation, bill distribution, payment collection, notice issuance for payment default, disconnection and litigation process in case of a longer payment default. As the numbers ramp up, managing these processes will become complicated.

In the case of postpaid metering, the consumer cannot monitor his consumption and weekly / monthly trend of gas usage. The consumer gets bi-monthly bills based on his consumption, and there is a possibility of incorrect billing because of manual intervention, coffee shop or erratic reading.

The power sector has experienced substantial financial stress, with bad debt amounting to INR 4.3 lakh crore, primarily due to delayed consumer payments on account of the postpaid billing system. Based on learnings from the power sector, the Government of India finally decided on prepaid metering instead of prevailing postpaid metering. It directed all discoms in India to switch to smart prepaid metering through a Gazette Notification in the year 2021 and for replacement of all existing meters with smart prepayment meters within defined timelines.

After the 9th – 11th round of bidding in 2020 / 2021, the number of domestic PNG connections is increasing rapidly due to year-on-year basis contractual obligations under the minimum work program (MWP). Currently, CGDs are working in metros or big capital (state) cities where the challenges related to payment collection are less

because of better socio-economic conditions. Now, CGDs are expanding to tier-1 and tier-2 cities too. With the increase in domestic consumer numbers, they can face similar challenges of bad debt. Hence, it will be wise to utilise the learnings of the power sector in the CGD sector so that they can avoid falling into the same trap of high bad debt and delayed payments with an increasing number of domestic connections.

2. Few facts and government initiatives in the power sector

Indian discoms have continued to register financial losses and have repeatedly required government support. As per the report published by the Power Finance Corporation (PFC), the billing and collection efficiency of the revenue cycle at the national level for FY 2019-20 was 85% and 92%, respectively, and total ATC (Aggregate technical & commercial) loss was about 20%.

As per the report published by Power Finance Corporation (PFC) over "Performance of Power Utilities 2021-22"; a few realities about discoms in India are as follows:

At the end of the financial year

	Unit	2021-22	2020-21	2019-20
Receivables for sale of power	Rs crore	2,48,632	2,36,384	2,15,837
Receivables for sale of power	Days	142	159	136
Payables for purchase of power	Rs crore	2,78,878	2,74,458	2,57,897
Payables for purchase of power	Days	163	178	166
Net worth	Rs crore	(53,559)	(52,358)	(39,163)
Accumulated losses (as per balance sheet)	Rs crore	(5,52,507)	(5,24,811)	(5,05,361)
Total outstanding debt	Rs crore	6,17,928	5,82,547	5,00,310
State government loans	Rs crore	60,252	66,220	76,001
State government loans as % of total debt	%	9.75	11.37	15.19

Looking at the above performance, power distribution utilities have consistently witnessed poor financial performance, and their net worth continues to be negative. Persistent financial problems resulted in delayed payments / non-payments of outstanding dues to their electricity suppliers, i.e., generators.

To improve the financial condition of discoms, the Government of India vide Gazette Notification G.S.R. 818(E) dated 31-Dec-2020 and F. No. 23/35/2019-20-R&R dated 17-Aug-2021 has mandated the placement of smart meters in prepayment mode for all consumers (other than agricultural consumers) based on the urbanisation and communication network availability.

Ministry of Power has released the following notifications for smart prepayment meters:

- The Electricity (Rights of Consumers) Rules, 2020 was notified on 31-Dec-2020 and as per this Rule, ***no connection shall be given without Smart prepayment meter or prepayment meter.***
- Ministry of Power vide letter dated 26-Feb-2021 had requested all the States to prepare a road map for ***shifting to smart prepayment meters' / prepayment meters***.
- Ministry of Power vide notification dated 17-Aug-2021 has issued timelines for the ***replacement of existing meters with smart meters.***

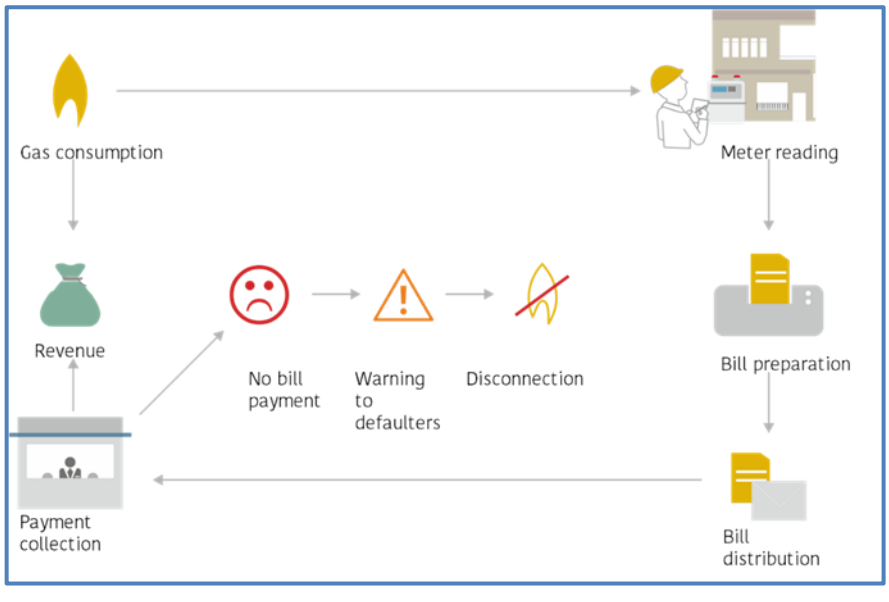
A snapshot of GAZETTE NOTIFICATION pertaining to smart prepayment meters by MINISTRY OF POWER (MoP) is as follows.

G.S.R. 818(E) dated 31-Dec-2020: Metering – No connection shall be given without a meter and such meter shall be the smart prepayment meter or pre-payment meter. Any exception to the smart meter or prepayment meter shall have to be duly approved by the Commission. The Commission, while doing so, shall record proper justification for allowing the deviation from installation of the smart pre-payment meter or prepayment meter.

F. No. 23/35/2019-R&R. dated 17-Aug-2021 – In pursuance to the provisions made in clause 4(1) (b) of the Central Electricity Authority (Installation and Operation of Meters) (Amendment) Regulations, 2019 framed under sub-section (1) of section 55 read with clause (c) of sub-section (2) of section 177 of the Electricity Act, 2003, the Central Government hereby notifies the timelines for the replacement of existing meters with smart meters with prepayment features. All consumers (other than agricultural consumers) in areas with communication network, shall be supplied electricity with Smart Meters working in prepayment mode, conforming to relevant IS.

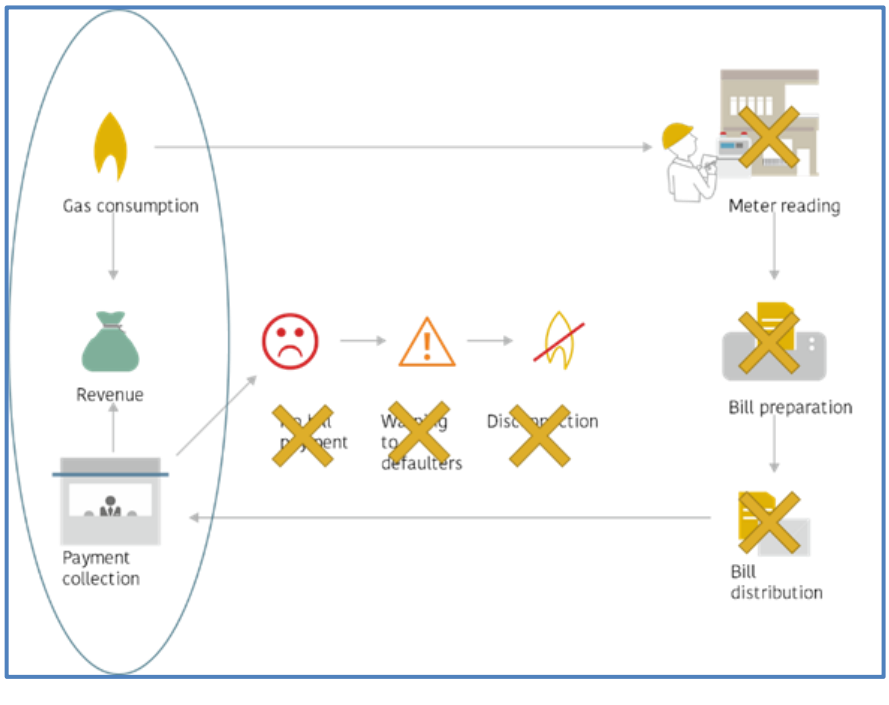
Smart prepaid meters can be an important component in addressing metering, billing and collection-related challenges as they increase the efficiency of this process by reducing human intervention and consequently empowering both consumers and discoms.

3. Prepaid Vs postpaid metering



Out of ~1.2 Cr domestic PNG connection as of September 23, more than 99% gas meters are conventional postpaid meters. Meter readers do a physical meter reading at a set frequency, i.e. a bi-monthly billing cycle for almost all CGDs. In this recurring revenue cycle, a whole set of operations involving meter reading, bill preparation, distribution, payment collection and billing-related consumer grievance handling is part of the overall cycle. The conventional process of credit metering process is shown in the diagram here. Payment is received almost 3-4 months after consumption.

The alternative method for cooking is LPG gas cylinders. According to the current revenue mechanism, the payment against LPG gas cylinders is collected as an advance at delivery, similar to the prepayment system.



Smart meters are becoming increasingly prominent in the power distribution segment, owing to their ability to improve utilities' operational and financial performance. Smart metering in prepaid mode will benefit the discom's financial health. The distribution segment is a crucial segment of the power sector value chain, considering it to be the primary source of cash flow for the entire sector and the only link in the entire chain to face end-consumers. A similar drive may be pursued in another utility sector, i.e. CGDs. Like the power

sector, smart prepaid metering for domestic PNG connections would benefit CGDs in terms of improved operational and financial performance. Smart metering will remove many of the Opex-intensive business processes of CGDs and result in a revenue-centric business process, as shown above. If CGDs switch from a traditional revenue cycle of postpaid to prepaid, many non-value added business processes will be eliminated, and manpower can be deployed for value-adding jobs.

Benefits to consumers: The prepaid solution will offer consumers convenience in payments, insights into consumption patterns, flexibility in determining the frequency and amount of each recharge, increased ability and active engagement to monitor and adjust their consumption, as well as the elimination of late payments, defaults, and disconnections.

Value delivery of smart prepaid metering solution

A. On-time revenue collection

Being a prepaid meter, it needs a top-up before allowing gas to be consumed, ensuring the revenue is collected in advance and there is no outstanding. Further, it is flexible as it allows them to top-up by any amount at a time, thus helping in budgeting.

B. Debt management

Suppose a smart meter replaces a normal postpaid meter. In that case, the consumer's existing debt can be transferred to the smart meter and collected gradually with each recharge until fully paid off.

C. Budgeting: Pay as you go

The average person does not understand kWh/SCM units or the tariff structure, but they understand money. In addition to showing energy units, the meters display the actual remaining credit, consumption in terms of money and the approximate number of balance days left. This helps consumers manage their gas purchases based on their requirements. Displaying credit also allows them to relate the tariff to their expenditures.

D. Transparency to consumers

The prepayment system gives consumers consumption information and estimated days the gas will last. This way, they are aware of their remaining balance at any given time, as opposed to bi-monthly bills, which can be surprising. A continuous flow of information between CGD and the consumer through the meter helps avoid disputes related to consumption and billing.

E. Facilitates audit and reconciliation

Smart meters address the issue of staggered meter readings by taking snapshots of data from every meter at midnight and the end of each month. This allows for daily, weekly or monthly reconciliation and loss assessment. Correct reconciliation ensures exact measurement of consumption and tax components, facilitating accurate GST and VAT calculations.

F. Revenue leakage prevention

Smart meters can detect a range of abnormalities and act accordingly. Key features are as follows:

- Prevention (immune) - Magnet, reverse flow (stops flow), tilt
- Detection – High / overflow, leakage after meter, low pressure
- Deterrence - Cover open (stops flow)

The records of these occurrences are set up to be transmitted to the utility backend, allowing them to keep track of endpoint connections and take appropriate action if needed.

G. Tariff updation

Starting from April 2023, APM gas prices will be revised monthly, as per the government's directives, instead of the previous practice of revising them every six months. The smart meter enables frequent tariff updates on a need basis as the new tariff can be pushed into the meter remotely over the network. This capability helps in ensuring correct revenue realisation.

4. Way forward - Smart Gas Metering

The same consumer using electricity in his house uses gas, so from now on, the discom / CGD struggles and consumer inconvenience will remain the same. Recognising these challenges, the Government of India has mandated smart prepayment meters.

As more Indian households use natural gas, the Government of India / PNGRB / CGD should consider implementing smart prepayment metering for domestic PNG connections. This proactive step can help avoid the challenges encountered in the power sector, ensuring that CGDs experience the full value and benefits of smart prepaid gas metering right from the beginning.

With the government promoting natural gas to increase its share in the overall energy mix, the gas sector is expected to grow rapidly in the coming years. Adopting and adjusting business processes for smart prepaid solutions will be easier for CGDs with fewer consumers in the picture. This is in contrast to the later stage, where a significant consumer database may require a large-scale replacement effort, similar to challenges faced in the power sector. Leveraging lessons learned from the power sector, the gas sector can benefit both CGDs and consumers through the implementation of smart prepaid solutions.

Pillar One – Re-allocation of taxing rights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1. Background:

The digital revolution has enabled companies to sell products or provide services across the borders without requiring any physical presence in the country where the customer is located. Under traditional tax system this business activity is taxable in the home country of the non-resident instead of market jurisdiction where the activity is consumed.

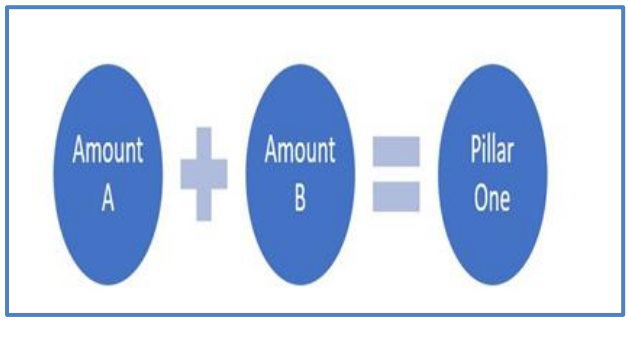
To give an example, UK resident company selling its products in India is not taxable in India if it does not have physical presence in India. This income is taxable only in the UK under India-UK tax treaty. As can be seen from this example, the market jurisdiction was not given any taxing rights on the profits of the UK company, despite being a major contributor to its profits.

In view of the above, some countries even imposed unilateral taxes, like India imposed Equalization Levy ('EL') for e-commerce and online advertisements and introduced Significant Economic Presence ('SEP') to tax goods and services consumed in India.

EL is a tax levied on the non-resident if it provides online advertisements and other related services for provision of digital advertising space or facilitates e-commerce sale of goods or services. SEP creates deemed business connection of a non-resident in India if they supply goods or service to Indian customers if it exceeds specified threshold of 3 lakhs customer or revenue of INR 2 crore.

However, EL and SEP is not sufficient to cover all goods and services as EL applies on certain specified activities and a non-resident is still not taxable under the tax treaty with India as SEP rules do not overrider tax treaty provisions.

These tax challenges on account of the digitalisation of the economy were identified as one of the key areas of focus of the OECD[1]/G20[2] Base Erosion and Profit Shifting (BEPS) Project. Hence, Pillar One[3] was developed as part of the OECD's BEPS initiative. Pillar One consists of Amount A and Amount B.



Foot note

1. Organisation for Economic Co-operation and Development – It is an international organization dedicated to shaping policies for sustainable economic growth.

2. The Group of Twenty (G20) is the main forum for international economic cooperation. It plays an important role in defining and strengthening global architecture and governance on all major international economic issues. The G20 or Group of 20 is an intergovernmental forum comprising 19 sovereign countries and European Union

3. The initial discussions on the Pillar One approach started in 2019 followed by the release of blueprints and time to time public consultation documents by the OECD.

- Amount A – It is the fundamental element of Pillar One that aims to provide taxing rights to market jurisdiction in respect of non-routine profit calculated at Multinational Enterprise (MNE) group level under a formulary approach; and
- Amount B – Fixed return for defined baseline marketing and distribution activities taking place physically in a market jurisdiction

Considering that Amount B provisions / rules are not yet released / finalized, the same is not discussed in this article.

2. Amount A:

'Amount A' focuses on re-allocation of some taxing rights from home countries to market countries regardless of physical presence or any business activity.

The Amount A shall be implemented by way of entering into the Multilateral Convention (MLC). On 11 October 2023, the OECD published the text of the MLC to Implement Amount A of Pillar One along with its explanatory statement. This article briefly covers select key provisions of the MLC. There are other provisions of the MLC which needs to be analysed separately to determine applicability and impact of Amount A.

2.1 Applicability of Amount A

Amount A applies only to the Covered Group. A Multinational Enterprise (MNE) group is considered as a Covered Group for a period[4] if in that period:

- 'Adjusted Revenues'[5] of Covered Group is greater than EUR 20 billion (Approx. INR 183,102 crore); and
- 'Pre-tax profit margin'[6] of Covered Group is greater than 10%

Where an MNE group does not meet the revenue and pre-tax profit margin thresholds but one of its reported segments in the consolidated financial statements (CFS) does on a standalone basis, the segment would be subject to Amount A.

Foot note

4. Where a Period of a Covered Group is either shorter than or longer than twelve months, any monetary amount in the MLC that is determined by reference to a Period shall be proportionately increased or reduced to correspond with the length of the Period.

5. Adjusted Revenues means the revenues reported in the Consolidated Financial Statement of the Group, subject to prescribed adjustments, as defined in Article 2(c) of the MLC

6. The term "pre-tax profit margin" means the Adjusted Profit Before Tax divided by the Adjusted Revenues of that Group for the Period.

Considering the revenue threshold of EUR 20 billion, this shall mainly apply to large and profitable MNE groups. However, the revenue threshold may be reduced to EUR 10 billion (Approx. INR 91,551 crore), contingent on successful implementation of Amount A seven years after entry into force.

Apart from the above basic conditions, additional conditions prescribed under Article 3 of the MLC should be checked to evaluate applicability of Amount A.

2.2 Exclusion (includes oil and gas sector extractive activities)

There are certain specific businesses which are excluded from the scope of Amount A. Hence, revenues from such business are not subject to Amount A. The MLC provides detailed method for excluding revenues from such businesses. We have discussed below the extractive business which is specified under the exclusion:

In case of extractive businesses, the Covered group needs to qualify as 'Qualified Extractives Group' (QEG) i.e. the Covered group is engaged in exploration, development or extraction as a principal on its own account and derives extractives revenues with substantial connection to its exploration, development or extraction In nutshell (i) a revenue test (i.e., the sale of an Extractive Product"); and (ii) an activities test (i.e., conduct Exploration, Development or Extraction) must be satisfied to qualify as QEG.

The language used exploration, development "or" extraction signify that a Covered Group is not required to do all three activities to meet the activities test.

The Covered Group shall not be regarded as QEG if it is engaged in purchasing products extracted by other QEG and perform processing without doing the extraction (such as a refinery or smelter) or only engaged in transportation (such as a pipeline), or only engaged in trading and selling extractives commodities.

The term 'principal on its own account' used in activity test signify that the Group must be involved in and exposed to the **economic risks** of the exploration, development or extraction. For example,

the holder of the licence or rights to explore or exploit would generally be acting as a principal on its own account. It does not require that the Group be conducting the exploration, development or extraction itself (and for this reason, the language further uses the term "engaged in" rather than "conducting"). However, the contractor or service provider shall not be regarded as engaged in the activities as a principal on its own account, and hence not regarded as QEG.

Thus, evaluation of oil and gas sector group is required to ascertain whether it will be regarded as QEG or not.

Example 1

Petrol is sold by A Ltd. (Country A) of QEG to another group entity B Ltd. (Country B). Country A is the jurisdiction of extraction in which entity A extracts crude oil which is processed to petrol. The revenue booked from sale of fossil fuels as reported in the A Ltd.'s financial statements shall be considered as extractive revenues. The revenue of B Ltd. from sale of the petrol and the further processing of petrol (i.e. bitumen, aviation fuel) shall not be considered as extractives revenue, as it is not revenue reported in the jurisdiction of extraction (which was Country A).

Example 2

If in the above example C Ltd., independent non-related contractor, provides exploration services to A Ltd. C Ltd group shall not be regarded as QEG as extraction is carried out by A Ltd on its own account.

2.3 Identify eligible market / customer jurisdiction

Once the group is identified as a Covered Group, the next step is to identify market / customer jurisdictions where the end customer consumes or uses goods or services. To undertake this exercise detailed revenue sourcing rules[7] are provided in the MLC.

Among all the identified market / customer jurisdiction, it is ONLY the ELIGIBLE jurisdiction which will get the allocation of the relevant portion of the Amount A Profit of a Covered Group for that Period. This is called the Nexus rule. For determination of eligibility for profit allocation, a quantitative threshold is prescribed in the rules (i.e. sourced revenue above EUR 1 million, reduced to EUR 250 thousand for jurisdictions with GDP below EUR 40 billion).

For example, revenues earned by Group A from various jurisdictions on sale of lubricants are as under:

Market Jurisdiction	Australia	UK	USA	Germany	France
Revenues (in EURO)	87 million	7.5 million	53 million	950 thousand	550 thousand
Eligible Market jurisdiction	**Yes**	**Yes**	**Yes**	**No**	**No**

Hence, only those market / customer jurisdiction which crosses the above threshold shall become eligible and the Covered Group shall be treated as having a nexus in a jurisdiction for a period.

2.4 Calculation and allocation of portion of excess profit (i.e. Amount A)

As discussed earlier, Amount A i.e. portion of excess profit shall be available for allocation to eligible market jurisdiction. Amount A Profit is defined in the MLC as under:

Amount A profit = [Adjusted Profit Before Tax[8] **–** (10% **x** Adjusted Revenues[5])] **X** 25%

Total Profit — Routine Profit

Foot note

7. Articles 6 and 7 and Annex D of the MLC

8. Adjusted Profit Before Tax is profit as per consolidated financial accounts of the MNE subject to book-to-tax adjustments and prior period losses incurred by the MNE, if any, as defined in Section 2(1) of Annx B of the MLC.

In a nutshell, 25% of non-routine profit is available for allocation to eligible market jurisdiction. The same is further explained with the help of following examples:

Adjusted Revenues (A)	Adjusted PBT / Total Profit (B)	Routine Profit (C) (10% of A)	Non-routine Profit (D) (B – C)	Amount A profit (25% of D)
1200	**100**	120	-20	No Amount A
900	**100**	90	10	2.5
800	**100**	80	20	5

The calculated Amount A profit shall be distributed to eligible market jurisdiction in the ratio of adjusted revenues of that jurisdiction to adjusted revenues of the covered group. However, in cases where market jurisdiction already has the ability to tax profits under existing profit allocation rules, the allocated amount A profit shall be reduced by 'Marketing and Distribution Profits Safe Harbour Adjustment'[9] to prevent double counting of profits.

Taking the example of para 2.3 further and assuming Amount A profit is EUR 25 million:

Market Jurisdiction	Australia	UK	USA	Germany	France
Revenues (Total EUR 150 million)	87 million	7.5 million	53 million	950 thousand	450 thousand
Eligible Market jurisdiction	**Yes**	**Yes**	**Yes**	**No**	**No**
Allocation of Amount A	**$\frac{25 * 87}{150}$**	**$\frac{25 * 7.5}{150}$**	**$\frac{25 * 53}{150}$**	**NA**	**NA**

The allocation of Amount A shall impact effective tax rate and increase administrative compliance.

2.5 Elimination of double taxation

Part IV of the MLC contains the rules for the elimination of double taxation. The same are not discussed here for the sake of brevity.

2.6 Removal and Standstill of Digital Services Taxes and Relevant Similar Measures

The MLC provides for preventing the imposition of digital services taxes (DSTs) and other similar measures[10] on all companies (whether or not they are within scope of Amount A). List of existing measures that the Parties commit to withdraw when Amount A starts applying are specified in Annex A of the MLC. Any breach of these commitments leads to the denial of Amount A. The list of existing measures includes Equalization Levy (EL) by India on e-commerce and online advertisement services.

Further, as discussed, in Indian context tax treaty overrides the SEP and hence it will not be impacted as Amount A will be implemented as part of tax treaty.

Some countries have concerns regarding removal of DSTs and implementation of Pillar One to offset the same. The same is evident from OECD's statement published 18 December 2023 stating that work is ongoing to resolving difference including DST and other relevant measures.

Foot note

9. Please refer Article 5(2) of the MLC. Brazil, Columbia and India have expressed certain objections to definitions/calculations prescribed for determination of 'Marketing and Distribution Profits Safe Harbour Adjustment'

10. Three cumulative criteria to define the measures are: (1.) the tax is applied by reference to market-based criteria (e.g. location of customers and users); (2) it is ring-fenced to non-resident or foreign-owned businesses; (3) it is outside the scope of tax treaties.

2.7 Implementation

For the MLC to enter into force, it needs to be ratified by at least 30 jurisdictions including the headquarters jurisdictions of at least 60% of MNEs currently expected to be within Amount A's scope. On meeting the conditions, the states that have ratified can decide when the MLC will enter into force.

Existing bilateral tax treaties will continue to apply but will be superseded by the MLC to the extent needed to permit the application of Amount A. Tax treaties with Jurisdictions which are not parties to the MLC will not be affected.

3. India Impact

Currently, India's consumer market is one of the top 5 consumer markets. As per the BMI (Business Monitor International) report, India's consumer market is set to become the world's third largest by 2027, behind the U.S. and China. Due to a large consumer market, it is expected that India will benefit by getting allocation of profits.

However, considering the threshold and profit criteria, currently it will cover only top 70 to 100 companies and hence there may be limited allocation of profits. Once it is implemented fully such that it applies to more groups, India may have more benefits as compared current tax collection under EL.

It is also pertinent to note that India had objected on the application of certain points / formula under the MLC.

4. Concluding thoughts

On account of Amount A, the MNEs may need to evaluate the tax impact at group level. Also, MNEs may require to collate additional information and data for Amount A calculations, examine changes in the existing system of recording data and transactions, and additional administrative compliance.

The approach and rationale of developing Pillar One and BEPS action plan is unprecedented and attempts to bring a paradigm shift to traditional tax systems. However, success of the same depends on its implementation.

As per the OECD, it is expected to finalize text of the MLC by the end of March 2024 and hold a signing ceremony by the end of June 2024. The objective is to implement Pillar One and enter into force in 2025.

In view of the above, MNEs need to closely monitor the development in coming months regarding finalization, signature and ratification of the MLC as well as the implications for DSTs and similar measures.

The information contained herein is of a general nature and is not intended to address the circumstances of any particular individual or entity. The views and opinions expressed herein are those of the author.

Events

Webinar on 'Digital Personal Data Protection Act, 2023'

Federation of Indian Petroleum Industry (FIPI), in association with EY as knowledge partner, organised a webinar on '**Digital Personal Data Protection Act, 2023'** on 5th December 2023. The webinar was conducted in order to shed light on the Act that provides processing of digital personal data in a manner which recognizes both the right of individuals to protect their personal data and the need to process such personal data for lawful purposes.

Mr. Vivekanand, Director (Finance, Taxation & Legal), FIPI began the session with the opening remarks. He said that with India being the most populous country in the world with more than 1.4 billion population, internet penetration has increased over the recent years resulting in country's digital population totalling to 700 mn active users which includes 470 million social media users creating mammoth digital data. The generation of digital data has thus assumed greater significance in terms of ownership, sharing, data protection and maintenance of mutual trust among data transmitters. He highlighted that law to protect data privacy is thus important and hence, the need and importance of Digital Personal Data Protection Act arises. He said that Digital Personal Data Protection Act marked the first law in India to safeguard the rights and responsibilities associated with management of extensive digital personal data within the economy. He welcomed the notification on the DPDP Act and said that it would pave a way for conscious digital data collection, storage, its usage, and protection.

Mr. Rajiv Chugh, Partner, and National Leader, Policy Advisory and Specialty Services Ernst & Young LLP said that with technology being the defining paradigm of the 21st century, the DPDP Act underscores the nation's focus on building a strong data privacy regime. He mentioned about the recent data breaches that has occurred in India such as – ICMR data leak of personal information of 81.5 crores Indians, Taj Hotel data breach of personal data of 15 lakh people, RailYatri data leak etc. He said that building strong data privacy governance programs within the organisations is not only a business risk requirement but also crucial for building a transparent, long-term sustainable organisation for the future.

He highlighted a major point under the Act mentioning that the time between the notification of the Act and the constitution of the Act under Data Protection Board (DPB) should not be considered as an immunity period for companies as in case there is data breach in the intermittent period, the Data Protection Board (DPB) will take necessary action against it.

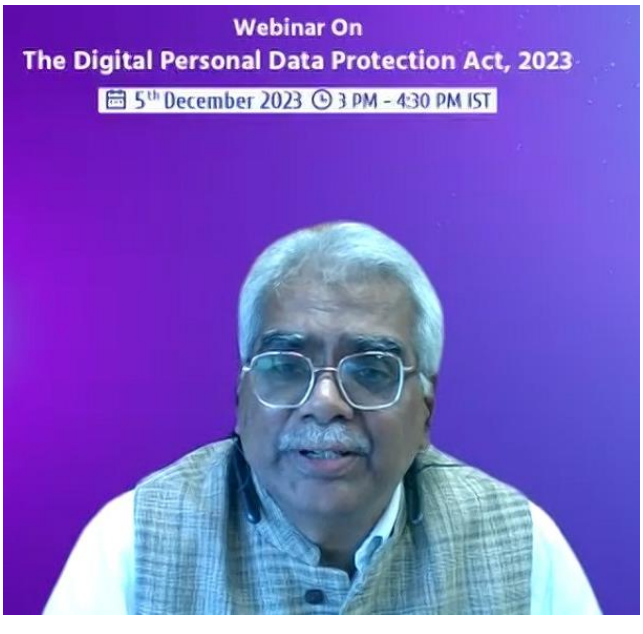
He further said that many Indian companies have already incorporated Global Data Protection Regulations (GDPR) within their organisations systems which ensures their state of readiness to comply with data privacy. He said many countries have adopted these regulations, with Australia being the first country to adopt it within their country.

He explained the intricacies of the Act. He highlighted that the DPDP Act is applicable to any personal data which is collected either in a digital form or in a hard copy which is subsequently digitised within the Indian territory or any information that is made available to a person outside the Indian territory required for the purpose of supply of goods or services in India. The processing for domestic or personal purposes by individuals or personal data made public by Data Principal out of their own consent does not come under the purview of this Act.

He then spoke about the 5 pillars of DPDP Act 2023- Data Principal, Data Fiduciary, Consent, Processing, and Certain Legitimate uses. He mentioned that a notice is required to be given by Data fiduciary to Data Principal for obtaining consent to process the data. The notice shall give the purpose of processing the data and the way Principal can exercise their rights and make a complaint to the Board. They have an option to access the notice in English and other regional languages as specified in the Constitution.

Last but not the least, he spoke about the data touch points for MNCs- login credentials (name, date, address etc; KYC details like Aadhar Card, PAN, passport details; data collected from vendors – bank account details, business profile data etc. He also spoke about the monetary penalty payable on account of non-compliance to prevent data breach and thus stressed the need for maintaining the data in a rightful manner.

The presentations were followed by a Q&A session wherein various queries posted by participants were well addressed by Mr. Chugh.



Lastly, Mr. DLN Sastri, Director (Oil Refining & Marketing), FIPI in his vote of thanks, emphasised that the topic for todays' webinar was relevant for all individuals as well as corporates that are handling and managing the client data. He complimented EY team for an elaborate presentation on the topic as it created an awareness on legal provisions of personal data protection. He said that Mr. Chugh very elaborately mentioned about the procedural aspects related to data privacy such as – consent and transparent data privacy rights, cross border transfer of data, data processing, liability and ways of safeguarding mandatory data breach notification, magnitude of penalties and enforcement, consumer rights and remedies etc. He also thanked the participants from the energy industry for their active and interactive participation during the event.

Events

Webinar on 'Carbon Markets'

Federation of Indian Petroleum Industry (FIPI), in association with S&P Global as knowledge partner, organised a webinar on 'Carbon markets' on 18th October, 2023. The webinar was conducted to delve into the fundamentals of carbon markets, exploring carbon credits and allowances while distinguishing between Voluntary and Compliance markets. The webinar gave an insight about India's proposed carbon market model (ICM) as well as Carbon Border Adjustment Mechanism (CBAM) and its potential implications on Economically Important Trade-Exposed (EITE) economies, including India's oil and gas sector. The webinar witnessed an overwhelming response with participation of more than 200 professionals working across the oil and gas value chain.

Mr. DLN Sastri, Director (Oil Refining & Marketing), FIPI began the session with the opening remarks. He spoke about the series of measures taken by Government of India to enhance energy security and improve efficiency in use of energy for inclusive growth and sustainable development. He said that in case of carbon markets, while they intend to facilitate the emission targets and support the sustainable projects, they also face several challenges viz, need for harmonised standards, verification and monitoring challenges, price volatility and uncertainty, lack of standardisation in project types etc. He mentioned that as a step towards environment sustainability, the green credit programme was announced by the Government of India, aligning with India's climate goals under the Paris Agreement. Further, he talked about the notification on Carbon Credit and Trading Scheme published in June 2023, which is anticipated to create a whole system of mechanisms that would govern the Indian carbon and greenhouse gas emissions scenario in the coming few years.

Ms. Marie-Louise du Bois, Global Head of Carbon Pricing at S&P Global Commodity Insights, talked about the need for carbon pricing and stressed the relevance of these prices to have standardisation that helps in setting benchmarks which can be widely used as a reference point by buyers, sellers, or traders. She talked about the pricing methodology and the workflow adopted by Platts which includes - from gathering the required information from a cross- section of market participants to discuss the activity in terms of bid, offers and trades - to their team reviewing the market information to assess market value at a specified point of time. She mentioned that Platts publishes and regularly reviews detailed methodology for each of the markets it covers and at the same time ensures market transparency within the system.

Ms. Agamoni Ghosh, Managing Editor for Global Compliance Carbon Markets at S&P Global Commodity Insights talked about Voluntary Credit Markets (VCM) which is the international VCM market where project-based credit is traded and is driven by methodologies that are overseeing by private standards like Verra and Gold Std. She also talked about the Compliance Credit Markets (CCM) that are authorised markets which could be defined by a region, country, or city and these are driven by methodology standards that could be an authorised approved entity or a government. She then talked about the Article 6 markets that are the Paris agreement credits which are futuristic credits which are yet to be generated as of now. She then elaborated on the difference between carbon allowance and carbon credit. While carbon allowance is a permit to emit in future, carbon credit is a certificate awarded for a proactive initiative which reduces or removes emissions.

The presentations were followed by a Q&A session wherein various queries posted by participants were well addressed by panellists.

Lastly, Mr. Vivekanand, Director (Finance, Taxation & Legal), FIPI in his vote of thanks, complimented the S&P Global team for making a comprehensive presentation on varied topics viz- voluntary and compliance markets, pricing methodology, carbon allowances, carbon pricing mechanism in various geographies, India's carbon pricing scheme, CBAM and Article 6. He said that as environment is a critical issue globally, the role of carbon credit becomes a valuable tool in the global fight against climate change. He said that India's carbon credit scheme is going to play a vital role in this regard. He thanked the participants from the energy industry for their active and interactive participation during the event.

Events

India Pavilion at ADIPEC 2023

The Abu Dhabi International Petroleum Exhibition & Conference (ADIPEC) 2023 was held from 2nd October to 5th October 2023 at Abu Dhabi, UAE under the patronage of the UAE President His Highness Sheikh Mohamed bin Zayed Al Nahyan. Organised by Abu Dhabi National Oil Company (ADNOC), the conference brought together the international energy industry to discuss and collaborate on energy-related technology, innovation, and digitalization under the theme of 'Decarbonizing. Faster. Together.'

This year, ADIPEC included four specialized areas that facilitated cross-sector collaboration and game-changing partnerships – Decarbonization Accelerator, Maritime and Logistics Zone, Digitalization in Energy Zone, and Manufacturing, Industrialization Exhibition and Conference.

India was among the 30 countries with dedicated country pavilion at ADIPEC which hosts 160,000 participants from 164 countries.

Federation of Indian Petroleum Industry (FIPI) under the aegis of Ministry of Petroleum and Natural Gas (MoP&NG) co-ordinated to set-up the India Pavilion on behalf of the Indian Oil & Gas industry in ADIPEC 2023. India's major oil & gas companies viz. ONGC, IOCL, BPCL, HPCL, OIL, GAIL, EIL, PLL and Nayara Energy participated and displayed their technologies & facilities to the global organizations during the event. Theme for this year's India Pavilion was **"Innovation & Collaboration - Driving India's Energy Transformation"** wherein capabilities of Indian Oil & Gas companies were displayed to the world.

On 2nd October 2023, Secretary Ministry of Petroleum & Natural Gas, Shri Pankaj Jain and Chairman ONGC & Chairman FIPI, Shri A.K. Singh along with several other dignitaries from Indian Oil & Gas industry attended the Opening Ceremony on the topic "Fast tracking the Energy Transition: innovative new policies and a more inclusive approach".

Later in the day, Chairman ONGC & Chairman FIPI along with MDs/CMDs from member companies welcomed Shri Hardeep Singh Puri, Hon'ble Minister of Petroleum & Natural Gas and Housing & Urban Affairs at India Pavilion. Shri Hardeep Singh Puri inaugurated the India Pavilion at ADIPEC 2023 in the presence of Senior officials from Indian oil & gas companies, Ministry of Petroleum & Natural Gas, and Indian Embassy.

On the side-lines of ADIPEC 2023, Hon'ble Minister Shri Hardeep Singh Puri held bilateral Ministerial meetings with H.E. Mr. Suhail Mohamed Al Mazrouei, UAE Minister of Energy & Infrastructure and H.E. Dr. Sultan Ahmed Al Jaber, Group CEO & Managing Director, ADNOC & Minister of Industry & Advanced Technology, UAE. He discussed about the growing energy partnership between India and the UAE and avenues for future collaborations. He also wished the UAE a successful COP 28 that kicks off on November 30, 2023.

Honourable Minister Shri Hardeep Singh Puri with HE Suhail Al Mazrouei, UAE's Minister of Energy and Infrastructure

Honourable Minister Shri Hardeep Singh Puri with HE Dr Sultan Al Jaber, UAE Minister of Industry and Advanced Technology and COP28 President Designate

Honourable Minister Shri Hardeep Singh Puri with OPEC Secretary General, HE Haitham Al Ghais

Session on 'Energy Talks: India's energy industry: from diversification to economic growth

The Hon'ble Minister of Petroleum & Natural Gas & Housing and Urban Affairs Shri Hardeep Singh Puri had various meetings with heads of international energy organizations and CEOs of global oil & gas companies viz; Mr. Joseph McMonigle, Secretary General, International Energy Forum (IEF); H.E. Mr. Haitham Al Ghais, Secretary General, OPEC; Mr. Lorenzo Simonelli, CEO, Baker Hughes; Mr. Murray Auchincloss, Interim CEO, BP; Mr. Patrick Pouyanne, CEO, Total Energies; Mr. Anders Opedal, President & CEO, Equinor; Mr. Olivier Le Peuch, CEO, SLB. The Hon'ble Minister also discussed emerging trends and developments in the field of energy and explored opportunities of partnership between the energy company and Indian oil and gas industry.

A meeting was held with Senior Officials of FIPI, Indian Oil & Gas Industry and DMG Events to review the preparations made for the India Energy Week 2024 being organized from 6th -9th February 2024 at Goa, India.

Also, a meeting was held between API, FIPI and IOCL wherein API team expressed their interest to continue MoU with FIPI in identifying activities of mutual interest. API team also contemplated to establish an office in India for close liaison with standard setting organizations such as BIS, PESO and OISD with the help of FIPI.

On 3rd October 2023, Hon'ble Minister participated in the session on the topic - "Energy Talks – India's energy industry: from diversification to economic growth" with Moderator (Anchor and Correspondent CNBC) Dan Murphy. He discussed that the economic growth-energy correlation is evident in India from the fact that it is now the world's 3rd largest energy consumer. The Minister expressed concern over the impact of the high price of $100 a barrel of oil on other developing nations, even as he remained robust about India's response to the same.

During ADIPEC, the Hon'ble Minister of Petroleum & Natural Gas & Housing and Urban Affairs Shri Hardeep Singh Puri conducted a series of interviews with international media including Bloomberg, CNN, Al Arabiya, BBC and shared views on global access to energy.

On 3rd October 2023 itself, a reception was held at India Pavilion wherein Mr. Praveen Mal Khanooja, Additional Secretary, Ministry of Petroleum & Natural Gas (MoP&NG) briefed audiences about the second edition of India Energy Week (IEW) and invited them to participate in the event.

India's participation at ADIPEC 2023 is a testament to its commitment towards being part of a solution driven agenda to accelerate clean energy transition and decarbonisation.

India showed its potential as a key player, showcasing innovation and fostering collaboration in the global energy landscape. India's dedicated energy pavilion was highly appreciated by everyone as its showcased various business opportunities to people from all facets of the oil and gas industry. With India emerging as one of the largest economies in the world, heavy footfall was witnessed in India Pavilion from global major oil and gas companies, researchers and innovators.

STATISTICS

INDIA: OIL & GAS

DOMESTIC OIL PRODUCTION (MILLION MT)

		2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	2022-23 (P)	April-Sept 2023 (P)	
												% of Total
Onshore	ONGC	6.1	5.8	5.9	6.0	6.1	6.1	5.9	5.8	5.9	3.0	41.0
	OIL	3.4	3.2	3.3	3.4	3.3	3.1	2.9	3.0	3.2	1.6	22.8
	Pvt./ JV (PSC)	9.1	8.8	8.4	8.2	8.0	7.0	6.2	6.3	5.6	2.6	36.2
	Sub Total	**18.5**	**17.8**	**17.6**	**17.5**	**17.3**	**16.2**	**15.1**	**15.1**	**14.7**	**7.2**	**100**
Offshore	ONGC	16.2	16.5	16.3	16.2	15.0	14.5	14.2	13.6	13.5	6.7	89.4
	OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pvt./ JV (PSC)	2.7	2.5	2.1	1.9	1.9	1.5	1.1	1.0	0.9	0.8	10.6
	Sub Total	**18.9**	**19.1**	**18.4**	**18.1**	**16.9**	**16.0**	**15.4**	**14.6**	**14.5**	**7.4**	**100**
Total Domestic Production		37.5	36.9	36.0	35.7	34.2	32.2	30.5	29.7	29.2	14.7	100.0
	ONGC	22.3	22.4	22.2	22.2	21.0	20.6	20.2	19.5	19.5	9.6	65.6
	OIL	3.4	3.2	3.3	3.4	3.3	3.1	2.9	3.0	3.2	1.6	11.2
	Pvt./ JV (PSC)	11.8	11.3	10.5	10.1	9.9	8.4	7.4	7.3	6.5	3.4	23.2
Total Domestic Production		**37.5**	**36.9**	**36.0**	**35.7**	**34.2**	**32.2**	**30.5**	**29.7**	**29.2**	**14.7**	**100**

Source : MoP&NG/PPAC

REFINING

Refining Capacity (Million MT on 1st April 2023)

Indian Oil Corporation Ltd.	
Barauni	6.00
Koyali	13.70
Haldia	8.00
Mathura	8.00
Panipat	15.00
Guwahati	1.00
Digboi	0.65
Bongaigoan	2.70
Paradip	15.00
Total	**70.05**
Chennai Petroleum Corp. Ltd.	
Narimanam	0.00
Chennai	10.50
Total	**10.50**
JV Refineries	
HMEL	11.30
JV Total	**11.30**

Bharat Petroleum Corp. Ltd.	
Mumbai	12.00
Kochi	15.50
Bina	7.80
Total	**35.30**
Hindustan Petroleum Corp. Ltd.	
Mumbai	9.50
Visakhapattnam	11.00
Total	**20.50**
Other PSU Refineries	
NRL, Numaligarh	3.00
MRPL	15.00
ONGC, Tatipaka	0.07
Total PSU Refineries Capacity	**154.42**
Private Refineries	
RIL, (DTA) Jamnagar	33.00
RIL , (SEZ), Jamnagar	35.20
Nayara Energy Ltd. , Jamnagar	20.00
Pvt. Total	**88.20**

Total Refining Capacity of India 253.95 (5.02 million barrels per day)
Source : PPAC

CRUDE PROCESSING (MILLION MT)

PSU Refineries	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Sept 2023 (P)
IOCL	53.13	53.59	58.01	65.19	69.00	71.81	69.42	62.35	67.66	72.41	36.52
BPCL	22.97	23.20	24.10	25.30	28.20	30.90	31.53	26.22	29.84	38.40	19.47
HPCL	15.51	16.20	17.20	17.80	18.20	18.44	17.18	16.42	13.97	19.09	11.15
CPCL	10.70	10.70	9.60	10.30	10.80	10.69	10.16	8.24	9.04	11.32	5.73
MRPL	14.60	14.60	15.53	15.97	16.13	16.23	13.95	11.47	14.87	17.12	7.61
ONGC (Tatipaka)	0.10	0.05	0.07	0.09	0.08	0.07	0.09	0.08	0.08	0.07	0.03
NRL	2.60	2.78	2.52	2.68	2.81	2.90	2.38	2.71	2.62	3.09	0.85
Sub Total	**119.61**	**121.12**	**127.03**	**137.33**	**145.22**	**151.04**	**144.71**	**127.50**	**138.08**	**161.50**	**81.36**

JV Refineries	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Sept 2023 (P)
HMEL	9.27	7.34	10.71	10.52	8.83	12.47	12.24	10.07	13.03	12.74	6.52
BORL	5.40	6.21	6.40	6.36	6.71	5.71	7.91	6.19	7.41	-	-
Sub Total	**14.67**	**13.55**	**17.11**	**16.88**	**15.54**	**18.18**	**20.15**	**16.26**	**20.44**	**12.74**	**6.52**

Pvt. Refineries	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Sept 2023 (P)
NEL	20.20	20.49	19.11	20.92	20.69	18.89	20.62	17.07	20.16	18.69	10.11
RIL	68.03	68.10	69.50	70.20	70.50	69.14	68.89	60.94	63.02	62.30	31.83
Sub Total	**88.23**	**88.59**	**88.61**	**91.12**	**91.19**	**88.03**	**89.51**	**78.01**	**83.19**	**81.00**	**41.94**

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Sept 2023 (P)
All India Crude Processing	**222.40**	**223.26**	**232.90**	**245.40**	**251.90**	**257.25**	**254.38**	**221.77**	**241.70**	**255.23**	**129.81**

Source : MoP&NG/PPAC

CRUDE CAPACITY VS. PROCESSING

	Capacity On 01/04/2023 Million MT	% Share	Crude Processing April-Sept 2023 (P)	% Share
PSU Ref	154.4	60.8	81.4	62.7
JV. Ref	11.3	4.5	6.5	5.0
Pvt. Ref	88.2	34.7	41.9	32.3
Total	**253.9**	**100**	**129.8**	**100**

Source : MoP&NG/PPAC

POL PRODUCTION (Million MT)

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Sept 2023 (P)
From Refineries	216.4	217.1	227.9	239.2	249.8	257.4	258.2	229.3	250.3	263.0	134.8
From Fractionators	3.9	3.7	3.4	3.5	4.6	4.9	4.8	4.2	4.1	3.5	1.7
Total	**220.3**	**220.7**	**231.2**	**242.7**	**254.4**	**262.4**	**262.9**	**233.5**	**254.3**	**266.5**	**136.6**

DISTILLATE PRODUCTION (Million MT)

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Sept 2023 (P)
Light Distillates, MMT	62.7	63.2	67.1	71.0	74.7	75.4	76.8	71.4	76.5	76.2	39.3
Middle Distillates , MMT	112.8	113.4	118.3	122.5	127.5	130.8	130.2	110.7	120.2	130.4	67.2
Total Distillates, MMT	**175.5**	**176.6**	**185.4**	**193.5**	**202.2**	**206.1**	**206.9**	**182.1**	**196.7**	**206.6**	**106.5**
% Distillates Production on Crude Processing	**77.6**	**77.8**	**78.5**	**77.8**	**78.8**	**78.6**	**79.9**	**80.6**	**80.0**	**79.9**	**80.9**

PETROLEUM PRICING
OIL IMPORT - VOLUME AND VALUE

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Sept 2023 (P)
Quantity, Million Mt	189.2	189.4	202.9	213.9	220.4	226.5	227.0	196.5	212.0	232.6	115.9
Value, INR '000 Cr.	864.9	687.4	416.6	470.2	566.5	783.2	717.0	469.8	899.3	1260.9	525.5
Value, USD Billion	143.0	112.7	64.0	70.2	87.8	111.9	101.4	62.2	120.4	157.5	63.7
Average conversion Rate, INR per USD (Calculated)	60.5	61.0	65.1	67.0	64.5	70.0	70.7	75.5	74.7	80.1	82.5

OIL IMPORT - PRICE USD / BARREL

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Sept 2023 (P)
Brent (Low Sulphur - LS- marker) (a)	107.5	85.4	47.5	48.7	57.5	70.0	61.0	44.3	80.7	96.0	82.6
Dubai (b)	104.6	83.8	45.6	47.0	55.8	69.3	60.3	44.6	78.1	92.4	82.2
Low sulphur-High sulphur differential (a-b)	2.9	1.7	1.8	1.7	1.6	0.7	0.6	-0.3	2.7	3.5	0.4
Indian Crude Basket (ICB)	105.52	84.16	46.17	47.56	56.43	69.88	60.47	44.82	79.18	93.15	82.33
ICB High Sulphur share %	69.90	72.04	72.28	71.03	72.38	74.77	75.50	75.62	75.62	75.62	75.62
ICB Low Sulphur share %	30.10	27.96	27.72	28.97	27.62	25.23	24.50	24.38	24.38	24.38	24.38

INTERNATIONAL PETROLEUM PRODUCTS PRICES EX SINGAPORE, ($/bbl.)

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Sept 2023 (P)
Gasoline	114.3	95.5	61.7	58.1	67.8	75.3	67.0	47.5	89.7	107.2	94.8
Naphtha	100.2	82.2	48.5	47.1	56.3	65.4	55.1	43.9	79.9	78.4	66.4
Kero / Jet	121.2	66.6	58.2	58.4	69.2	83.9	70.4	45.8	87.3	125.5	102.3
Gas Oil (0.05% S)	122.0	99.4	57.6	58.9	69.8	84.1	74.1	50.0	90.2	132.8	104.0
Dubai crude	104.6	83.8	45.6	47.0	55.8	69.3	60.3	44.6	78.1	92.4	82.2
Indian crude basket	105.5	84.2	46.2	47.6	56.4	69.9	60.5	44.8	79.2	93.2	82.3

CRACKS SPREADS ($/ BBL.)

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Sept 2023 (P)
Gasoline crack											
Dubai crude based	9.7	11.7	16.1	11.1	12.0	5.9	6.7	2.9	11.7	14.7	12.7
Indian crude basket	8.8	11.3	15.6	10.6	11.4	5.4	6.5	2.6	10.5	14.0	12.5
Diesel crack											
Dubai crude based	17.4	15.7	12.0	12.0	13.9	14.8	13.8	5.5	12.2	40.3	21.9
Indian crude basket	16.5	15.3	11.5	11.4	13.4	14.2	13.6	5.2	11.0	39.6	21.7

DOMESTIC GAS PRICE ($/MMBTU)

Period	Domestic Gas Price (GCV Basis)	Price Cap for Deepwater, High temp Hingh Pressure Areas
October 17 - March 18	2.89	6.30
April 18 - September 18	3.06	6.78
October 18 - March 19	3.36	7.67
April 19 - September 19	3.69	9.32
October 19 - March 20	3.23	8.43
April 20 - September 20	2.39	5.61
October 20 - March 21	1.79	4.06
April 21 - September 21	1.79	3.62
October 21 - March 22	2.90	6.13
April 22 - September 22	6.10	9.92
October 22 - March 23	8.57	12.46
1 April 23 - 7 April 23	9.16	12.12
8 April 23 - 30 April 23	7.92	
1 May 23 – 31 May 23	8.27	
1 June 23 – 30 June 23	7.58	
1 July 23 – 31 July 23	7.48	
1 August 23 – 31 Aug. 23	7.85	
1 Sept. – 31 Sept. 23	7.85	
1 Oct. – 31 Oct. 23	9.20	9.96

Source: MoP&NG/PPAC/OPEC

GAS PRODUCTION

	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Sept. 2023 (P)
ONGC	21177	22088	23429	24677	23746	21872	20629	19969	9751
Oil India	2838	2937	2881	2722	2668	2480	2893	3041	1517
Private/ Joint Ventures	8235	6872	6338	5477	4770	4321	10502	11440	6611
Total	**32250**	**31897**	**32648**	**32875**	**31184**	**28672**	**34024**	**34450**	**17879**

		2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Sept 2023 (P)
Onshore	Natural Gas	8845	9294	9904	10046	9893	9601	10471	10368	5041
	CBM	393	565	735	710	655	477	518	673	325
	Sub Total	**9237**	**9858**	**10639**	**10756**	**10549**	**10078**	**10989**	**11042**	**5366**
Offshore		23012	22038	22011	22117	20635	18428	22869	23409	12513
	Sub Total	**23012**	**22038**	**22011**	**22117**	**20635**	**18428**	**22869**	**23409**	**12513**
	Total	**32249**	**31897**	**32649**	**32873**	**31184**	**28506**	**33858**	**34450**	**17879**
	(-) Flare loss	1120	1049	918	815	927	721	727	786	375
	Net Production	**31129**	**30848**	**31731**	**32058**	**30257**	**27785**	**33131**	**33664**	**17504**

	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Sept. 2023 (P)
Net Production	31129	30848	31731	32058	30257	27785	33131	33664	17504
Own Consumption	5822	5857	5806	6019	6053	5736	5760	5494	2728
Availabilty	25307	24991	25925	26039	24204	22049	27371	28170	14776

AVAILABILITY FOR SALE

	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Sept. 2023 (P)
ONGC	16076	17059	18553	19597	18532	16972	15874	15519	7631
Oil India	2314	2412	2365	2207	2123	1930	2190	2287	1141
Private/ Joint Ventures	6917	5520	5007	4235	3549	3147	9307	10364	6004
Total	**25307**	**24991**	**25925**	**26039**	**24204**	**22049**	**27371**	**28170**	**14776**

CONSUMPTION (EXCLUDING OWN CONSUMPTION)

	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Sept. 2023 (P)
Total Consumption	46695	49677	53364	54779	58091	54910	59277	54817	29886
Availabilty for sale	25307	24991	25925	26039	24204	22049	27371	28170	14776
LNG Import	21388	24686	27439	28740	33887	32861	31906	26647	15110

GAS IMPORT DEPENDENCY

	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Sept. 2023 (P)
Net Gas Production	31129	30848	31731	32058	30257	27785	33131	33664	17504
LNG Imports	21388	24686	27439	28740	33887	32861	31906	26647	15110
Import Dependency (%)	40.7	44.5	46.4	47.3	52.8	54.2	49.1	44.2	46.3
Total Gas Consumption*	**52517**	**55534**	**59170**	**60798**	**64144**	**60646**	**65037**	**60311**	**32614**

* Includes Own Consumption

Source: MoP&NG/PPAC

SECTOR WISE DEMAND AND CONSUMPTION OF NATURAL GAS

		2020-21	2021-22	2022-23 (P)	2023-24						
					April	May	June	July	August	September	Total
Fertilizer	R-LNG	11227	12363	15315	1376	1528	1372	1415	1520	1506	**8717**
	Domestic Gas	6554	5716	4085	234	251	242	251	255	262	**1495**
Power	R-LNG	3564	2670	1235	511	234	267	215	397	292	**1916**
	Domestic Gas	7272	6260	6918	522	553	562	507	582	531	**3257**
City Gas	R-LNG	4456	5238	3164	201	270	232	265	276	209	**1453**
	Domestic Gas	4774	6890	8864	839	839	812	839	842	880	**5051**
Refinery	R-LNG	6136	3924	2437	265	302	262	278	278	295	**1680**
	Domestic Gas	1775	1389	1472	71	171	171	214	240	183	**1050**
Petrochemical	R-LNG	2660	2425	1116	164	132	75	88	117	110	**686**
	Domestic Gas	412	334	843	92	115	93	131	108	96	**635**
Others	R-LNG	3590	3376	2506	225	200	303	240	335	256	**1559**
	Domestic Gas	3636	8933	10748	822	873	995	1123	1184	1161	**6158**

Qty. in MMSCM Source: PPAC

CGD INFRASTRUCTURE

	Segments	As on 31st March 2019	As on 31st March 2020	As on 31st March 2021	As on 31st March 2022	As on 31st March 2023	As on 31st Oct. 2023
PNG	Domestic	50,43,188	60,68,415	78,20,387	93,02,667	1.10 Cr	1.19 Cr
	Commercial	28,046	30,622	32,339	34,854	37,772	39,586
	Industrial	8,823	10,258	11,803	13,215	16,563	17,648
CNG	CNG Stations	1,730	2,207	3,101	4,433	5,665	6,088
	CNG Vehicles	33.47 lakhs	37.10 lakhs	39.55 lakhs	44.09 lakhs	51.40 lakhs	56.93 lakhs
LNG	LNG Vehicles					56	191

Source: PPAC/Vahan

MAJOR NATURAL GAS PIPELINE NETWORK as on 31.09.2023

Nature of pipeline		GAIL	GSPL	PIL	IOCL	AGCL	RGPL
Operational	Length	11,007	2,716	1,479	143	107	304
	Capacity	167.2	43.0	85.0	20.0	2.4	3.5
Partially commissioned#	Length	4,714			1040		
	Capacity	55.0			84.7		
Total operational length		**15,720**	**2,716**	**1,479**	**1,183**	**107**	**304**
Under construction	Length	3,955	100		456		
	Capacity	26.3	3.0		1.0		
Total length		**19,676**	**2,816**	**1,479**	**1,639**	**107**	**304**

Nature of pipeline		GGL	DFPCL	ONGC	GIGL	GITL	Others*	Total
Operational	Length	73	42	24				15,895
	Capacity	5.1	0.7	6.0				
Partially commissioned#	Length				1,285		365	7,403
	Capacity				122.5			-
Total operational length		73	42	24	1,285	0	365	23,298
Under construction	Length				916	220	4,361	10,009
	Capacity							-
Total length		73	42	24	2,201	220	4,726	33,307

*Includes AGCL, DFPCL, ONGC and excludes CGD pipeline network

Source: PPAC/PNGRB

EXISTING LNG TERMINALS

Location	Companies	Capacity (MMTPA) As on 01st Dec.'23	Capacity Utilisation (%) April- Oct.'23
Dahej	Petronet LNG Ltd	17.5	95.1
Hazira	Shell Energy India Pvt Ltd	5.2	37.1
Dabhol*	Konkan LNG Ltd	5	34.3
Kochi	Petronet LNG Ltd	5	19.5
Ennore	Indian Oil LNG Pvt Ltd	5	16.8
Mundra	GSPC LNG Ltd	5	12.2
Dhamra	Adani Total Pvt Ltd	5	26.0
Total Capacity		47.7 MMTPA	

*To increase to 5 MMTPA with breakwater. Only HP stream of capacity of 2.9 MMTPA is commissioned
Source: PPAC

2023 WORLDWIDE ACTIVE RIG COUNT

REGION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
US	772	758	753	752	728	687	673	647	632	623	619	623
Canada	226	248	196	109	90	146	186	189	188	192	197	161
Latin America	170	181	183	178	190	189	177	173	175	175	175	174
Europe	117	111	118	120	109	122	124	121	115	122	118	122
Middle East	318	327	323	337	339	329	334	329	327	337	347	336
Africa	92	94	97	93	94	101	102	109	105	111	120	109
Asia Pacific(1)	126	125	132	144	158	151	148	143	141	140	141	137
India	78	77	77	75	75	75	76	77	77	77	77	77
TOTAL	1899	1921	1879	1808	1783	1800	1820	1788	1760	1777	1794	1739

Source: Baker Hughes, (1) Excluding India's Rig Count

Member Organizations

S.No	Organization	Name	Designation
1	Adani Welspun Exploration Ltd.	Mr. Arvind Hareendran	Sr. Vice-President (Exploration)
2	Axens India (P) Ltd.	Mr. Siddhartha Saha	Managing Director
3	Baker Hughes, A GE Company	Mr. Neeraj Sethi	Country Leader
4	Bharat Petroleum Corporation Ltd.	Mr. G. Krishnakumar	Chairman & Managing Director
5	Bliss Anand Pvt. Limited	Mr. Vikas Anand	Managing Director
6	BP Exploration (Alpha) Ltd	Mr. Sashi Mukundan	President, bp India & Senior Vice-President, bp Group
7	Cairn Oil & Gas, Vedanta Ltd	Mr. Sunil Duggal	Group CEO, Vedanta Ltd
8	Central U.P. Gas Ltd.	Mr. Rathish Kumar Das	Managing Director
9	Chandigarh University	Mr. Satnam Singh Sandhu	Chancellor
10	Chennai Petroleum Corporation Ltd.	Mr. Arvind Kumar	Managing Director
11	Chi Energie Pvt. Ltd.	Mr. Ajay Khandelwal	Director
12	CSIR- Indian Institute of Petroleum	Dr Harender Singh Bisht	Director
13	Decom North Sea	Mr. Will Rowley	Interim Managing Director
14	Dynamic Drilling & Services Pvt. Ltd.	Mr. S.M. Malhotra	President
15	Engineers India Ltd.	Ms. Vartika Shukla	Chairman & Managing Director
16	Ernst & Young LLP	Mr. Rajiv Memani	Country Manager & Partner
17	ExxonMobil Gas (India) Pvt. Ltd.	Mr. Monte Dobson	Chief Executive Officer
18	FMC Technologies India Pvt. Ltd.	Mr. Housila Tiwari	Managing Director
19	GAIL (India) Ltd.	Mr. Sandeep Kumar Gupta	Chairman & Managing Director
20	GSPC LNG Ltd.	Mr. Anil K. Joshi	Chief Executive Officer
21	Goa Natural Gas Private Limited	Mr. Mohd Zafar Khan	Chief Executive Officer
22	h2e Power Systems Pvt Ltd.	Mr. Siddharth R. Mayur	MD &CEO
23	Hindustan Petroleum Corporation Ltd.	Dr. Pushp Kumar Joshi	Chairman & Managing Director
24	HPCL Mittal Energy Ltd.	Mr. Prabh Das	Managing Director & CEO
25	IIT (ISM) Dhanbad	Prof. J. K. Pattanayak	Director (Officiating)
26	IMC Ltd.	Mr. A. Mallesh Rao	Managing Director
27	Indian Gas Exchange Ltd.	Mr. Rajesh Kumar Mediratta	Managing Director & CEO
28	Indian Oil Corporation Ltd.	Mr. S.M. Vaidya	Chairman
29	Indian Strategic Petroleum Reserves Ltd.	Mr. L.R. Jain	CEO & MD
30	IndianOil Adani Ventures Ltd.	Mr. Anubhav Jain	Managing Director
31	Indradhanush Gas Grid Ltd.	Mr. Ajit Kumar Thakur	Chief Executive Officer
32	Indraprastha Gas Ltd.	Mr. Kamal Kishore Chatiwal	Managing Director
33	International Gas Union	Mr. Milton Catelin	Secretary General

Member Organizations

S.No	Organization	Name	Designation
34	IPIECA	Mr. Brian Sullivan	Executive Director
35	IRM Energy Pvt. Ltd.	Mr. Karan Kaushal	Chief Executive Officer
36	Jindal Drilling & Industries Pvt. Ltd.	Mr. Raghav Jindal	Managing Director
37	Lanzatech Pvt. Ltd.	Dr. Jennifer Holmgren	Chief Executive Officer
38	Larsen & Toubro Ltd.	Mr. S.N. Subrahmanyan	CEO & Managing Director
39	Mangalore Refinery & Petrochemicals Ltd.	Mr. Sanjay Varma	Director (Refinery) & MD (Addl. Charge)
40	MIT World Peace University Pune	Mr. Rahul V. Karad	Executive President
41	Nayara Energy Ltd.	Mr. Prasad K. Panicker	Chairman & Head of Refinery
42	Numaligarh Refinery Ltd.	Mr. Bhaskar Jyoti Phukan	Managing Director
43	Oil and Natural Gas Corporation Ltd.	Mr. Arun Kumar Singh	Chairman & CEO
44	Oil India Ltd.	Dr. Ranjit Rath	Chairman & Managing Director
45	Petronet LNG Ltd.	Mr. Akshay Kumar Singh	Managing Director & CEO
46	Pipeline Infrastructure Ltd.	Mr. Akhil Mehrotra	Chief Executive Officer
47	Rajiv Gandhi Institute of Petroleum Technology	Prof. A.S.K. Sinha	Director
48	Reliance BP Mobility Ltd.	Mr. Harish C Mehta	Chief Executive Officer
49	Reliance Industries Ltd.	Mr. Mukesh Ambani	Chairman & Managing Director
50	S&P Global Commodity Insights	Mr. Saugata Saha	President
51	Scottish Development International	Mr. Richard Baker	Head of Trade – Energy and Low Carbon Transition
52	Secure Meters Ltd.	Mr. Sunil Singhvi	CEO-Energy
53	Shell Companies in India	Ms. Mansi Madan Tripathy	Country Chair
54	Siemens Ltd.	Mr. Guilherme Vieira De Mendonca	CEO (Siemens Energy - India)
55	SLB	Mr. Vinay Malhotra	Manging Director
56	SNF Flopam India Pvt. Ltd.	Mr. Shital Khot	Managing Director
57	South Asia Gas Enterprise Pvt. Ltd.	Mr. Subodh Kumar Jain	Director
58	Sun Petrochemicals Pvt. Ltd.	Mr. Padam Singh	President
59	THINK Gas Distribution Pvt. Ltd.	Mr. Hardip Singh Rai	Chief Executive Officer
60	Topsoe India Private Limited	Mr. Alok Verma	Managing Director
61	TotalEnergies Gas & Power Projects India Pvt. Ltd.	Ms. Ahlem Friga-Noy	Country Chair
62	University of Petroleum & Energy Studies	Dr. Sunil Rai	Chancellor
63	VCS Quality Services Pvt. Ltd.	Mr. Shaker Vayuvegula	Director
64	World LP Gas Association	Mr. James Rockall	CEO & Managing Director

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