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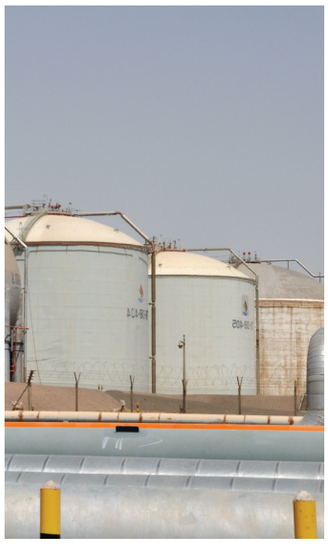
Content



THE FULL VERSION OF ALL ARTICLES CAN BE VIEWED THROUGH THE FOLLOWING LINK: http://vmshofygp1677:93

Editor's Note

Khuloud Al-Mutairi
Corporate Communication Manager

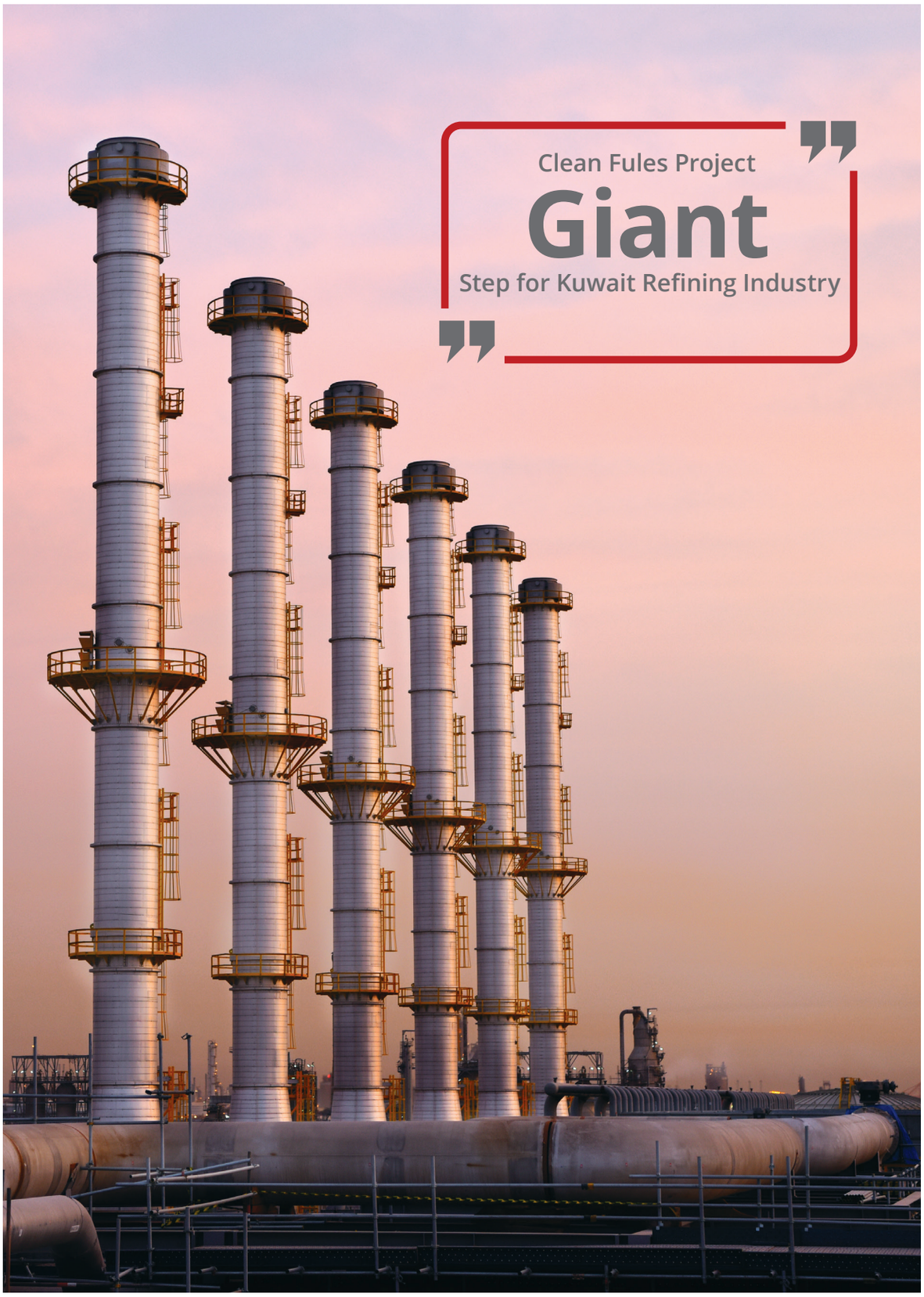
I am proud to present you with the 3rd issue of the KNPC TECH Magazine that tackles and covers a range of key topics, varying from Product Blending, to Oil Market Overview, Vapor Recovery to HSE Risk Management Process and many more as we continue to feature the main activities of the Refineries, Local Marketing, Market Research and MOG through working papers given at International Symposiums and Conferences, the 18th Kuwait - Japan Joint Symposium, entitled "Advancement in Petroleum Industries" and BASF's International Multi-User FCC Conference held in Spain to name a few.

Such papers reflect the high technical competency of our KNPC Engineers, and properly serving the purpose of our Magazine to share knowledge and findings with the rest of the team.

Other articles featured within tackle advanced applications utilized by the Company or about its Refineries, all the way to Diesel Additives applied to improve the operational excellence and profitability.

This issue of the KNPC TECH Magazine features an article covering an invention, which was patented in USA. This invention is useful in maintaining assets and facilities along with the safety of individuals, equipment and the environment, thus, adding another safety element to our business.

I invite you today to browse through our Magazine's content and benefit from the various articles that cover the broadest technical topics possible, as we continuously strive to make them available to the wider segment of our readers.


Clean Fules Project
Giant
Step for Kuwait Refining Industry

A News Letter from MAB Operational Planning

Mina Abdullah Refinery (MAB) issues quarterly reports about the Refinery operations, including the daily throughput, performance, profitability and other useful information that reflects the true position of the Refinery.

MAB crude throughput was 271.1 kbpd during the 4th Quarter, 2017/2018. The main units operations were close to the set plan. e.g. the ARDS-12 Unit operated at maximum throughput of 84 kbpd, and HCR-14 feed rate operated at 42.4 kbpd by undertaking various in-house PIP steps like CGO processing at 1-2 kbpd in unit. Whereas, the HCR-14 profitability averaged 22.5 $/Bbl, while Coker-20 profitability averaged about 16.7 $/ Bbl during the quarter.

Quarterly latest price update

- KEC prices were in range of 59.0 – 67.3 $/ Bbl;
- LPG prices were lower than Naphtha (average 81.2 $/ ton);
- ATK prices were higher than 500 ppm diesel (average 1.1 $/bbl);
- Fuel Oil prices ranged between 342.8 to 383.9 $/ ton.

News in brief

1. Oil prices reduced lower as US production increased and also due to refinery maintenance shutdown.
2. Sweet Sour differential lowered except in Europe where difference between Brent Urals increased.

3. Crude oil demand was in range of 100 mmbpd. Growth of 1.6 % higher than previous year.
4. Gasoline cracks were down in US, it were up in Europe & Asian market.
5. Jet cracks were down in US, it was up in Europe & Asian market.
6. Diesel cracks were down in US, Europe & Asian markets.
7. Fuel Oil was up in Europe & Asian market.

Source: Oil News/ EIA survey

MAB performance highlights

- Coker Feed-rate was lower in quarter due to non-availability of sufficient ARDR from MAA (ARDS 80/81 S/D at MAA);
- Naphtha yield was increased by 2-2.5 kbpd by lowering LPG yield due to economics;
- HYD-03 unit idle as per Hydrogen Management from 30th Jan 2018;

- HSAR processing at 3-5 kbpsd in Vac-13 Tr-I unit as per PIP opportunity to enhance CFS;
- Diesel Hydrotreater -216.

Diesel Hydrotreater-216 is being targeted to be ready for early start-ups.

MAB Major Accomplishments in FY 2017/ 18

- **Performance**: MAB Refinery performance was excellent. The crude processing reached a maximum level and major planned shutdown were successfully completed. The Refinery continued its remarkable improvement in most of key Solomon KPIs featuring in Quartile-1 or 2 in 2017. Customer satisfaction was the prime motto with highest product quality standards with very minimal finished products quality giveaways.
- **CFP Project**: Works remained in progress on full swing including formation of various teams for walk-throughs, monitoring progress, conducting basic information lectures, etc. as well as in-house trainings/ presentations to Refinery staff.
- **Refinery brought** laurels to international repute by British Council International Awards with MERIT for year 2017 (every year since 2002), ROSPA President Award for occupational Health & Safety for the 12th consecutive year and KNPC-CEO HSE Bronze Award at site level for year 2017.
- **Integrated Management System (IMS)**, which integrates components of a business like integrated Environment Management System (ISO 14001:2004), Occupational Health and Safety Management System (OHSAS 18001) & Quality Management System (ISO 9001:2015) into one system was successfully launched in mid- 2017.
- **Cost Optimization & Profit Improvement** (COPI) was pursued relentlessly contributing immensely to MAB profitability.
- **Economic Awareness** drive was re-energized in this year apart from publication of Quarterly Economic News and various awareness presentations to refinery personnel.
- **A total** of 21 Capital Projects and 5 HSE Projects were taken up for implementation.

ARD Unit under construction at CFP

Nawal Al-Badou
Team Leader, Operational Planning, MAB

Customized Additives to Produce EURO-V Grade Diesel

Euro-4 and Euro-5 specifications are now the common standards in most countries. The aim is to further restrict the emissions, from both gasoline and diesel cars, of CO2, NOx, Sulfur and other pollutants, which pose the most serious health and environmental problems. After CFP is completed, KNPC products will meet those stringent standards.

Diesel production post CFP at MAB

Post CFP, Mina Abdullah Refinery (MAB) is designed to produce 10 ppm 'S' Diesel known as Ultra Low Sulfur Diesel (ULSD). ULSD will be produced mainly from two new HydroTreating Units (DHTU-116/216 under CFP) with feed comprising Raw Diesel ex Crude/Coker and Distillate from Atmospheric Residue Desulphurization (ARDS). ULSD produced as above shall be subsequently blended with the Hydrocracker Diesel stream. ULSD shall be supplied to Asian and European markets.

Some key additive dosing is required for Euro-V grade ULSD production based on new specifications as issued by Kuwait Petroleum Corporation (KPC), which is a challenge to MAB being the first time of its kind for procurement and usage while meeting commitment of Euro–V grade ULSD new specifications through product additives.

Apart from meeting new stringent Diesel grades, MAB revenue/profit is also projected to improve in comparison to earlier 500 ppm 'S' Diesel production (Figure-1).

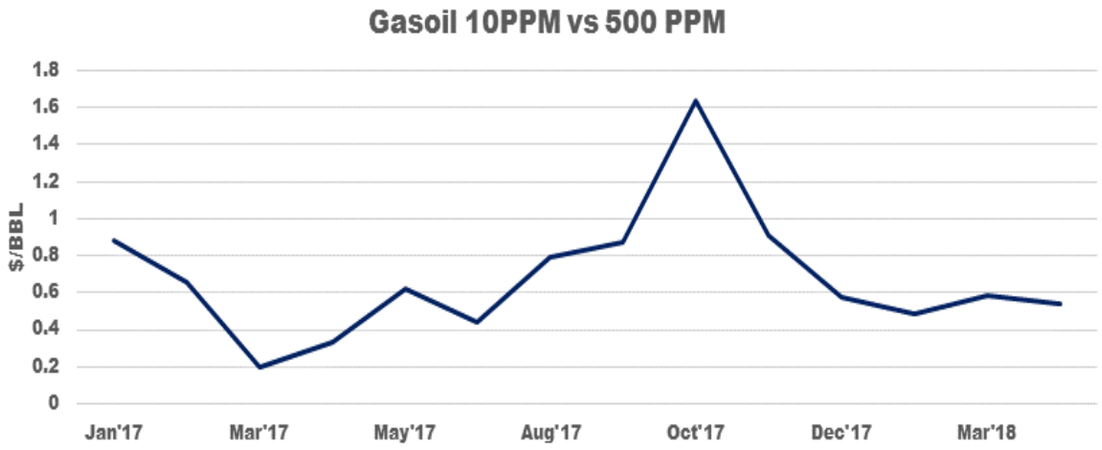


Figure 1: The plot above shows the difference of price in ULSD and 500 ppm 'S' Diesel on time line. ULSD price will be higher by approximately 0.8 $/BBL (avg).

Challenges to meet new EURO-V Diesel Specifications at MAB:

Following additives will be required to be doped before selling ULSD product for Asian and European markets (Euro-V grade).

1. Additional doping of new additives:

A. Antistatic additive (ASA) is required throughout the year for both the markets.

B. Wax Anti Settling Additive (WASA) is mandatory for Europe winter Grade ULSD only.

2. Cold Flow Plugging Point (CFPP) specification has been revised from design level of maximum (20-)°C to (22-)°C for Europe winter Grade ULSD.

3. More efficient Lubricity Improver (LI) such as Ester based LI may have to be added replacing Acid Based LI.

Development of combined additives Lubricity + ASA and CFPP+ WASA to overcome system limitations to handle additional two additive doping is an additional challenge. Combined additive doping will benefit MAB by avoiding multiple additive handling and ease to procure in ISO containers.

Study requirements and approach

MAB has already studied these requirements and approached chemical manufactures for a study in their R&D Center to customize the most suitable additive for MAB. In order to overcome the above challenges, following stepwise approach has been devised:

STEP 1: ASA additive is required for improving conductivity so that static charges produced during Diesel transfer are dissipated fast. This is required for ULSD due to deep removal of sulfur from Diesel in Post CFP-HTUs.

STEP 2: Lubricity Additive (LI): Higher efficient LI additive (Ester based). Yet to be confirmed at MAB laboratory, will be checked and certified.

STEP 3: CFPP & WASA Additives: These additives are to be customized. Improvement of CFPP is dependent on type of Diesel. MAB Diesel falls in the category of Super Narrow Boiling Diesel (difference in temperature at 90% recovery and temperature at 20% recovery less than 80°C), which is difficult to treat.

Hence a customized additive is required to be developed for improving CFPP by 8°C : (base CFPP (-14)°C, target CFPP (-22)°C.

STEP 4: Combined Additives: Following combination, additives will also be studied for customization:

A. Lubricity + ASA
B. CFPP + WASA

Additive approvals requirement for EURO-V grade ULSD to Europe market

All Diesel additives must be DGMK approved for exporting as EURO-V grade in Europe market. DGMK is a German institution that directly manages German fuel quality. Extensive laboratory "No Harm" testing is required by additive supplier per DGMK.

All Diesel additives for Europe Grade Diesel, must be Multi Product Pipeline (MPP) approved under Energy Institute (EI) EI1535 Protocol with limitation of maximum doping rate.

Previous study experiences

Last year MAB has conducted a successful research work on chemical development of De-haze additive and combined additive for Lubricity+ De-haze & Lubricity + CFPP+ De-haze additive for Diesel in order to reduce demurrage charges mainly due to higher certification time because of moisture problem in Diesel and to improve MAB profit as part of product development. MAB will use those resources and experience for conducting this study.

Conclusion

MAB is fully confident to overcome the above challenges well in time with our earlier experience. MAB will always ensure to meet market commitments with higher revenue through superior quality products that are consistent with KNPC`s Corporate Mission and Vision.

Isocracker Unit - MAB

Product Blending

Refiners should maintain the highest quality for oil products and ability to react swiftly and positively to whatever changes or even conflicting requirements in the international markets. One of the refiners most critical commercial issues is the selection of the ideal mixture or combination of ingredients to produce the requested finished products according to the needed specifications. Blending is not merely mixing of components, but it may involve multiple streams, each of which crucially affects the finished product specification and cost.

What is blending?

The art of mixing the different components in a desired/ controlled proportion referred to as "Blending."

What to blend? Why to blend?

All refiners in the world mix various intermediate components (both low value and high value products) to achieve a finished product which is both marketable and profitable.

In other words, petrochemical naphtha can be sold as a product, but blending naphtha into gasoline is more profitable to the Company.

Khaled Al-Ajmi
Team Leader, Operations, MAA

Objectives

- The primary objective of blending is to maximize the refinery profit;
- Produce a variety of products as per market demand;
- Produce products with required specifications at the lowest cost;
- Utilize all intermediate refinery products to produce finished products in optimized way.

Blinding Products

The major refinery products produced by blending includes:

- MOGAS / GASOLINE
- DIESEL/ GASOIL
- FUEL OILS
- ATK/ JET FUELS

Important blending properties

For blending the products, the following properties define the cost and usage:

1. Density: is the mass of a liquid per unit volume denoted as kg/liters;
2. Specific Gravity: (relative density) is the ratio of mass of volume of given liquid at 60 °F to the mass of equal volume of water at the same temperature;
3. Octane number: is specific for blended gasoline (knocking tendency);
4. Cetane number: is specific for blended diesel (ignition delay);
5. Vapor pressure: is applicable to all and calculated as an average of mole percentage of each components (boiling range, RVP);

6. Cloud Point: of a fluid is the temperature at which dissolved solids are no longer completely soluble, precipitating as a second phase giving the fluid a cloudy appearance (gum formation);

7. Flash Point: is the temperature at which the product releases enough vapor to form a mixture with air that will ignite in presence of a flame (storage, handling and handling safety);

8. Pour Point: of a liquid is the lowest temperature at which it becomes semi solid and loses its flow characteristics, mainly used for fuel oil (handling and usage);

9. Viscosity: is a measure of the resistance of a fluid to flow, which is being deformed by either shear or tensile stress;

10. Sulfur Concentration: is the average weight percentage of sulfur in individual component (cost, environmental, handling and usage).

Online Analyzers used in blending systems

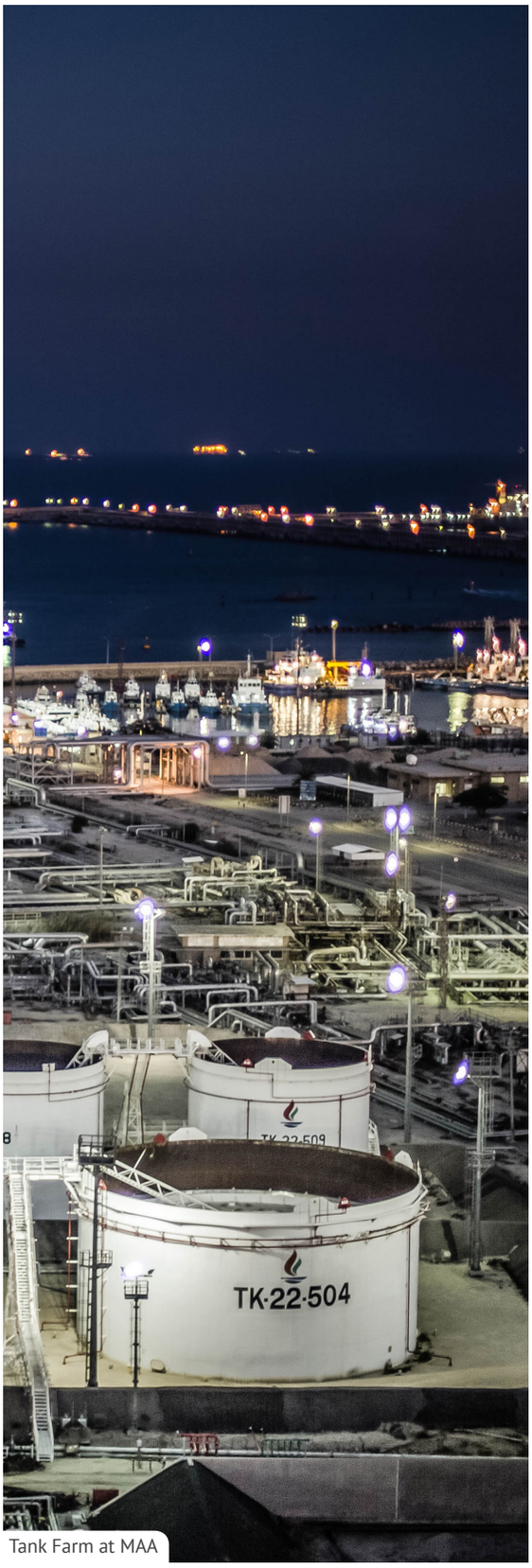
During mass production, several types of online analyzers are used in blending systems to ensure correct quality and to facilitate blending supervisory system to adjust the blend according to the output quality.

Types of Analyzers:

1. Density Analyzer
2. RVP Analyzer
3. Sulfur Analyzer
4. Gas Chromatograph
5. Octane Analyzer
6. Distillation Analyzer
7. Moisture Analyzer

Although these Analyzers are provided to ensure quality online, the final quality of the blended product will be on lab analysis only.

Every sold product will be accompanied by a Product Quality Certificate to the customer.



Tank Farm at MAA

Blending can be done on either:

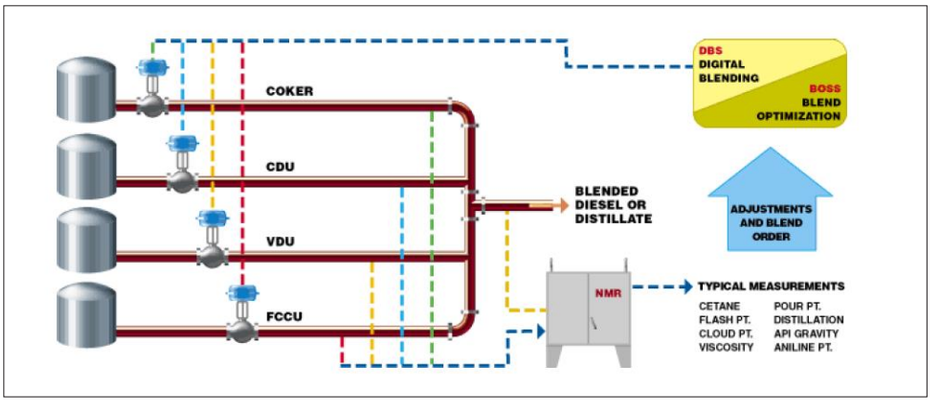
1. Open Loop

Open loop is when the components are blended via static mixer with reference to prescribed volumetric ratios only. (Deviation in blend gets indications/alarms only).

2. Closed Loop

Closed loop is when the components are blended via static mixer with adherence to volumetric ratio with reference to the output quality. This is done by Digital Blending System and Blend Optimization Supervisory System. (deviation in blend gets indications/ alarms and rectified by BOSS through adjusting the component ratio accordingly in order to get a quality product).

Schematic Blending Diagram



Online Blending

- Due to a limited storage space, many refineries today have the ability to use computer-controlled in-line product blending.
- Inventories of blending stocks, together with cost and physical property data are saved in the computer.
- When a certain volume of a given quality product is specified, the computer uses linear programming models to optimize the blending operations (select the optimum volume of blending components) to produce the required product at the lowest cost.
- To ensure that the blended streams meet the desired specifications, stream analyzers, such as boiling point, specific gravity, RVP, and research and motor octane are installed to provide feedback control of blending streams and additives (if necessary).
- Blending components to meet all critical specifications most economically is a trial-and-error (iterative) procedure which is easily handled by a computer.
- The large number of variables leads to a number of equivalent solutions that give the approximate equivalent total overall cost or profit.
- Optimization programs (PIMS for example) permit the computer to provide the optimum blend to minimize cost and maximize profit.

- Both linear and non-linear programming techniques are used.

- Non-linear programming is preferred if sufficient data are available to define the equations because components blend non-linearly and values are functions of the quantities of the components and their properties (specs).

Typical refinery sources for Gasoline (blending components)

- Reformate
- FCC LN/HN
- Hydrocracker LN
- Alkylate
- MTBE
- ARDS/Naphtha
- Coker Gasoline
- Isomerization (isomerate)
- Octane improve (MTBE / METHANOL etc.)

These gasoline blending-stocks have different molecular contents and performance qualities (RON, MON, RVP, API, BP range, etc.).

Blending components must meet all desired specifications as boiling point, specific gravity, RVP, Research Octane Number (RON) and Motor Octane Number (MON).

The product is designated 'off spec' if it does not meet one or more of the required specifications which could make it unsalable or salable for a lower price.

Exceeding one or more of the required product specifications is termed 'giveaway', which is also a loss for the refinery because it is selling higher quality product for a lower price.

MAA Blender capacity (existing & post CFP)

PRODCUT	Existing Capacity BPSD	Post CFP Capacity BPSD
PCNA (NAPHTHA)	79,800	75,000
MOGAS (98/95/91)	80,400	50,000
	--	230,000 (New BL)
GAS OIL	154,800	61,800
	-	45,000 (New BL)
LSFO (FUEL OIL)	87,400	No change

MAA Blender post CFP status

PCNA Blender

- Capacity of PCNA BL will almost remain same;

- No modification in blender except new stream from the units is added;

- ARDS/Coker Naphtha from Unit-141 (ARDS);

- Unit-136(DCU) NC5+ is routed from Unit-137 (DIP);
- Naphtha from Unit-144 (GOD);
- Off-Spec Isomerate from U-107 (C5/C6 Isomer) or LN from U-25/26 (CCR).

MOGAS Blender

- Existing MOGAS blender will be modified to meet the new marketing parameters for MOGAS specification;
- New MOGAS blender is installed along with NIR analyzer (to meet the projected increased demand of MOGAS);
- Both blenders can be operated in parallel;
- Two new components will be added to existing MOGAS blender;
- Isopentane (IC5) produced from unit 137/138 to existing and new MOGAS blender;
- Isomerate from unit 107 to existing and new MOGAS blender.

Gasoil Blender

- The existing Gas Oil Blender will be modified to produce 10 PPM 'S" grade diesel product for export and local market.
- New 500ppm S Blender to provide 500ppm S Diesel to MEW power plant.
- Existing Gasoil Blender is producing 500 PPM S & 2000 PPMS grade Gasoil.
- Modified Existing Gasoil Blender will be capable of producing total MAA diesel production as 10 PPM 'S' grade (max production ~ 95 KBPSD).
- Components:

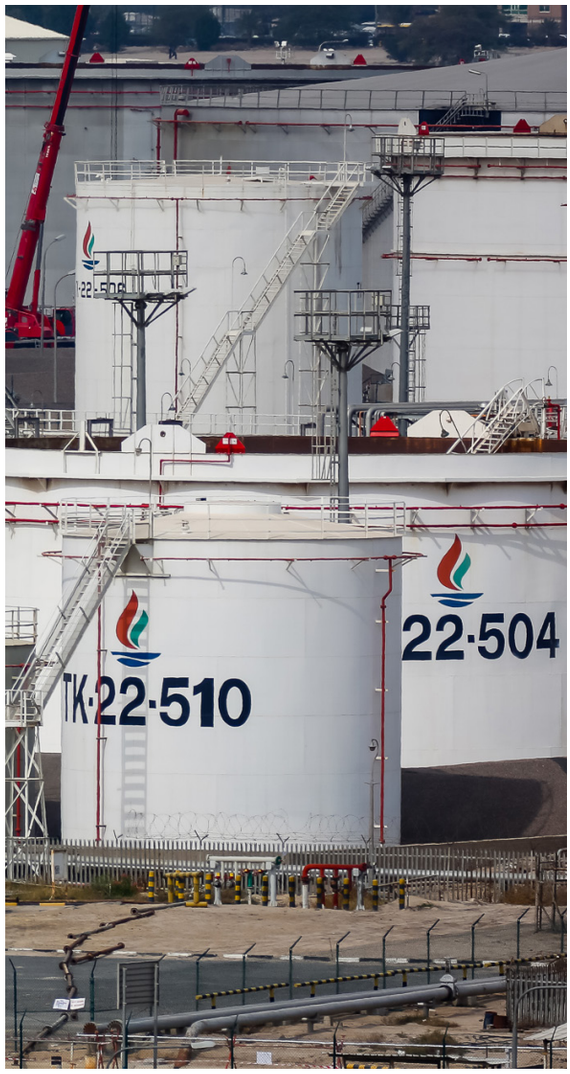
a) ULSD is a main component especially in 10 PPM S GO blender produced from new GOD unit-144.

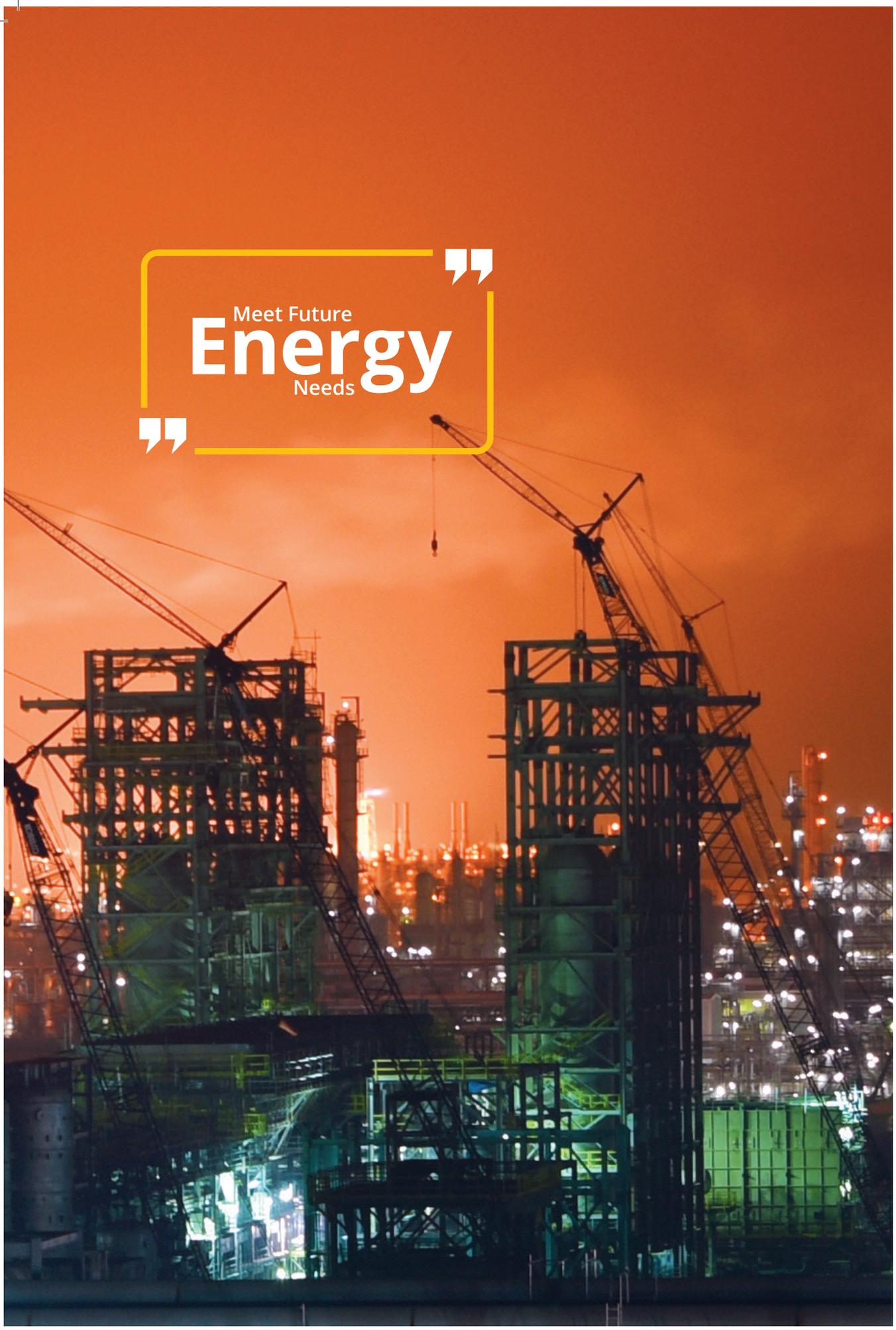
b) ATK and ARDS Diesel are main component for New 500ppm S Blender.

LSFO Blender (Fuel Oil)

- LSFO BL having no modification. HFO/LFO blender will not be in service post CFP (CDU-3 retiring and excess residue from Eocene Unit to U-141 (ARD unit)
- Existing LSFO blender will be modified to produce material with 1% S grade for Bunker` Components.

- (VR from existing Unit-83 (VR) and Unit-183 will be additionally blended to produce 1.0 % LSFO)




Meet Future
Energy
Needs

Market Research: Oil Market Overview

This article reflects the latest coverage of the global oil market conducted by Market Research Division to keep the reader informed of key market developments.

Naila Baqer
Team leader Market Research

Yasmine Khaled
Market Research

World oil demand/supply and price outlook

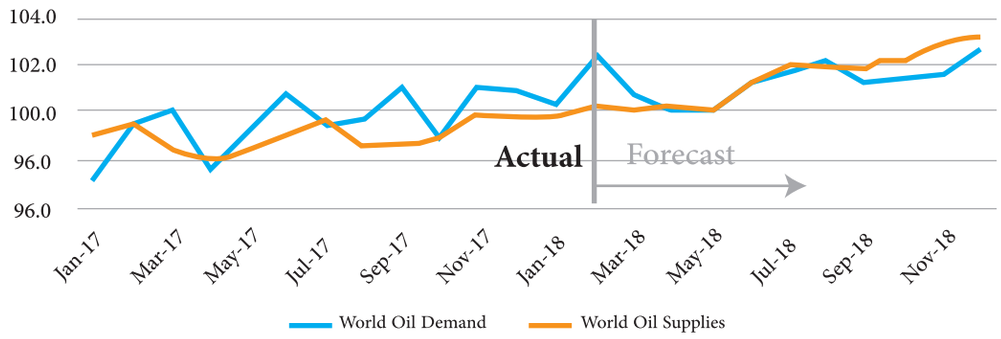
Over the last three years, global oil demand has increased by around 4.5 mmbpd. The Year on Year (y-o-y) growth in oil demand was 1.7 mmbpd in 2017 and is projected to reach 1.6 mmbpd in 2018. The main reason for the growth projection is the continued strong growth in China and India.

The United States crude production is projected to average 10.4 mbpd in 2018 and 11.2 mbpd in 2019 in light of higher prices. Increase in production will result in higher profits and higher ROI (Return on investment).

OPEC Supply, in collaboration with Russia, will restrict any growth in 2018. This is an adherence to the production cut agreement which is expected to continue till end of 2018. Currently production plans for 2019 is of gradual increase instead of a complete comeback once the agreement ends.

Inventory levels will decrease due to OPEC agreement, despite increase in US production; since overall OPEC cuts are more than the increase in US production, (see below graph).

Monthly world oil demand/supply 2017-2018

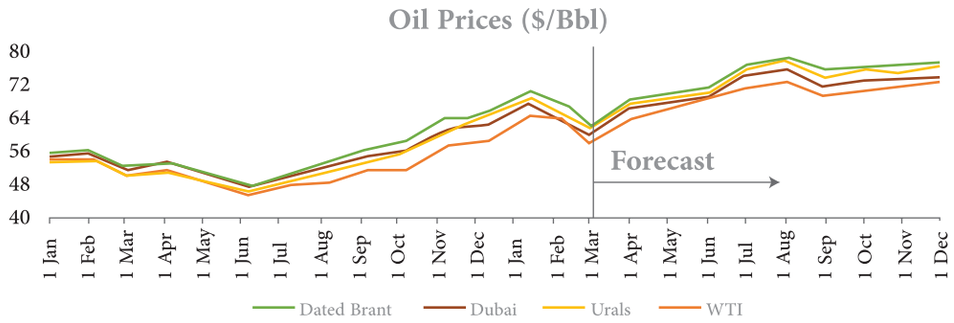


Due to a tighter supply/ demand oil Market, Brent settled at $71.56 /Bbl on 11 January 2018; the highest level in three years. From a fundamental standpoint, prices have been supported by a significant global stock draw during 2017 (especially in the US). Moreover, the continued commitment to the OPEC/Russia production agreement combined with strong demand growth in 2017, tightened the supply and demand balance.

Although the oil price has dropped back quite sharply in the last couple of weeks, the fundamentals are still leading us to a bullish conclusion. Many forecasts show that the stocks position will get even tighter during

the next few months. As OPEC/ Russia have re-affirmed their commitment to continue output constraint till they meet again on 22 June 2018.

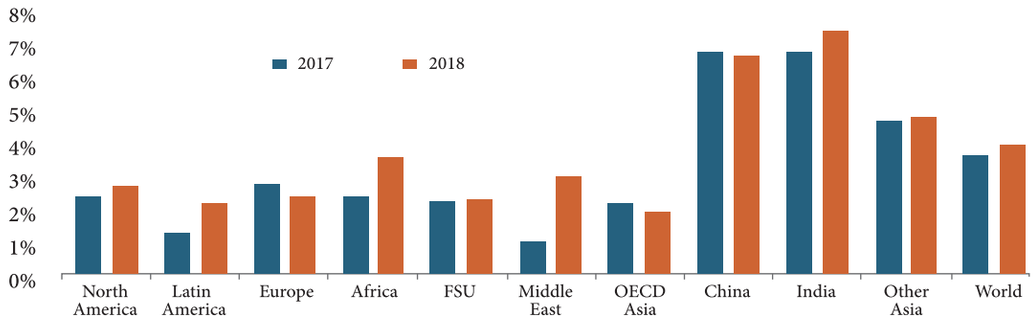
Dated Brent price forecast for 2018 was raised to $70/Bbl on average; possibly hitting $75/Bbl in 2H 2018. Which (if true) will have a detrimental impact on oil demand. Below is a chart showing Monthly averages of the Actual Oil Prices for Y 17 to Feb-18 and the forecast to end Y 18.



There is, however, another aspect that may counter balance the negative impact of higher prices on demand: The world Economy.

Global economic growth

According to IMF's (International Monetary Fund) recent update in late January, the world economy is forecasted to grow by 3.9% in 2018 and in 2019. This is the highest y-o-y growth since 2011, reflecting an increased global growth momentum. In most of the regions, the GDP growth in 2018 will accelerate as from 2017. Below is a chart showing the regional Y-o-Y GDP Growth (IMF Forecast, January 2017):



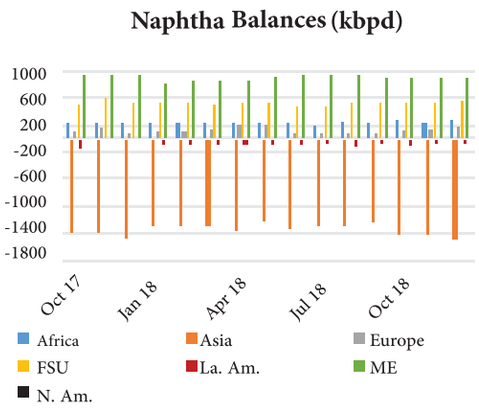
Although the highest absolute numbers are coming from Asia, 6-7% from China and India respectively; the highest incremental growth will be coming from Latin America, Africa and the Middle East compared to 2017.

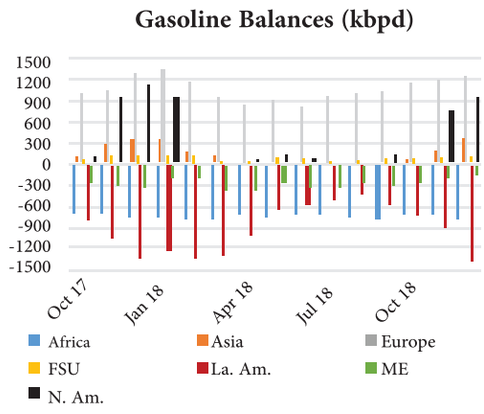
Global product outlook

Currently, product supply is low, resulting in a significant tightness in the market, leading to higher prices and higher margins. This benefits the refining industry in the short term but may kill demand in the long term as end user will be reluctant to pay high prices for products. Refining margins in 2018 are expected to

be very similar to those in 2017. Support for refinery margins may continue to come from strong and robust light distillate (naphtha and gasoline) demand.

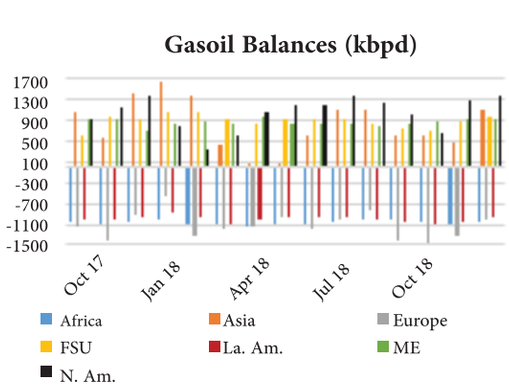
The below graphs explain which regions are exporters with high supply (above the line), and which regions are importers with high demand (below the line).

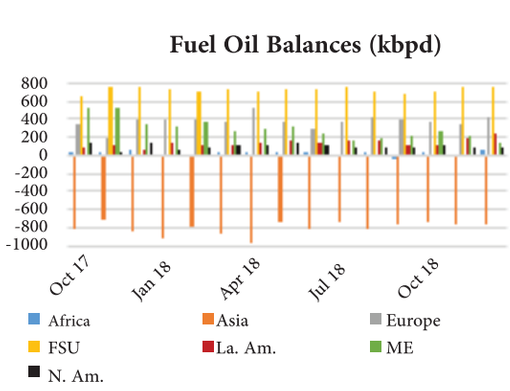




Naphtha: Naphtha cracks have fallen from their high levels at the end of last year due to plentiful supplies from Europe into the Asian market. Additionally, weak propane prices mean propane is actively competing as petchem feed and substitues naphtha. Naphtha/propane differentials are currently $75/T. Cracks are expected to increase in the short term, tracking the expected increase in gasoline cracks when the summer driving season arrives.

Gasoline: Lower stock levels together with the seasonal improvement in demand and lower supply during the US refinery maintenance period in 1H 2018 will offer support to cracks. Gasoline demand growth is 350-400 kbpd, mostly around 240 kbpd in Asia-Pacific.





Gasoil/Diesel: Cracks have been strong recently on the back of refinery issues (both hurricane-related and other unplanned outages, especially in Latin America), as well as a very cold weather (polar vortex) on the USEC. Further support has come from increasing drilling activity in the US, which is boosting diesel demand growth.

Fuel Oil: After a sluggish start for fuel oil cracks in 2018, new fuel oil destruction capacity at refineries will keep supplies tight and margins supported. However, volumes displaced by LNG in power generation, plus extra barrels from higher runs in Latin America, could put downward pressure on cracks in 2H 2018.

IMO bunker fuel regulation by 2020

The International Maritime Organisation (IMO) Marine Environmental Protection Committee met in October 2016 (MEPC 70) and decided the global marine fuels sulphur limit of 0.5% will be enforced in 2020 rather than pushed back to 2025.

The sulphur cap will affect 3.4 mbpd of high-sulphur fuel oil (HSFO) currently used in the global bunker market. Alternative compliance options such as installing scrubbers on vessels or switching to LNG are expected to have limited impact by 2020.

The main compliance option will initially be switching to low-sulphur marine fuels. The use of ultra-low-sulphur fuel oil (ULSFO) is expected to emerge.

Full compliance with the regulation by 2020 is not expected, but rather that 33% of the marine fuels market will continue burning HSFO without having a scrubber installed.

Levels of compliance are expected to be lower in areas of Southeast Asia, South America, Iran, Africa and Russia, due to low availability of compliant fuels.

As the number of scrubbers installed rises between 2020 and 2025, all fuels are expected to be compliant by 2025.

Berthing at Sea Island


Meeting Local &
International Demand for
Fuel

Importance of Reconciliation & Analysis of CFS Plan

The purpose of this document is to highlight key activities of Planning & Scheduling-MOG, which require continuous monitoring of day to day refinery operations / retro analysis and reconciliation for the effective execution of the plans.

Proper planning of refinery operations has always achieved profits. Realizing its importance, KNPC-MOG (Manufacturing Optimization Group) is committed to make consistent, realistic and efficient plans for running its Refineries. In order to be transparent at every stage of the plan, to have a broader outlook, to capture and concentrate on loss making periods, plans are revised periodically, viz:

- Yearly Budget Plan: A Broader Plan
- Quarterly Mid-Term Plan: Yearly Plan is zoomed into Quarterly Plan
- Monthly Short-Term Plan: Quarterly Plan is zoomed into Monthly Plan
- Weekly Conversion Feed Stock (CFS) Plan: Monthly Plan is zoomed into Weekly Plan

This document elaborates on What / Why / How "Retro Analysis and Reconciliation" is carried-out considering actual unit operations at refineries. The weekly plans are revived precisely to generate a more feasible and realistic CFS Plan.

Ahmad Alfailakawi
Manager, MOG

What is CFS all about?

Below is a glimpse of what is being and followed for making CFS Plan within KNPC Refineries.

CFS balancing is meant for operating Primary and Secondary units at maximum capacity with available feed stocks across MAA/MAB. The Conversion feed stocks available at Refineries with potential economic value are namely:

- Atmospheric De-Sulfurized Residue (ARDR) from ARDS units;
- Vacuum Gas Oil (VGO) from Vacuum units;
- Trim Gas Oil (TGO) from Vacuum units;
- Coker Gas Oil (CGO) from Coker units;
- Un-converted Oil (UCO) from Hydrocracker units.

General guidelines for making CFS Plan

1. CFS balance considers Net Pumpable stocks in assigned conversion feed tanks at each refinery. CFS balance will be worked out taking into consideration the minimum strategic levels in conversion feedstock at KNPC Refineries.

- ARDR minimum stocks : 200 mbbls
- VGO minimum stocks : 114 mbbls
- CGO minimum stocks : 30 mbbls
- TGO/UCO Mix : 40 mbbls

Pratap Kumar Mekala
Planning & Scheduling Engineer

Units feed rates and S/Ds are as per SD schedule. As per the business process unit throughputs and S/Ds are inputs taken from the LP Model.

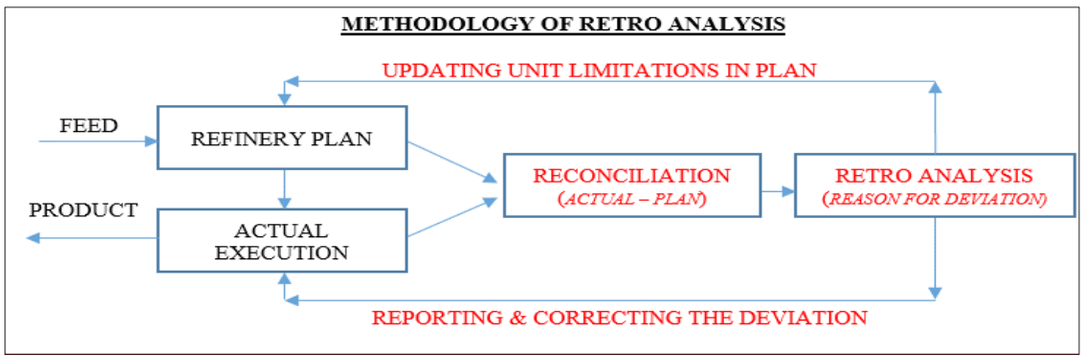
Unit Profit Margin of Hydro-Cracker & Coker units are high. Thus, throughput are considered Maximum through-out the period. In-case of VGO Inventory shortfall, HCR and FCC unit thru-puts are based on Unit Profit Margin.

Vacuum unit throughput at MAB is based on the Coker unit availability and saturation. MAA VR along with ARDR should be spiked to MAB for saturating Coker capacity.

Percentage of VR spike in the ARDR Mix (Pumped from MAA to saturate Coker at MAB) should not be more than 45% because of pump Limitation at MAB. It has to be regulated as per Viscosity Limitation.

Retro analysis of CFS plan

The procedure followed is a framework for achieving pre-determined goals in complex systems, where unplanned emergencies are expected. The procedure refers as a planning approach to "Look Back" and find deviations from the Plans. Once Actual Vs Plan is reconciled, strategies are laid to mitigate the deviations incurring losses to the company.



It is evident that Back-casting of Plans has always proved beneficial. But, the frequency of the back-casting is one of the greatest challenge to revive the plans in the situation where deviations are likely to recur. MOG follows weekly reconciliation procedure to mitigate losses due to the unforeseen emergencies. MOG believes in reviving plans based on accounted emergencies / deviations due to operational constraints which are always prone to happen in a complex refinery.

Benefits of retro analysis on "Actual Performance"

1. Comparison of "Actual" Vs "Plan" will disclose the reasons of deviations
2. Helps to capture and measure gaps in the plan
3. Helps in figuring out the quantum of actual deviation from the plan
4. Strategies are laid to mitigate the deviations incurring losses to the company based on reconciled reports
5. Reflecting realities/considering unit constraints in plan will make the plan more feasible
6. Reviving plans in accordance with actual situation will minimize deviations
7. Revived new Plan and Approach will increase efficiency of the plan
8. Gives clear vision to meet the targets laid and helps in refinery plans coordination

Reconciliation procedure – CFS Global Orion Model

Introduction

This chapter describes the workflow to accomplish Reconciliation of weekly CFS plan. Reconciliation Procedure mainly includes the following.

1. Reconciliation of "Unit Throughputs" and "CFS Stocks"

- Reconciliation of "Unit Throughputs" & "CFS Stocks" is an excel report
- Here we calculate average Throughputs of primary and secondary units pertaining to CFS balance as a part of day to day activities
- Average Throughputs are used to calculate %VR in MAB ARDR tanks using Orion Model
- CFS ORION Model is unique as it is integrated with Refineries. It monitors the total availability of stocks at Refineries. It indicates the quantum of IRT requirement by individual Refinery as per CFS requirement and availability
- Hence, it is very important to understand that opening Inventories of CFS streams at Refineries are required to start Reconciliation of Stocks
- We compare Total actual stocks available in the tanks at Refineries with the CFS balance projection for each day. Day to Day deviations are captured and acknowledged
- The reasons for the deviations are logged and highlighted to Refineries on weekly basis

Weekly reconciliation of "CFS Stocks"

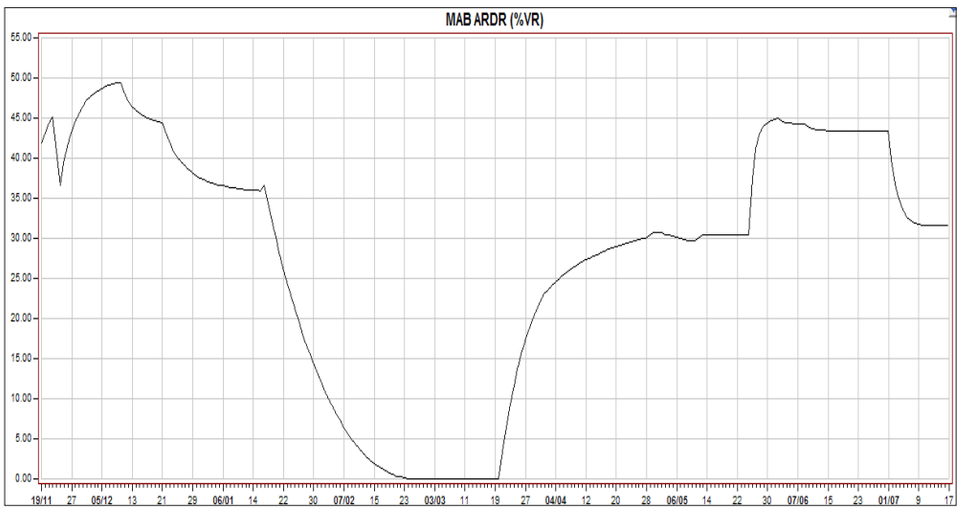
Comparion of Actual stocks Vs Projected stocks dated 24/12/2017.				
CFS Streams	Projected Stocks (ORION)	Actual Stocks	Deviations	Remarks
ARDR	456	362	-94	1) Lower VR spiking at MAA than plan. 2) commisioning TK-161 in ARDR service @ MAB (40 MBBLS heel).
VGO	357	369	12	
CGO	151	164	13	
TGO	167	155	-12	1) TGO/UCO mixed at MAA.
UCO	62	52	-10	

2. Calculation of %VR in MAB ARDR tanks (CFS Global Orion Model)

- The calculated average unit Throughputs are used to calculate % VR in MAB ARDR tanks.
- VR spiking to ARDR tank at MAA plays important role in generation of VGO /TGO/Coker Feed at MAB, as the ARDR+VR Mix is transferred to MAB ARDR tanks to saturate Coker units. VR spiking is monitored and the deviations are highlighted to Refineries.
- Actual VR spiking from MAA to MAB.

Date	VR spike plan, MBPD	Actual VR spike, MBPD Advisor report
10.12.17	30.0	33.0
11.12.17	30.0	31.2
12.12.17	30.0	36.6
13.12.17	30.0	31.1
14.12.17	30.0	33.0
15.12.17	30.0	36.3
16.12.17	30.0	34.3

- MAA ARD-41/42/81/82 and Vacuum Unit Throughputs are changed as per actual and actual VR spiking rate for the week (Advisor report) is updated in the CFS Model.
- Model will predict the new %VR at MAB ARDR tanks by calculating the excess ARDR available at MAA and quantity of VR spike to measure %VR in MAB ARDR tanks.



- %VR is not calculated anywhere in the Refinery other than CFS Orion Model. VR spike is important to calculate MAB Vacuum Unit Throughputs which run as per Coker unit requirement.
- The projected %VR is input to Orion Model for making weekly CFS plan.

3. *Monitoring/Correcting of CFS Tank qualities*

Before addressing the subject, we shall talk about what CFS quality is all about.

The quality of Conversion feed stock may be defined as its ability to fulfil the requirement of the unit at various conditions. CFS Quality is pre-defined and agreed within MAA/MAB Refineries as shown below.

Property	Unit	ARDR/VR Mix		VGO		TGO		CGO	
		ARDR (Max)	VR (Max)	Min	Max	Min	Max	Min	Max
Color	ASTM				3.5	Report		Report	
SPG at 15^{0}C	Kg/L	Report							
Sulphur	%mass	0.75	1.2		0.8		0.8		1.3
Viscosity @50^{0}C	cst	700		Report					
%5 Recovery	^{0}F			585		585		585	
%95 Recovery					975		1075		975
Nitrogen	% mass	0.2			0.1		0.1		0.2
Ni + Va	ppmw	20+8	40+15		0.5		2.3		0.5
Conradson Carbon Residue (CCR)	% mass				0.2		0.8		0.4
Asphaltene	Mg/Kg				100				
PCI	Mg/Kg				800				

Below is the table for monitoring Conversion feed stock quality within the agreed specifications. The deviations are addressed to Refineries for correction.

Date	TGO Tk-50-151 (CCR 0.8% wt max)	CGO Tk-52-159 (CCR 0.4% wt max)	CGO Tk-50-150 (CCR 0.4% wt max)	ARDR Tk-756 Vis (cst)/S <1000 cst/<1.0 wt%	ARDR Tk-757-157 Vis (cst)/S <1000 cst/<1.0 wt%	ARDR Tk-52-157 Vis (cst)/S <1000 cst/<1.0 wt%	ARDR Tk-52-166 Vis (cst)/S <1000 cst/<1.0 wt%	ARDR Tk-52-161 Vis (cst)/S <1000 cst/<1.0 wt%	VGO Tk-52-172 COLOR)3.5 Max)
17.12.17	0.86	.....	0.3	.....	822 S=1.41	876 S=1.36	.....	.....	.....
18.12.17	.....	.....	.....	.....	.....	880 S=1.34	898 S=1.40	.....	.....
19.12.17	.....	.....	.....	.....	.....	.....	.....	.....	.....
20.12.17	.....	.....	.....	.....	970 S=1.30	932 S=1.4	.....	.....	.....
21.12.17	1.1	0.273	.....	.....	905 S=1.40	.....	956 S=1.41	.....	.....
22.12.17	.....	.....	.....	.....	.....	.....	.....	.....	.....
23.12.17	.....	.....	.....	.....	997 S=1.46	876 S=1.42	.....	.....	.....

Vapor Recovery Unit at Sabhan and Ahmadi Depot

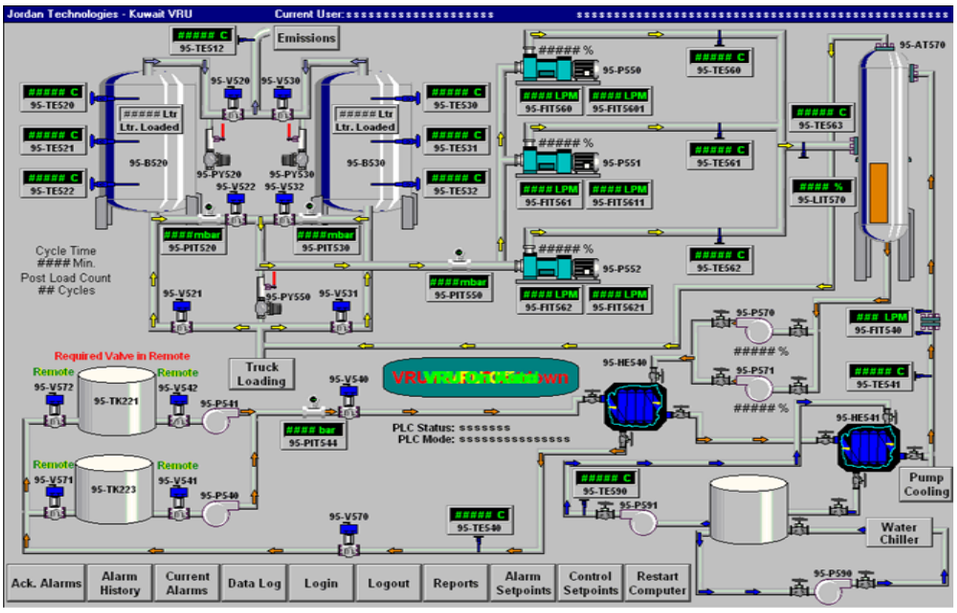
Humoud Al-Azmi
Team Leader, Depots

In order to eliminate hydrocarbon vapours sneaking into atmosphere while loading / unloading or transfer operation and in line with KNPC's HSE Policy to run the business to safeguard health of our employees and minimize environmental emissions, KNPC - Local Marketing carried out a project for Vapour Recovery Unit (VRU) at Sabhan & Ahmadi Depots for Gasoline products.

The Stage IA of VRU with activated carbon bed adsorption technology from Jordan Technologies, USA is designed to recover the hydrocarbon vapors brought to Depots from petrol filling stations via road tankers in addition to the vapors produced during tanker loading operation.

- The VRU is an automated (unmanned) system operated by a Programmable Logic Control (PLC) unit.
- The PLC is linked to a Human Machine Interface (HMI) desktop used to determine VRU running status, monitor trends of key process parameters, diagnose problems and make system operational adjustments.
- The VRU can be remotely accessed to monitor real-time operating data or to perform maintenance works or change settings, which ultimately result in more efficient VRU operation and reduced downtime.
- The Annunciation (dial-out) feature of VRU is enabled to inform operations/maintenance personnel by telephone about fault shutdowns.
- The VRU is equipped with firefighting and alarm systems in addition to 2 gas detectors installed at different locations within the skid.
- Due to Kuwait's hot climate and to reach the most efficient recovery, chiller unit along with heat exchangers were supplied to cool down gasoline being pumped into the skid to less than 30 deg. C.
- The Vapor Recovery Unit is capable of recovering vapors with inlet HC concentration up to 50% at a maximum rate of 2.5 liter of gasoline per 1,000 liters of gasoline loaded.
- The basic VRU system is comprised of two identical activated carbon beds alternating on a 15-minute time cycle, one absorber tower, dry screw vacuum pumps and gasoline supply and return pumps.
- When one carbon bed is on stream (adsorption mode) receiving air-vapor mixture in from the loading gantry, the other vessel is off stream in the regeneration mode.

Vapor Recovery Unit



Vapor Recovery Units Control System Panel

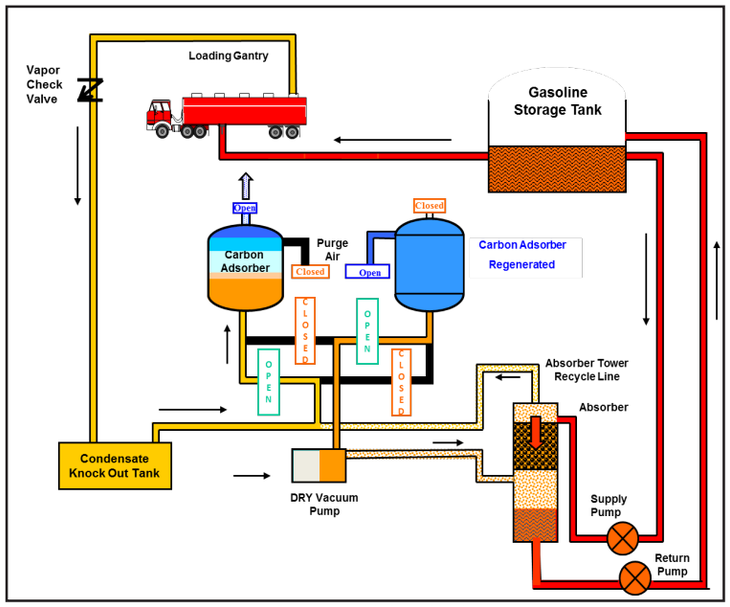
- Switching valves are provided at the inlets and outlets of carbon vessels to automatically alternate the carbon vessels between adsorption and regeneration cycles to assure uninterrupted vapor processing capability.

- Temperature and pressure instruments along with level indicators are provided on various applicable VRU equipment.

- During adsorption cycle, the activated carbon inside carbon beds adsorbs the hydrocarbon vapor and allows clean air to vent from the bed with only minimal hydrocarbon content.

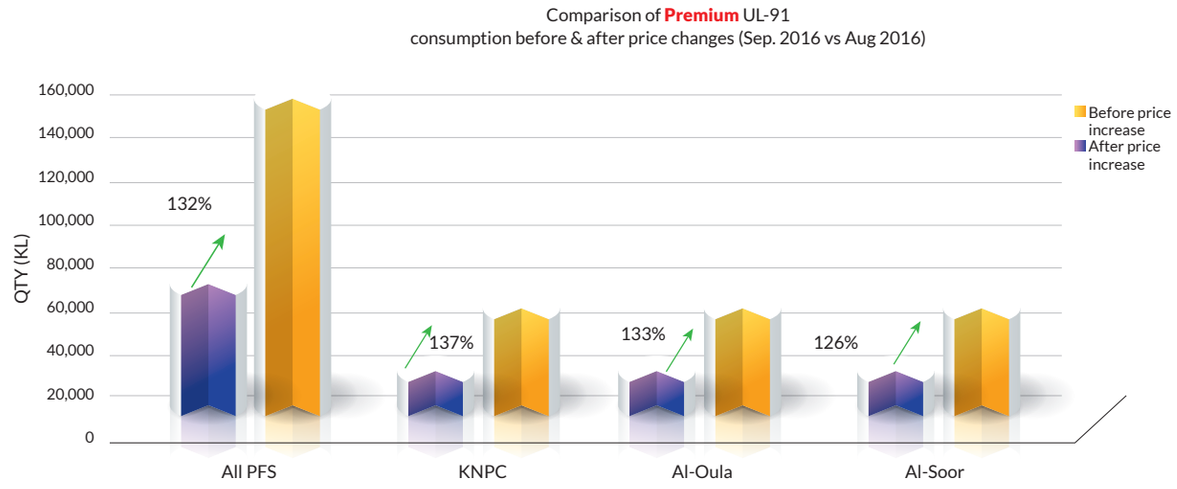
- During regeneration cycle, the adsorbed vapor is removed from the carbon bed by vacuum pumps and sent to the absorber tower. Ambient air is purged into the carbon bed in a controlled manner during the last 25% of the cycle to restore carbon's ability to adsorb vapor.

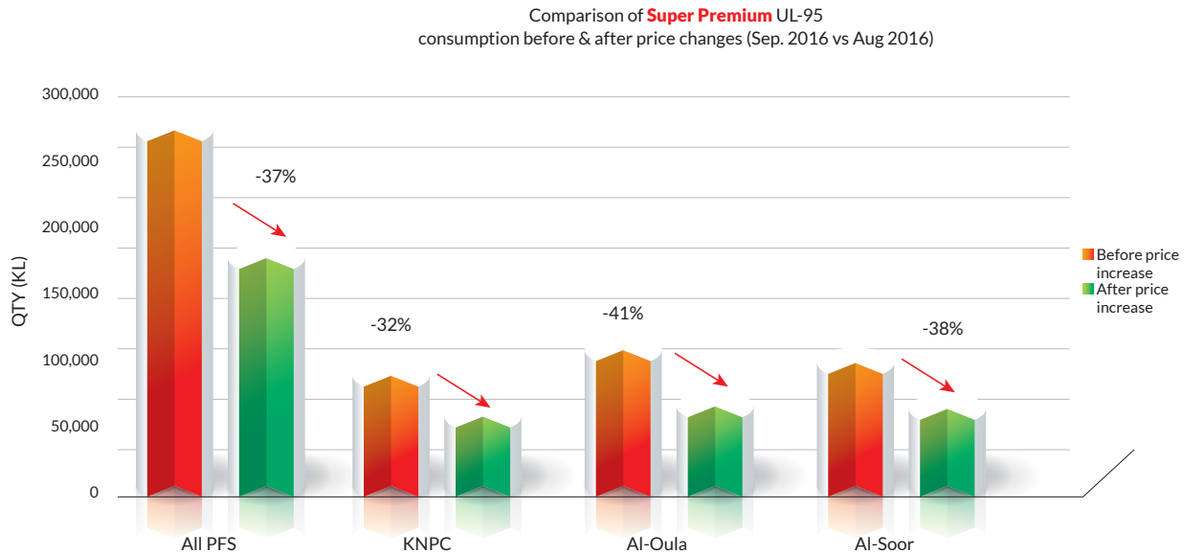
- Cooled gasoline (absorbent) is pumped to the VRU skid from the supply tank for use as lean oil in the absorber tower. Inside the absorber tower, the vapor is liquefied and the recovered hydrocarbon (gasoline) is returned back to the supply product tank.



Vapor Recovery Units of LM

- The VRU will automatically start when a loading operation is ongoing and change to standby mode when the operation is complete.
- The VRU is set to shutdown mainly when faults occur, for example, improper regeneration, improper valve switching, high carbon temperature, high/low absorber tower level, pump failure, etc..
- Currently, both VRUs are recovering approximately 7,000 liters per day of useful product.
- As of the end of March 2018, the VRU at Local Marketing Depots had an availability of over 99% and had recovered more than 4.72 million liters of hydrocarbon vapors as product since they passed the Performance Test in July, 2009.





Local Marketing Future Forecast Plan

Steps are being taken in preparing future forecast plan for filling stations (KNPC and Private) and bulk customers. Among those stepes:

1. Review actual sales of fuel products of the previous year and compare them with the previous year's plans
2. Co-ordinate with Marketing, Customer Services and Filling Stations (KNPC and Private) Divisions to request their inputs
3. Prepare plan with the input from Customer Service, Filling Stations (KNPC and Private) Divisions as follows:
    - Filing Stations actual consumption for private and KNPC stations
    - Local Marketing Depot bulk customer's actual consumption
    - Filling Stations planned consumption for private and KNPC stations
    - Local Marketing Depot Bulk customers planned consumption
    - Filling Stations actual consumption for private and KNPC stations for the previous month/year
    - New Bulk customer, if any
    - New Filling Stations, if any

Ahmadi Depot

4. Analyse the changes or any addition in the actual consumption compared to the planned and previous years' actual consumption
5. Prepare forecast for the upcoming year as per trend/ factors of the demand.
6. Monitor the yearly forecasting plan and track any changes in the plan
7. Inform Refineries, Operational Planning, KPC Supply Operations and Operation Analysis, Corporate Planning, Manufacturing Optimization Group (MOG) and Local Marketing Depot Operation about any changes in the yearly plan

World vs. Mina Al-Ahmadi FCC Performance

FCC Unit in Mina Al-Ahmadi (MAA) Refinery is strategic in KNPC refining business. For that, the unit (licensed by UOP) underwent post commissioning (1984) and two major revamps in 1997 and 2015.

Abstract

MAA revamp objectives were to increase the unit capacity, process of heavier feedstock, improve unit reliability, optimize unit conversion and improve environmental performance. The main operating goal for the unit is to meet local Gasoline demand while meeting the Propylene commitment.

2015-revamp scope included complete Reactor replacement with the-state-of-art technology (Elevated Optimix™ Feed Distributor, VSSTM Riser Termination, AF™ Stripper). The modification was aligned with downstream modification in Main column and Gas Concentration plant that enabled the unit to process a difficult feedstock (Coker Gas Oil, Trim Gas Oil ,Un-Converted Oil) and discontinuing VGO in the combined feed (UOP K Factor: 11.9). The Unit's post commissioning and stabilization operation successfully met the revamp objectives.

KNPC evaluates the Unit performance against Solomon Benchmarking. The results are analyzed and compared with other refineries. Accordingly, the MAA FCC 2014 and 2016 data, along with comparison to other refineries, have been analyzed through this article.

Abdulrahman Al-Sumaie
Process Engineer - MAA

Solomon benchmarking (KPI's)

The MAA FCC Unit data was evaluated and compared with World Best (WB) and Rest of World (ROW) FCC Units based on Solomon benchmarking. The selected KPI's from the benchmarking are basically related to the process performance of the units: Characteristics of FCC Unit, Operational Availability, Process Utilization, Yields Gaps, Reactor Operation Volume Gain, Diesel in FCC Feed and Unit Energy Intensity Index (EII).

Rashed Al Fadhli (Left)
Team Leader, Process Engineering - MAA

Characteristics of FCC Unit

The Unit's capacity and utilization along with the feed qualities to the units are the major factors that can be used to characterize the FCC Unit. Table.1 below indicates the comparison of the study.

Parameter	2014 WB Average Characteristics	2014 ROW Average Characteristics	2014 MAA FCC Characteristics	2016 MAA FCC Characteristics
FCC Capacity kbbl/d	46.4	45.2	43	43
Feed Density kg/m3	917	912	898	90.5
Feed Sulfur, wt%	0.3	0.2	0.6	0.7
UOP-K Factor	12.0	11.9	12.1	11.9
Average Utilization, %	89.1	82.0	85.6	87.2

Table 1: Characteristics of FCC Unit

The comparison confirm that MAA FCC started handling difficult feed stocks as the density gone up in 2016. Also the UOP-K Factor indicated the same. The unit is operating with a slightly higher Feed Sulfur than the feed in the other units. For the Average Utilization significantly improved for MAA FCC in 2016 and it came closed to WB Average Utilization.

Operational availability

WB figures were compiled for three studies (2010/2012/2014) where for the MAA Unit was only one study for a specific year figures as shown in Figure 1. In 2014, the Operational Availability (OA) was poor and on behind as the Unit was running more than turnaround period (three years). In 2016, OA improved and reached a position better than rest of the World's ROW and closed to WB. The same was due to unplanned shutdown of 16 days due to a Heat Exchanger leak and Main column inspection.

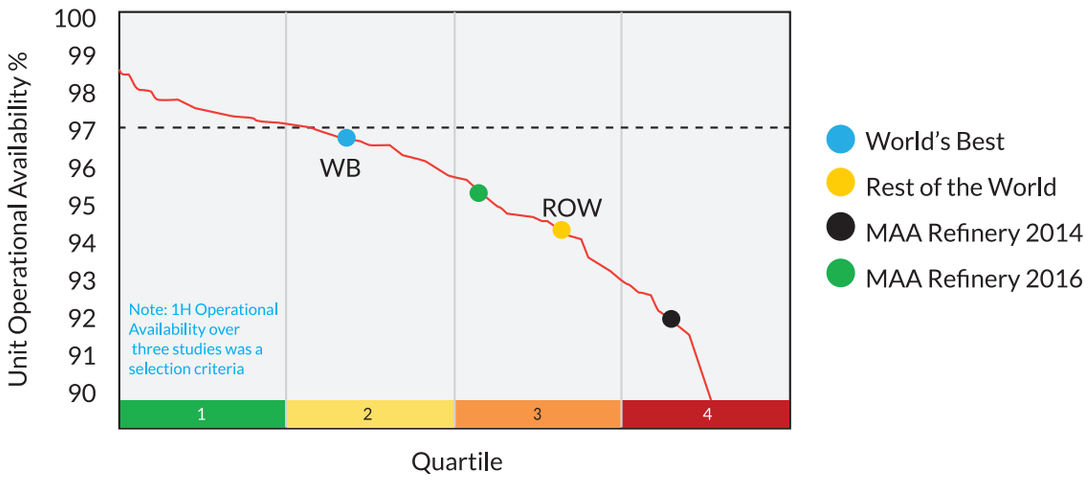


Figure 1: FCC Operational Availability

Process utilization

The CFP design capacity for the MAA Unit is 42.5 MBPD of a combined feed composed of Coker Gas Oil (CGO), Trim Gas Oil (TGO) and Unconverted Oil (UCO). However, the Process Utilization (PU) improved marginally in 2016 compared with 2014, and reached close to (WB). Processing a new feed stream (Waxy Distillate/ HGO) higher Sulfur feed in the Unit and absorbing higher production of (UCO) were the main reasons for the improvement. Figure 2 shows the same.

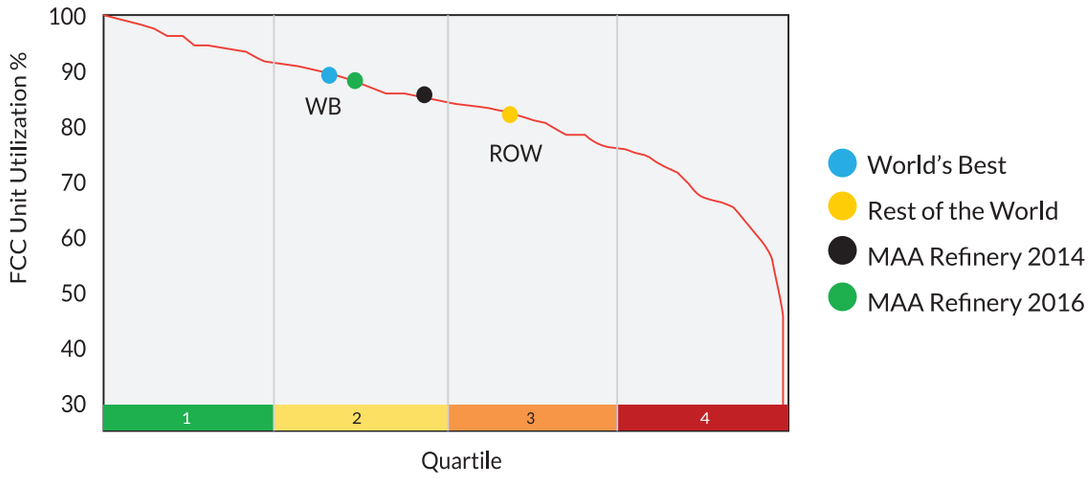


Figure 2: FCC Unit Utilization

Yield gaps

Solomon is calculating the yield gaps by the meaning of Modified Dynamic Activity (MDA) at the processed feed. The MDA is a function of feed quality (Nitrogen, ppm/ CCR, wt.%), Coke yield and Unit Conversion. (See Figure 3).

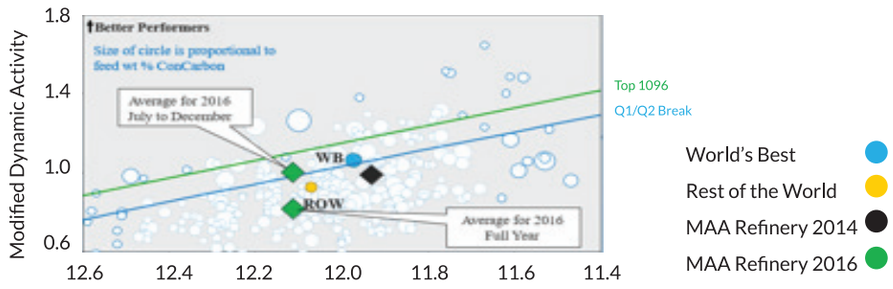


Figure 3: FCC Yields Gaps

Yield gaps for MAA Unit in 2016 were represented in two durations, Average for 2016 (Full year) and (July – December). The reason for reflecting the two durations is because the unstable operation of the Unit after startup from the revamp. The Unit achieved a successful work as the yield gaps moved to the 1st/2nd Quartile where the WB during the stable operation. A lot of effort was done to improve the gasoline yield production in particular the Heavy Gasoline (HG) as the same was limited due to the Main Column fractionation issues after the revamp modification. HG endpoint relaxation to 210 Deg. C was the main adjustment in this improvement.

Reactor operation

FCC Units operate at higher Reactor Overhead temperature and Cat/Oil Ratio indicate an operation abundant from its constrains. In this case the desired product yields as Reactor vapor outlet can be achieved definitely. A significantly improvement was observed in 2016 compared with 2014, where the Unit was operating at higher rector temperature and Cat/Oil ratio closed to the WB in the 1st Quartile. (Refer Figure 4).

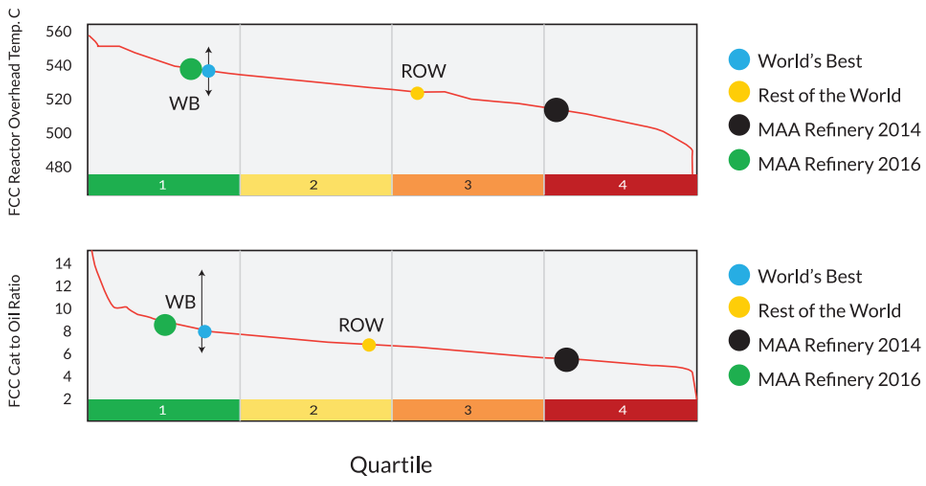


Figure 4: FCC Yields Gaps

Volume gain

The gas volume (Lighter Ends) produced in FCC Reactor is the factor to increase the volume gain. As WB make more LPG than gasoline, its volume gains always high compared with units make more gasoline than LPG. The MAA Unit seeks to maximize gasoline over production of more LPG, for that the volume gain is less and in the 4th Quartile.

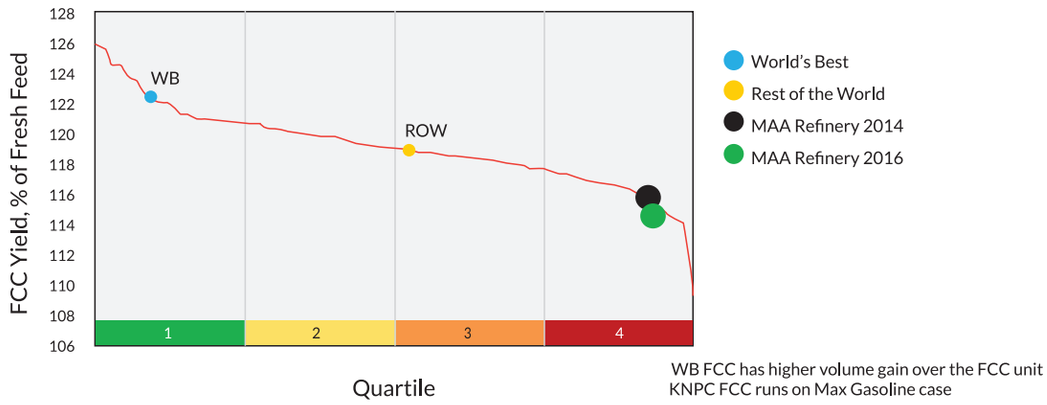


Figure 5: FCC Volume Gain

Conclusion

While the newly revamped cat cracker has suffered through some start-up related problems, Solomon Benchmarking indicates that the work done is excellent and successful. Several KPI's have moved from 3rd / 4th Quartile to 1st / 2nd Quartile while processing a heavier feed slate.

- Dynamic Activity moved to 1st Q
- Cat to Oil Ratio moved to 1st Q
- EII moved to top of 2nd Q

As per Solomon, "The MAA FCC might be a potential candidate for the future Solomon World's Best Cat Cracker peer group if it was able to maintain a high Operational Availability above 96%."

FCC Unit - MAA

Fitness For Service Assessment for Brittle Fracture

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Mohammad Al-Masilit and Bader Al-Harbi
MAA Refinery

Mechanical integrity is one of the key elements of the process safety management. Toughness of carbon steel plays an important role while designing pressure vessels for low temperature applications to avoid brittle fracture failure.

Abstract

Any process excursions to lower temperature than minimum design metal temperature (MDMT) may pose catastrophic failure of equipment. Recently polishing treater vessel in Gas Liquefaction plant experienced a temperature of -35°C that was lower than the MDMT of -23.3°C during upset operating conditions. In view of the incident, a Fitness For Service (FFS) level 1, 2 and 3 assessments, as per API-579/ASME – FFS, has been performed to check the vessel suitability for continued safe operation. The paper briefs assessment approaches and acceptance criteria for assumed pre-existing cracks, recommended inspection strategy and Integrated Operating Window (IOW) for safe operation of equipment.

System description

The Polishing Unit is required to remove the H2S and sulfur compounds in the regeneration gas. The polished regeneration gas being used for regenerating the propane treaters in the existing LPG Trains 1, 2 & 3. The Polishing Unit is having two treaters filled with C3 propane vapor molecular sieves which operate in a cyclic manner (12 hours), while one treater is adsorbing the other treater is out of service being regenerated. The normal operating pressure polishing unit between 12 (Adsorption) kg/cm2 and 9 kg/cm2 (regeneration), and temperature swing between 25 °C to 280 °C.

During upset operating condition, C3 propane liquid introduced into polishing treater vessel while it was being depressurized to 1 atmospheric pressure. This has resulted in auto refrigeration of fluid that led to vessel and piping subjected to lowest temperature, i.e. -35 °C.

Mohammad Al-Masilit
MAA Refinery

The design data of polisher vessels V-33-401A/B is shown in Table 1.

Table 1: Design details of polisher vessels V-401A/B

Equipment Type	Pressure Vessel (Vertical)
Design code	ASME Sec VIII, Division 1
Commissioned	1993
Shell Material	SA – 516Gr.70N Year 1998 (Impact tested)
Design Conditions (Press & Temp)	20.62 kg/cm650 @ 2 °F
Min Design Metal Temp (MDMT) Or Critical Exposure temp (CET)	°23.3-C at 20.62 kg/cm2
Minimum temp the vessel exposed	35- °C at 2 kg/cm2 (as per DCS trend)
Impact test value for plate material (ASTM A516- gr70N)	31 J at – 40 °C (min. Average lowest 33 J)
Post Weld heat treatment	No
Shell Thickness	30 mm
Shell Weld Joint Efficiency	1.0
Shell Corrosion Allowance	3.2 mm
Nozzle Thickness (maximum Thk.)	16.65 mm (say 17 mm)
Nozzle/Flange Material	SA106- / SA105- (Without impact testing)
Nozzle Weld Joint Efficiency	1.0

Inspection history

The vessel was commissioned in Sept. 2001 and since then three inspections were carried out. Full inspection using wet MPI of 100% welds from inside was done on April 15th, 2012. Hardness of welds was also carried out during February 2017 last inspection and found satisfactory.

Assessment techniques and acceptance criteria

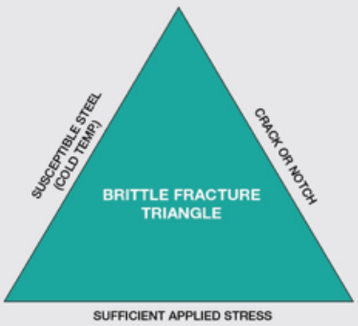
An overview of the process for assessment of the vessels and piping is shown in Figure 1 (API 579).

Faisal Salman
MAA Refinery

Brittle Fracture

Brittle fracture occurs when a vessel or piping is chilled due to auto-refrigeration. Excursion or post excursion stresses are sufficient to drive fracture at existing flaws. This behavior is often described by the brittle fracture triangle where closure of the triangle indicates the potential for brittle fracture as shown below.

Auto-refrigeration is unique in that potential scenarios must be proactively identified and mitigated. By their very nature these transient events occur under uncontrolled non-normal operating states (upset, startup, shutdown, etc.).



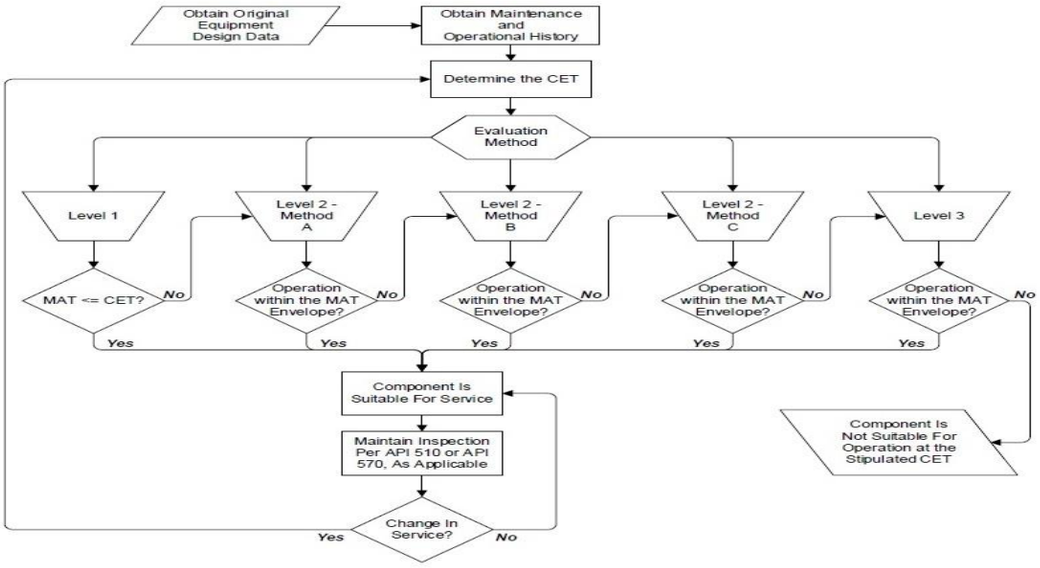


Figure 1: Overall Brittle Fracture Assessment Procedure for Pressure Vessels and Piping

A 3-level assessment is carried out

Level 1 assessment

Level 1 assessment is based on impact test results or impact test exemption curves. At this Level, a single value for the Minimum Allowable Temperature (MAT) is determined at the maximum operating pressure.

Level 2 assessment

Pressure vessels
As per this procedure, a reduction in the MAT from the Level 1 value may be applied to pressure vessel due to lower actual operating stresses at the low temperature pressurization condition as happened in this case. At the time of incident, the pressure was 2 Kg/ cm2 coincidence minimum temperature of -35 °C.

Since the actual temperature is within the (MAT) envelope, the vessel in question passes Level 2 assessment and considered safe for continued operation.

Level 3 assessment

Since Level 2 assessment passed, there is no need to go for Level 3 assessment. However, in this case, further Level 3 assessment is considered due to the following uncertainties:

1. Only one thermocouple at outlet was reading at the time of incident, hence it is not representative of minimum temperature across the vessel that was experienced

2. Nozzles are also stressed regions but nozzle/ flanges (SA-106/105) were not impact tested as per vendor data book

3. Vessel was not subjected to PHWT although applicable WPS/PQR were qualified with PWHT (essential parameter)

4. Vessel is in cyclic service on daily basis (Temperature 25 to 280 °C corresponding pressure 10 to 15 kg/cm2)

Fracture mechanics

Fracture mechanics is the discipline concerned with the behavior of materials containing cracks or other small flaws. What we wish to know is the maximum stress that a material can withstand if it contains flaws of a certain size and geometry. Fracture toughness measures the ability of a material containing a flaw to withstand an applied load. A typical fracture toughness test may be performed by applying a tensile stress to a specimen prepared with a flaw of known size and geometry. The stress applied to the material is intensified at the flaw, which acts as a stress raiser. For a simple case, the stress intensity factor, K (Irwin`s equation), is: $K = \beta\sigma\sqrt{(\pi a)}$.

where 'β' is a geometry factor for the specimen and flaw, 'σ' is the applied stress, and 'a' is the flaw size, refer figure 3a and 3b. Note that the analytical expression for K changes with the geometry of the flaw and specimen. If the specimen is assumed to have an "infinite" width, then β = 1.0. For a small single-edge notch, β =1.2. discrepancy with the below Figure 2.

By performing a test on a specimen with a known flaw size, we can determine the value of K at which a flaw would grow and cause failure. This critical stress intensity factor is defined as the fracture toughness, Kc, (KC = K required for a crack to propagate).

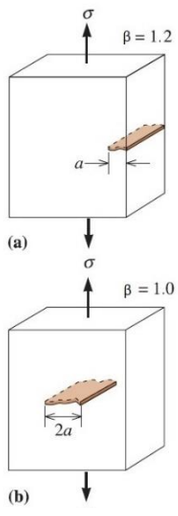


Figure 2: Fracture Toughness Specimens with a) edge and b) internal flaws

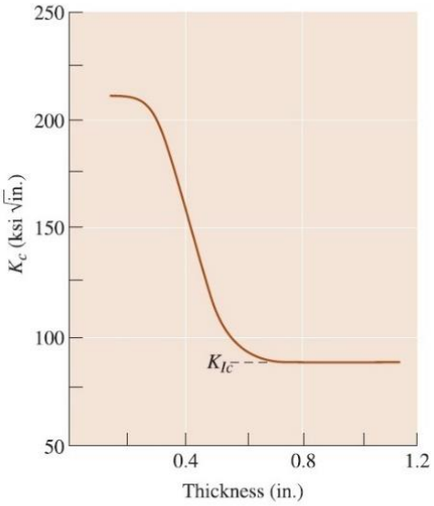


Figure 2c: Fracture Toughness Kc of a Steel Varying with Thickness

The value of Kc reaches a limiting value at large thickness, corresponding to the plane strain condition. This limiting value is termed as KIC so that becomes a reproducible material property as shown in Figure 2c.

If KIC is known, then it is possible to compute the maximum allowable stress for a given flaw size. While KIC is a basic material property, in the same sense as yield strength, it changes with important variables such as temperature and strain rate. KIC usually decreases with decreased temperature and increased strain rate. For a given alloy, KIC is strongly dependent on such metallurgical variables as heat treatment, texture, melting practice, impurities, inclusions, etc.

Conclusion

The vessel is fit for continued service despite experiencing lower temperature than the Minimum Design Metal Temperature (MDMT) condition.

FFS study failed in Level 1, however, it passed level 2. Although Level 3 study was not required, but to build confidence level, the same was conducted. The conclusion of level 3 was at incidental temperature -35 °C, the surface flaw size of 6.0 mm (12.0 mm embedded flaw) could have been sustained for coincidental stress with 99% confidence level.

Troubleshooting Hydrate Issue in NGL Section in KNPC

Ahmad Al-Own
Sr. Process Engineer – MAA

Karthik Rajagopalan
Process Engineer – MAA

KNPC was facing an issue of continuous hydrate formation in NGL section of Train-4 Unit. Higher pressure drop was encountered in cold box and de-Methaniser sections of NGL unit. Troubleshooting exercise along with important lesson learnt are being shared herewith.

Introduction

Train-4 unit is designed based on Gas sub-cooling process (GSP). Since commissioning of the unit, NGL section was encountering continuous higher pressure drop. Pressure drop increases initially in the feed reflux circuit and subsequently in De-Methaniser column.

Because of high pressure drop / choke in the column, flooding started in the tower. Repeated Methanol injection was carried out in pipelines and several warm-ups are carried out for De-Methaniser tower.

Troubleshooting

- **Gas driers**

  Gas driers are located upstream of NGL section, to remove saturated moisture to a level of 0.1 ppmv. Train-4 has 5-bed gas drier operation and at any point in time multiple beds are in adsorption mode.

  Troubleshooting started with the performance analysis of gas driers. Pressure drop of the bed will not help in identifying the mal-function, as we have multiple bed online at any point of time. Because of which, it is essential to have flow measurement in each bed to determine flow mal distribution.

  Regeneration profile, flow distribution, individual bed moisture online measurement did not indicate lower performance in any of the beds.

  Subsequently, portable high precision moisture analysers are sourced and connected to individual bed outlets. Exhaustive exercise revealed that one of the beds is slipping moisture within few hours of adsorption cycle. Respective dryer was isolated.

  However, hydrate formation in NGL section was still taking place after isolation of mal-functioning bed.

- **Carbon di oxide freezing**

  Feed gas to Train-4 is having around 1.5 – 2.0 % CO_2. Possibility of carbon di oxide freezing was studied.

Simulation exercise was performed to determine CO2 freeze temperature based on actual feed composition. Simulation exercise revealed an approach of more than 10°C between the freeze temperature and actual coldest temperature in NGL.

- **Components in feed gas causing freeze**

  It was suspected that some of the components in feed gas could freeze at the operating temperature.

  Detailed Hydrocarbon Analysis (DHA) of the feed gas was performed and all the components in feed gas are identified. Some of the components are found to have freezing point within the operating range (For Ex: Neo-Pentane).

  However, the concentration of the components in feed gas are not sufficient enough to freeze. In addition, it was observed that the block is continuously getting dissolved whenever Methanol was injected.

  Possibility of aromatics especially Benzene was suspected as one of the causes for frequent blockage. Tests were performed to analyse the concentration of Benzene, Toluene and Xylene (BTX) in feed gas. However, it was concluded that the concentration of aromatics is not adequate enough to freeze at operating temperature.

  In addition, as Methanol readily dissolves polar compounds compared to hydrocarbons, hydrate is again considered as the likely cause.

- **Impact on De-Methaniser**

  Over a period of time in operation, De-Methaniser tower started developing more pressure drop. Flooding started in the tower and overhead gas has become two-phase flow.

  Physical entrainment of liquid to overhead was observed continuously. Warm-up of

GT-4 MAA

the tower was necessitated time and again. Boroscopic inspection of the tower was performed at several possible locations but was not effective enought to identify root-cause.

Several locations are identified where water will settle as a result of warming up and was drained and checked regularly.

Control valve on the feed reflux line will keep opening to 100% and the feed to the unit started coming down. Condition can be restored partially once Methanol is injected in the circuit.

- **Source of Hydrate**

  Troubleshooting exercise was once again shifted to performance of gas dryers. However, data collected with various analysers did not indicate any moisture slippage at gas drier outlet.

  Analyser set-up was shifted to NGL section and data was recorded. Continuous moisture in the range of 5 ppm was detected in NGL section.

  It was later confirmed that the Moisture is formed in Mercury guard bed because of the side-reaction of H2S and CO2 in the presence of alumina.

  In order to establish the findings beyond doubt, Mercury guard bed was bypassed and no further hydrate formation was observed.

- **Importance of moisture analysers**

  Accurate moisture measurement is very important for day to day troubleshooting activities. Range of the analysers need to be decided in such a way that any moisture slippage is detected timely.

  Simulation was performed internally to identify the minimum moisture content at which hydrate will be formed.

  Train-4 gas dryers are designed with multiple online sample locations in gas dryer bed. Bed sample locations are used periodically to determine at which level breakthrough is happening.

  Automatic nitrogen purge was introduced in all sample points to avoid condensation of gas due to low ambient temperature.

  Sample conditioning skid also need to have in-built heater to maintain constant sample gas temperature.

  It is also important to identify rugged moisture measurement technology for online analyser to enable accurate moisture measurement.

- **Conclusion**
  - Gas dryers with multiple beds in adsorption need to have individual flow measurement to detect mal-distribution.
  - Suitable moisture analyser need to be selected during design phase which will assist in troubleshooting.
  - Sample conditioning system for moisture analyser need to be verified for accurate measurement.
  - Methanol injection points need to be reviewed carefully in design phase.
  - Methanol injection directly into De-Methaniser tower need to be explored to remove hydrates from the tower without warming up the unit.

GT-4 MAA

Performance Improvement of Super Austenitic Stainless Steels in Seawater Coolers

A new generation of stainless steels, such as high alloy/super-austenitic stainless steels, have been used in oil and petrochemical industries for over 20 years, due to their resistance against aggressive seawater corrosive environments.

Corrosion Eng. Mohammad Al-Hajeri (right)

Abstract

Several tube bundles, made of Super-austenitic stainless steels (UNS S31254), were introduced in Mina Al-Ahmadi Refinery (MAA) in mid 1990s in place of Monel tube bundles to mitigate corrosion. Performance of these tube bundles has not been satisfactory requiring frequent major repairs and replacement on tube bundles due to severe crevice corrosion. Beside high initial cost of these exchangers, the repairs are also costly and time consuming.

This paper elucidates on material selection, design improvements, and alternate repairs to improve performance of the super austenitic steel tube bundles highlighting limitations of these materials in seawater service conditions of tropical regions.

System description

Super-austenitic stainless steels, Avesta 254SMO (UNS S31254) tube bundles were introduced in MAA in mid 1990s in place of Monel tube bundles due to their pitting and crevice corrosion attack on gasket seating surface, and tube end erosion in seawater service. 26 tube bundles has been installed until date. Performance of these tube bundles have not been satisfactory, requiring major repairs and replacement over the years. As well, repairs of these exchangers are costly and time consuming.

Observation

Visual examination

1. Typical crevice corrosion and rat holes were observed on flange gasket surface of tube sheets and FTS covers as shown in Figure 1
2. Most of the exchangers have suffered from crevice corrosion under the gasket area. Once the carbon steel is exposed accelerated corrosion in the form of rat holes have been reported under the clad
3. Both types of tube-sheet design have experienced crevice at gasket area
4. Normal operating temperature of seawater supply is 34^{o}C and outlet temperature is varying between 350C and 400C
5. First lot of 10 tube bundles did not have seal welding between tube and tube-sheet. Within two years of service of these coolers, leaks were reported due to crevices and rat holes in the tube-sheets. Eventually the problem was resolved by seal welding although some pin-holes surfaced during subsequent inspections/dye checks
6. UNS S31254 clad FTS covers were introduced along with these bundles. Gasket seating surface was weld build up and machined; weld overlay thickness is 5mm after machine finish
7. Many tube bundles were re-tubed partially/fully after repairs in the tube sheets, and a few were replaced with new UNS S31254 bundles when the tube sheets were found beyond repairs.
8. Electrode/filler wire ERNiCrMo-3 (AWS A5.14), i.e. P-12 electrode (9% Mo) was used for the repairs and weld build-up of UNS S31254

Figure 1: Crevice Corrosion on Tube Sheet Gasket Surface

Discussion

Super austenitic stainless steels is particularly susceptible to pitting and crevice corrosion in strong electrolytic seawater containing high chloride ions. Other factors that increase the susceptibility for pitting and crevice corrosion are increased temperature, stagnant flow regime, presence of crevices, seawater deposits and chlorination. These effects are discussed below:

Pitting & corrosion resistance

It is well known that increasing the chromium content, adding molybdenum and nitrogen as A Pitting Resistance Equivalent Number (PREN) can be used in order to rank and compare the resistance of different stainless steels in terms of their resistance to pitting corrosion.

PREN = %Cr + 3.3 × %Mo + 16 × %N.

PREN for super austenitic stainless steel, is about 45, which is considered to be resistant to general corrosion and pitting.

However, in narrow crevices, the passive film may more easily be damaged and in unfavorable circumstances stainless steel can be subjected to crevice corrosion. Examples of such narrow crevices may be under gaskets in flange fittings, or under deposits.

Temperature
Temperature plays an important role to initiate pitting and crevice corrosion.

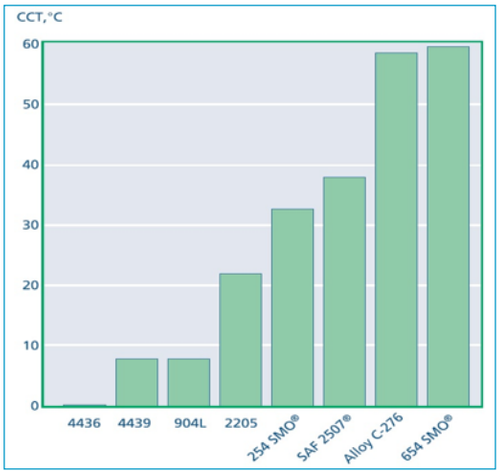


Figure 2: Critical Crevice Corrosion Temperatures (°C) for some Stainless Steels in %6 FeCl3

From figure 2, it is evident that in oxygen saturated seawater (Chloride about 30,000 ppm) UNS S31254 can resist pitting corrosion up to 24°C and crevice corrosion less than 20°C. This lower CCT makes UNS S31254 material very vulnerable to crevice corrosion in our application where the average temperature is well above 35°C.

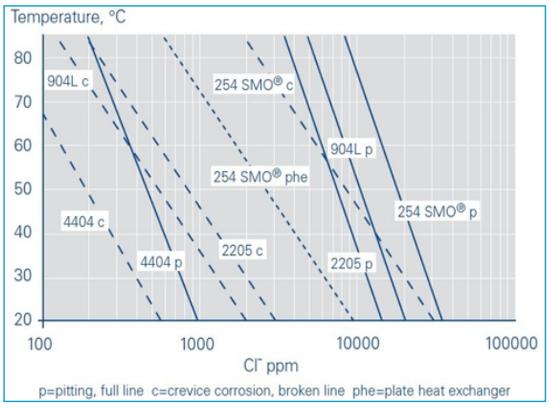


Figure 3: Engineering Diagram Illustrating the Risk of Pitting and Crevice Corrosion on high performance stainless steel in water of different chloride content or temperature

Chlorination
Chlorination, as oxidizing biocide, is being used to control bio-fouling, dosage has a significant effect on crevice corrosion rate.

The level of chlorination in our seawater return line was measured at site and a high level of around 2 ppm free chlorine was reported. The reason for higher dosing to maintain long pipelines with minimum of seawater macro-organism such as sea-shells and mussels etc.

Gasket material
There is no uniformity of use of gaskets in these exchangers during procurement and maintenance including use of graphite gasket.

Literature survey shows that recommended gaskets in seawater service for pressure system up to 10 bar, as in our case, shall be made of CNAF, i.e., Compressed Non-Asbestos Fiber. In order to avoid the chances of crevices close to the gasket, use of full gasket has been recommended.

Weld repair of gasket surfaces
Solidification after partial remelting, during welding, causes redistribution of certain elements such as molybdenum, chromium and nickel. These variations/segregation, remain in the cast structure of the weld and can impair the material's corrosion resistance in chlorinated seawater environments.

The effect of segregation after welding can also be reduced by subsequent heat treatment, quench annealing, but such action is normally limited to uncomplicated geometries, e.g., pipes, pipe fittings and end pieces.

Conclusion

1. Most of the current problem in UNS S31254 tube bundles is crevice corrosion under gasket surfaces.

2. After modifying the tube-to-tube sheet joints to welding after slight expansion, the magnitude of corrosion of the tube sheet around tubes is not significant.

3. Under the existing conditions of presence of crevices, normally high

seawater temperatures in Kuwait and level of chlorination, UNS S31254 will not perform satisfactorily for a desired long life.

Recommendations

- Not recommended to procure new UNS S31254 bundles, including in kind replacement in future;

- Full face gasket, CNAF Tube to Tube sheets joints are welded. Avoid crevice.

Existing UNS S31254 bundles
Continue to use existing UNS S31254 bundles with following optimal repairs to improve its service life:

1. Machine to 10 mm depth & Weld build up with High Mo Electrode like UNS N10276 (Hastelloy C276) or UNS N06625 (Inconel 625).

2. Establish WPS/PQR for repairs.

3. Use Low Heat input (2KJ/mm) and Inter pass temp < 100 °C.

4. PMI & Ferrite Content before and after repairs/machining.

5. Use only CNAF Gasket (avoid Graphite)

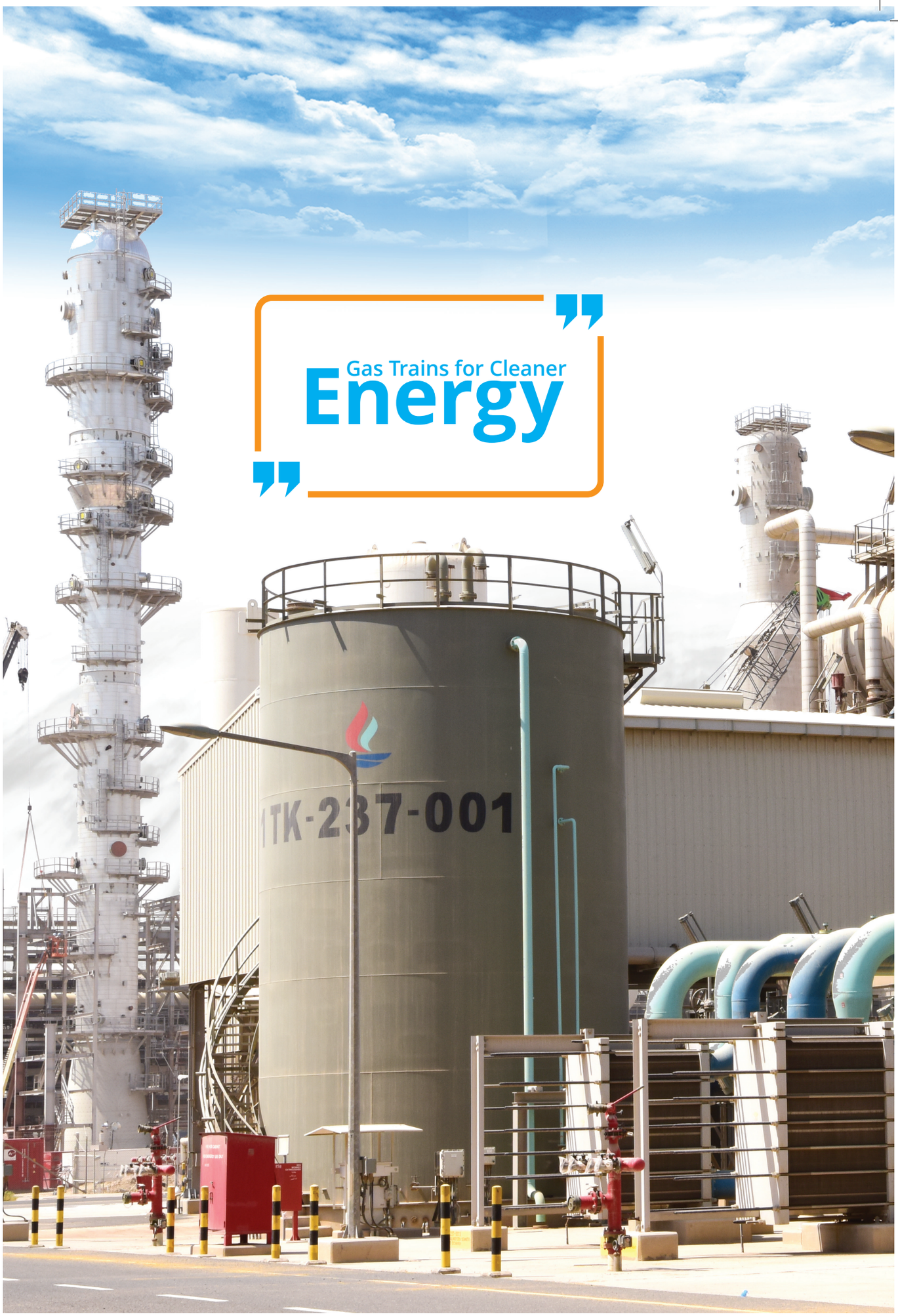
6. Full width gasket (eliminate crevice).

7. Use pneumatic torque for uniform bolt tightening.

8. Provide Sacrificial Zinc Anode in Channel box.

9. Regulate Chlorination between 0.3 -0.5 ppm FRC in seawater return.

Maintenance of tube bundles


Gas Trains for Cleaner
Energy


ANALYZER-HOUSE- 007

Equilibrium and Saftey Valve Maintenance

Engineer Hassan Abdullah Al-Kandari
Team Leader, Customer Management

Every industrial or oil facility requires safety valves to prevent or limit the possibility of accident occurrence and to cut fuel during emergency. Some of these safety valves remain working for more than 3 years and have no way to be isolated when the facility is in production.

Invention

This invention is useful in the protection of corporate assets and production facilities of public and private (oil, electrical and industrial facilities) and maintains the safety of individuals and equipment, environment and reputation. This invention adds another safety element and solves all existing or potential problems for existing inventions.

The invention was registered at the United States Patent and Trademark Office.

Prior art

The previous inventions have several problems. They have been developing solutions for these problems. However, the solutions are not effective and do not cover all problems, as well as may create other problems and may become more complex. Such as:

1. Shut off valve required fast closing within a second during emergency as per world standard.

2. DCS scan time within Millisecond.

3. The large number of elements added creates further complication with less safety due to diversity of their failure duration (main time between failures) either electronic or mechanical.

4. The high cost in implementing these inventions for green or brown fields compared with this invention.

5. The more elements added the more periodic maintenance.

Summary of invention

Every industrial or oil facility requires safety valves to prevent or limit the loss (of personnel, equipment and environment) and to cut fuel during emergency.

The nature of this valve is always open for long periods. So the valve cannot be subjected to periodic maintenance due to production lost. As per international standards, periodic maintenance must be done for each valve within 3 years. But some of these safety valves remain working for more than 3 years and have no way to be isolated when the facility in production as per world standard. It is impossible to do full maintenance of the valve during production.

Problems

That might occur when the safety valve is not subjected for maintenance for long time:

1. Stuck on position (100% open) when it is necessary to close.

2. Very slow closing (more than one second as per design data sheet).

3. Do not close fully (passing)

Therefore, it is required to find a way and make sure that the valve would act when it is needed.

The idea of partial stroke valve is to close the S/D Valve 10% and reopen 100% while the valve is on operation.

Equilibrium PST idea

By applying the theory of Pneumatic Equilibrium for any containers/cylinders, the time takes to equalize pressure (P1=P2) between two cylinders (cylinder no. 1 is having continuous P1=20 PSI along with air regulator as source of supply and other cylinder no.2 P2=zero PSI) once connected and opened to each others.

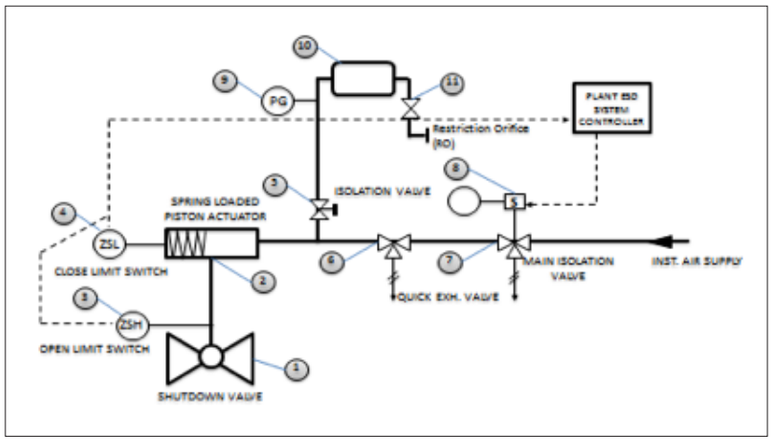
We call this a Time delay (the time takes when cylinder P1= cylinder P2). The Idea is to use this time delay for partial stroke test, when the valve is in use without affecting the process area.

Conclusion: If the valve performs closing and opening smoothly within reference time during testing, we declare that the valve is functional.

(Reference time = time once valve commissioned + cycle time).

Drawing summary

1. Valve Body
2. Piston Actuator
3. Open Limit Switch
4. Close Limit Switch
5. Isolation Valve
6. Quick Exhaust Valve
7. Main Isolation Valve
8. Solenoid Operated Valve
9. Pressure Gauge
10. Air Cylinder
11. Isolation Valve
12. Restriction Orifice



Detailed description

When PG No. 9 reads zero and isolation valve No. 11 is closed, then we open isolation valve No. 5, and the pressure drops down automatically in the positioner Actuator No. 2 and the pressure in the Air Cylinder No. 10 starts building up until pressure in both will become equal. So the duration time taken between cylinders pressure difference and until equalization, the shut off valve starts closing and then backs again to open position automatically. In order to detect the move, the valve open limit switch will change from on to off and then back on. This will verify that the valve will work when needed.

Protection elements

Identify the mechanism

The Partial Closing Test (PST) of the safety valve is a technique used in the safety system fitted to allow the user to test the percentage of potential failure modes that may arise on the safety valve without the need to close the valve 100%. All elements added to the existing protection system have no effect on the valve and will have none while it is working or under test. So if an error occurred, whether intentional or unintentional by keeping some of isolation valves open, the safety valve performance will not be affected. These possibilities were successfully tested at the workshop.

About the invention

The partial shutdown of the safety valve (PST) is a technique used in the safety system fitted to allow the user to test the percentage of potential failure modes without closing the valve 100%. Several methods used with pros and cons:

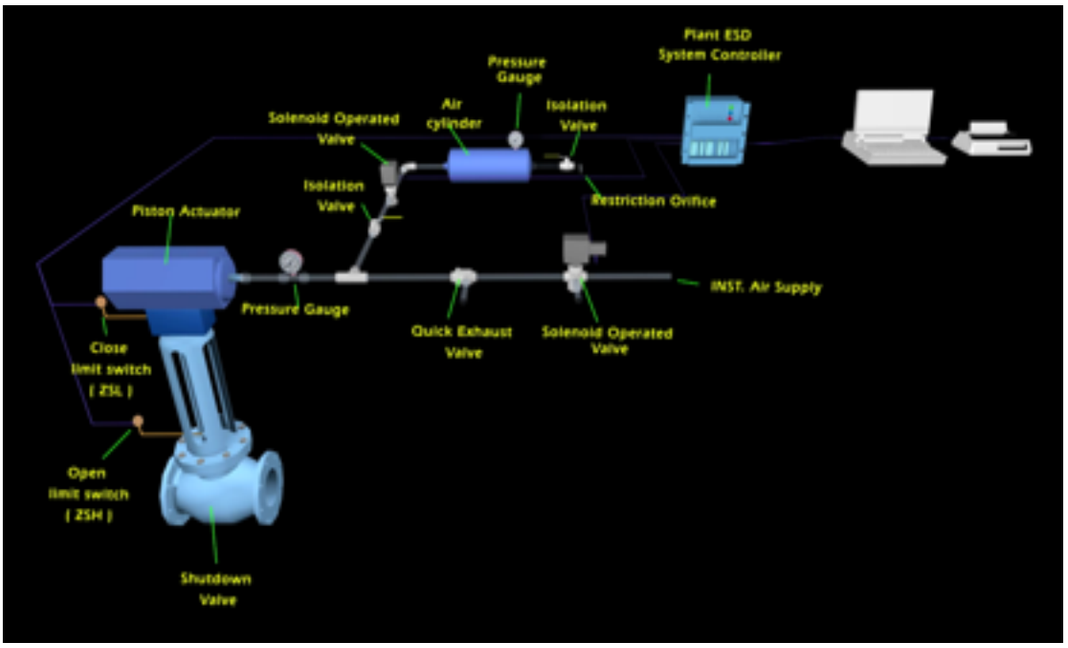
- Mechanical method (jammers)
- Way (Pneumatic valve positioner SIL3)
- Electronic Method (Electronic timer control system)

Disadvantages:

- First method is by abolishing the safety system during testing;
- The second is the loss of production in any malfunction in the positioner;
- Third way is the failure in working properly due to fast valve closing within a second. But the invention that was made does not have any negative impact and is 100% safe.

System layout

Existing parts: Instrument Air Supply, Main Solenoid Operated Valve, Quick Exhaust Valve, pressure Gauge, Shutdown Valve, Limit Switch ZSL and Alarm indication, Limit Switch ZSH and Alarm Indication, Plant ESD System Controller, HMI, Printer.



New addition parts: T Pipe Connection, Hand Isolation Valve, Solenoid operated Valve, Air Cylinder with Pressure Gauge , Hand Isolation Valve, and Air Restriction

Manual Test

Valve Partially Test Closing around 10 % and re-open:

- Once the unit is running and Shutdown Valve is fully open
- While Pressure Gauge is showing 20 PSI which means that Shutdown Valve is fully open
- Open Hand valve, main pressure Gauge indicator will drop until the Air cylinder pressure gauge is pressurized and both main pressure gauge and cylinder pressure gauge are equal
- During main pressure gauge start fluctuation due to hand valve was opened manually
- Both Limit Switches are off (ZSL, ZSH)
- The short duration time taking to stabilize and equalize the pressure between the actuator pressure and cylinder pressure. During this short time the valve will start closing around 10% and re-open back

The valve reopen

- Valve reopen back to 100 %
- ZSH will be on (Green)
- ZSL remains off (Red)

Auto Test

- While Main Solenoid Valve Energized
- ZSH is on (Green) indicating valve is fully open
- PST new Solenoid Valve de-Energized

General note

Most Shut down valves are designed for 1 second closing time for Oil and Gas use.

To start PST test the Cylinder pressure gauge should indicate zero.

To find out the valve needs to be dropped for maintenance. Time table comparisons between each preformed with reference time test.

Reference time test can be recorded when first the valve is run. Time stamp of the ZSH indication during first time testing the ZSH will become off and then on one pressure is equalized . This time stamp is your reference for next PST test.

K-MAX: Maximo Upgrade Embarking New Technology by IT Department

Nasser Al-Tayar, Anwaar Al-Nowh, Esraa Abul, Farah Al-Meshri, Manoj Verma
IT Depatment

This project is sponsored by IT Manager Mr. Abdulaziz Al-Duaij and will be implemented by Enterprise Applications Division headed by Team Leader Nabeel Haidar.

From left: Verma, Al-Tayar, Al-Nowh, Abul and Al-Meshri

New approach

The K-Max is a strategic project changing the culture of the traditional way of introducing new applications on existing infrastructure consisting of middleware, databases, and servers which are supported by various vendors into one complete bundle provided and supported by a single point of support.

Breif history

Maximo implementation started on May 18, 2002 as part of unifying commercial processes. 28 individual applications where merged into a Single Maximo software suite. Maximo went live on January 4th, 2004 for MAB (Mina Abdullah Refinery) followed by Shuaiba Refinery, MAA (Mina Al-Ahmadi Refinery), Local Marketing, Head Office Finance, Projects and Al-ZOR Refinery Project (Now with KIPIC). Maximo implementation has gone through two major upgrades, from 5.1 to 6.1, then to 7.5. Many Custom applications are added to Maximo software suite to meet KNPC business processes such as Commercial Directory, Catering Requests, CCAR (Catalog Creation & Amendment Request), VEC & CEC Master etc..The latest addition being Maximo Oil & Gas add-on along with HSE Applications.

Significant improvements

Maximo has made significant enhancements in Commercial, Finance and refineries processes which contributed significantly in cost optimization (Figure 1).

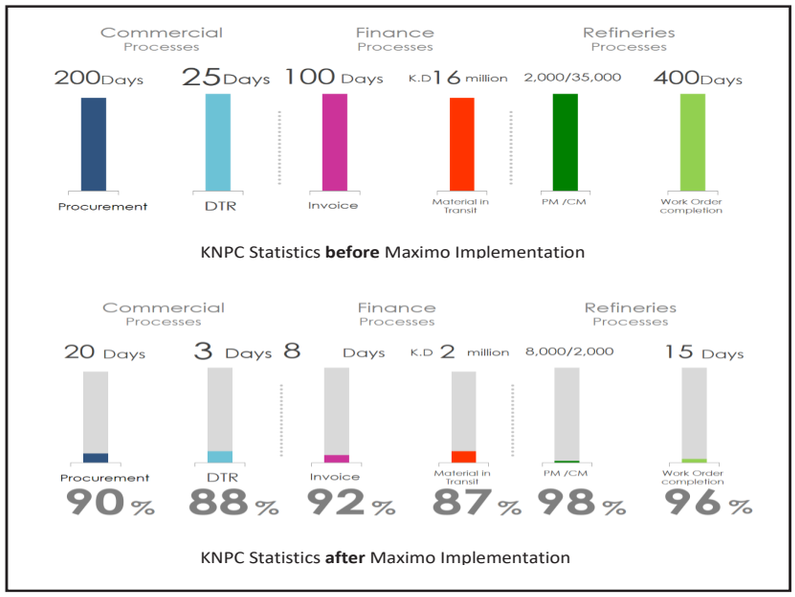


Figure 1: Maximo Statistics

2040 Strategy alignment with K-Max

In the approach of aligning with the KNPC 2040 Strategy, the K-MAX project was initiated to enforce the following strategic initiatives:

- Innovation: Develop strategic capabilities to incubate innovation and faster implementation of emerging technologies
- Mobility: Enable the enterprise with Mobility platform leading to quick and easy access to all enterprise systems thereby increasing the productivity
- Business Support: Maintaining relations with business by capturing demands, communicating expectations, changes, charges and performances
- IT/OT Integration: Integrate IT and OT technology planning, operations, governance and security, to ensure interoperability of systems

K-MAX objectives

- Serve Users at optimized cost
- Improve performance
- Build internal resources
- Meet User expectations
- Minimize customization
- Optimize resources utilization
- Keep pace with evolving technology
- Serving K-Companies

Architecture re-design

The upgrade will include the following infrastructure changes:

Maximo Version

- Maximo Version 7.5.x will be migrated to Maximo 7.6.x

Web Server Version: Optimized for the IBM Power Systems Architecture

- WebLogic Application Server v10.3.6.0 will be migrated to WebSphere Application Server V9.0

Operating System Version

- Currently running on Solaris 11.3 will be migrated to AIX Version 7.1

Database Version: to benefit from License, Performance and Maximo Multi-Tenancy

- Oracle 11.2 will be migrated to DB/2 11.1 (Needed for Mulit-Tenancy)

Computing Platform: to support better performance with existing resources and lower license costs

- Sparc M7 Servers Infrastructure to be migrated to IBM Power8 Server Infrastructure

Storage and Network Platform

- KNPC will reuse current Data centre, storage, backup/recovery, network and security, LDAP and oracle Infrastructure and investment

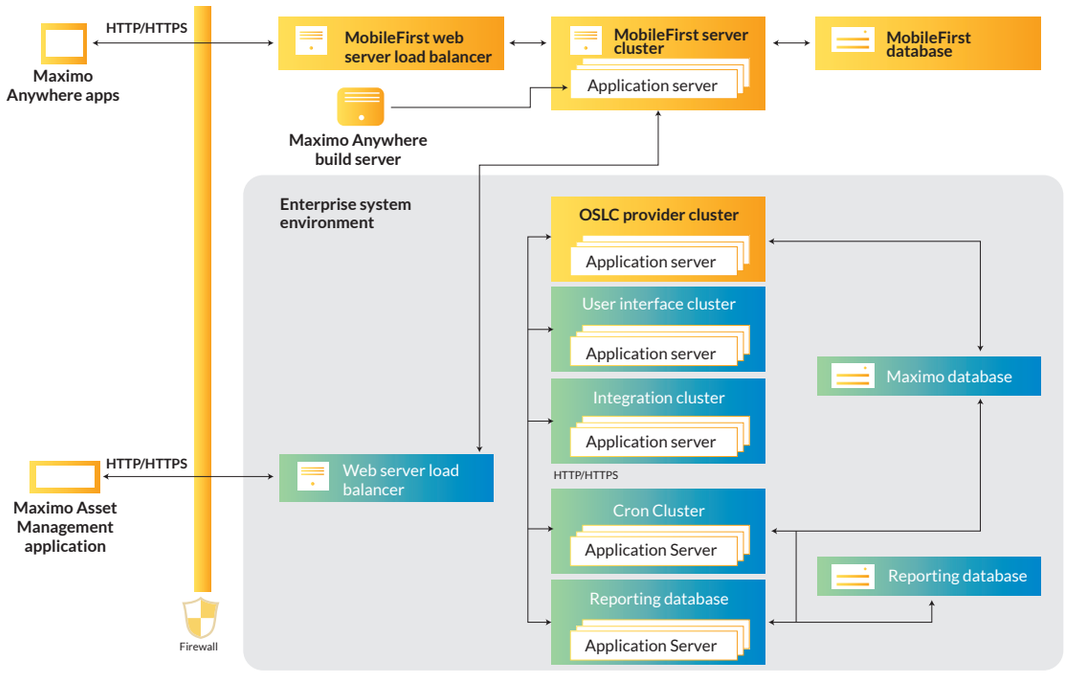


Figure 2: K-MAX Architecture

Pain area

Maximo 7.5 does not support most of the innovative technologies such as IIoT, latest mobility solutions (Anywhere & Everywhere) and analytics. In addition, current database and middleware do not support multitenancy (hosting Maximo to other K-Companies) as currently to host any new K-Company requires going through a costly procedure of copying from KNPC's server. Also, the integration between different technologies caused performance issues which will be overcome by the upgrade.

K-MAX project benefits

- Breakthrough innovation: End-to-end Industrial Internet of Things (IIoT) solution with predictive & Cognitive Maintenance Capabilities for future innovation
- Scalability: Support hosting additional users and organizations both internal and other K-Companies. Figure (3)
- Performance: Improved user experience and system throughput. (Figure 4)
- Clear product roadmap: Minimize future disruption and provide for futureproofing (all IBM) road map will be aligned with Brand
- Customization reduction: Ensure future upgradeability and supportability of Maximo Landscape
- Reduced license and Support cost: Database (Oracle) and Middleware (WebLogic) DB2(Database), WebSphere (Middleware), Everyplace & COGNOS are bundled with Maximo 7.6 upgrade
- Consolidation/ Alignment/ Restructuring of all Maximo Licenses: Leading to cost reduction up to 70 %
- Avoidance of third party licenses and reduction in Maximo license costs
- Guaranteed improved performance by IBM
- Multitenancy Environment enables the hosting of Maximo as a Service to other

K-Companies. leading to fulfilment of IT Profit Center concept (one deployment, one DB, single schema, multiple tenants, multiple users per tenant), as shown in figure (4)

- Effective utilization of infrastructure acquired by KNPC
- Leveraging on the knowledge acquired by IBM while carrying out similar jobs worldwide
- Building KNPC resources on new technology

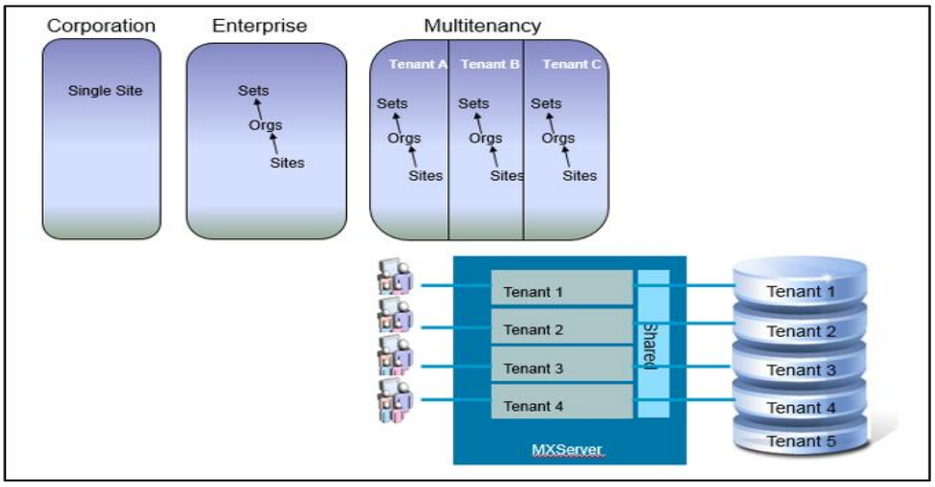


Figure 3: Evolution of Maximo from Single Instance to Multitenancy

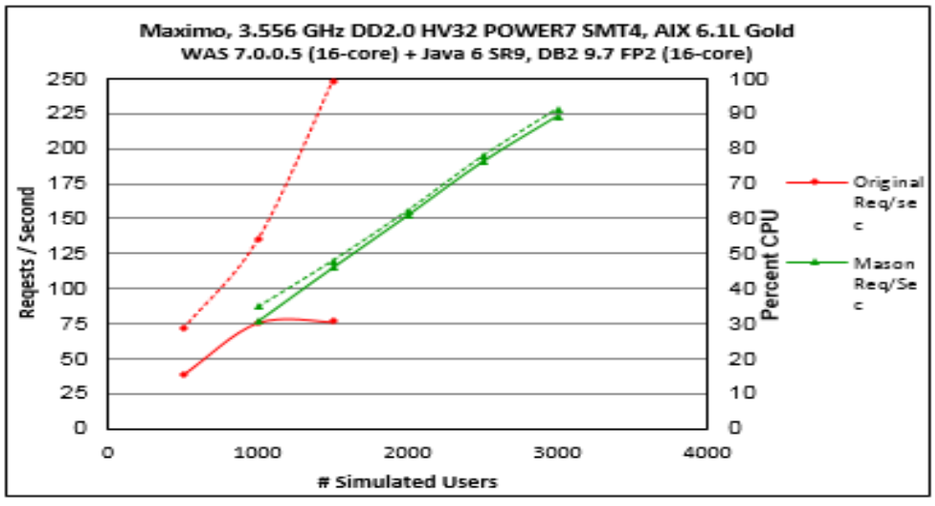


Figure 4: Optimized Maximo Performance on Power Platform

FCC:

Higher

Conversion Rate


Q8 Oils
Q8 Oils
Q8 Oils
Q8 Oils

HSE Risk Management Process at KNPC

Palanival Murugan
Safety Engineer
Technical Support-HSE

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Technical Support-HSE

Refining of crude, distribution and marketing of products and other associated activities related to hydrocarbon processing present major risks to the employees' health and safety as well as safety of the environment and community. KNPC is committed to conduct all its activities with a stated risk tolerance policy called 'As Low As Reasonably Practicable (ALARP)'.

This requires substantial efforts, resources, investment and a persistent management commitment. This commitment is reflected in KNPC Health, Safety, Security and Environment (HSSE) policy statement. The policy is further implemented through a structured management system called HSSE Management System. The current Management System, i-SHEMS is a derivative of earlier Safety Improvement System (CONOCO, 1997), SHEMS (DNV, 2001) and Process Safety Management program (KPC, 2007).

However, the risk management aspect got substantially addressed with the advent of 2016 revision of KPC HSSE Management System. KNPC is obliged to full compliance of this system, including element # 4 on Risk Management.

To ensure that it has the management system with the best features, KNPC has achieved international certifications for its HSE MS, i.e. ISO 14001 for Environment Management System and OHSAS 18001 for Occupational Health & Safety Management System. These are further integrated with ISO 9001 (Quality Management System standard) into a composite Integrated Management System (IMS).

Generic framework of Risk Management

The ISO 31000 provides an internationally accepted framework for Risk Management (Figure 1).

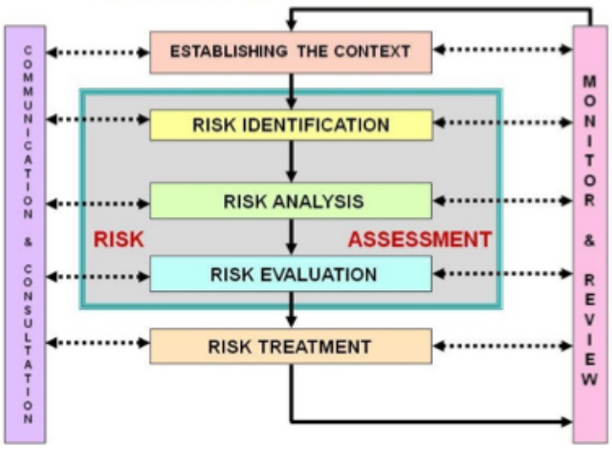

Figure 1: Risk Management Process

The above Risk Management process applies also to all aspects of HSSE including:

a) Occupational Health (i.e. those acute and chronic risks that originate from the exposure of personnel to chemical, biological, physical and psychological stresses)

b) Occupational Safety (those risks that originate from work activities conducted by people)

c) Process Safety (those risks that originate from the hazardous materials in use/being produced at a facility); and

d) Environment (those risks that originate from the use, handling and consumption of materials and energy, and the impact of the discharge of resulting products, including waste, into the environment)

The HSSE risks are covered under 'Operational Risk' in KPC's Enterprise Risk Management (ERM) Framework.

ARD Unit - MAA

How is KNPC controlling health and safety risks?

The industry has incorporated several improved tools and techniques for identification, control and monitoring of HSE risks. These are appropriate at various stages of plant lifecycle i.e. feasibility, engineering, construction, continuous operation and demolition.

Task or Activity Risk Assessment

Routine, non-routine and emergency tasks or activities have to be risk assessed and controls need to be put in place. HSSE Risk Management is not a one-off task, but must be an integral part of all business processes. No work activity shall start without an assessment of HSSE risk being conducted, noting that the HSSE risk assessment technique, extent to which it is applied and the level of depth of the assessment will vary and needs to be selected carefully to produce reliable and useful information.

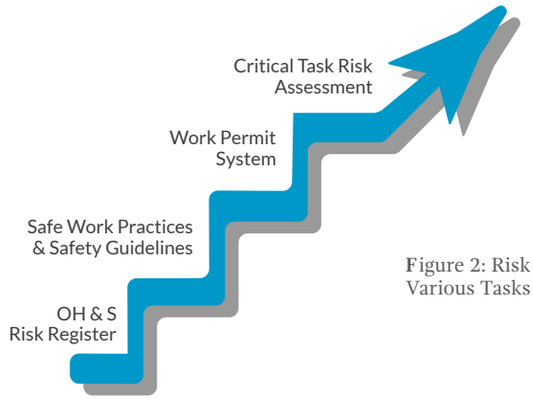

Figure 2: Risk Control Processes Related to Various Tasks / Activities at KNPC

Work Permit System

Work Permit system is the basic form of Task Risk Assessment process. Work Permits (Hot Work & Cold Work permits and Confined Space Entry authorization) are a basic form of HIRA & DC tool, which guides in Hazard Identification and Controls determination for specific (maintenance, construction & non-routine) activities.

In other words, a Work Permit system is one of the principal tools to manage work activities that have inherently higher risks or unique characteristics that could lead to a higher level of risk than routine or daily work activities.

Safe work practices and safety guidelines

Safe Work Practices, Guidelines specify hazards associated with specific activities and appropriate control measures to prevent exposure to hazards. They outline precautions to be taken while doing a specific job to reduce risks to PEAR {P (People), E (Environment), A (Assets) & R (Reputation)}.

OH & S Risk Register

The basic form of Hazard Identification, Risk Assessment & Determination of Control Measures (HIRA & DC) which considers all the activities (routine, non-routine & emergency activities) of a particular craft / division is the OH & S Risk Register. OH & S Risk Register deals with work place health and safety hazards.

It can be considered as a baseline risk assessment containing inventory of hazards for the activities of a

particular division. It also identifies and outlines the applicable 'legal requirements' to be complied with besides achieving the primary objective of reducing the residual risk to an acceptable level.

It needs to be revised whenever there is any change in process, operation, when a new machine is introduced, new chemical is introduced, whenever an accident takes place or annually, whichever is earlier.

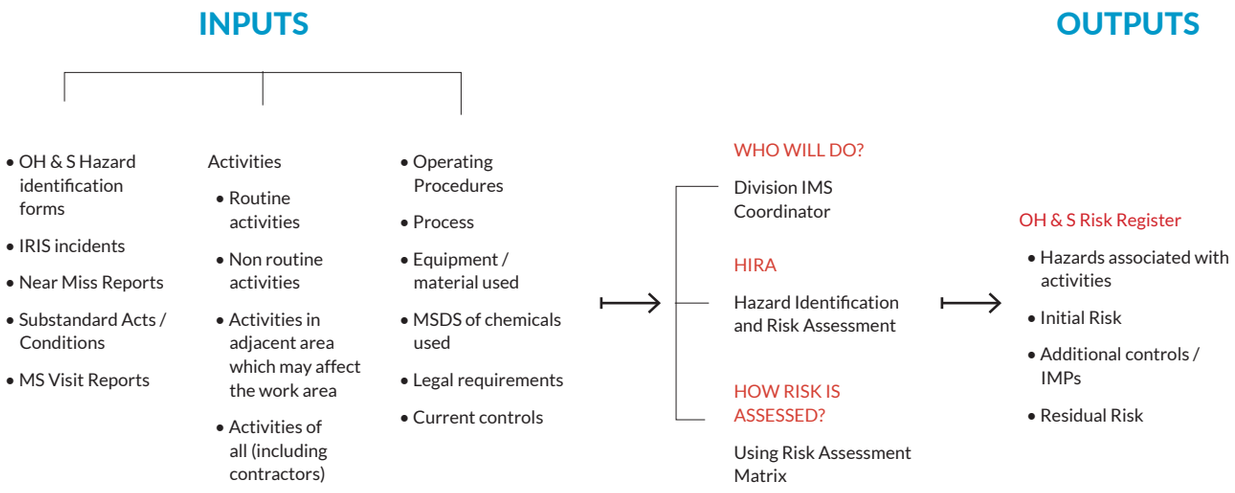

Figure 3: OH & S Risk Register Preparation Process

Critical task risk assessment

Critical Task Risk Assessment is a process applied at KNPC for specific activities (maintenance, construction & non-routine activities) which are identified as critical works. This is done by a multi-disciplinary team. It identifies the hazards associated with specific critical work at a specific location, done by a specific work crew, assesses the risks associated with it and determines the control measures to reduce the risk to an acceptable level.

Risk Management Process Vs. OHSAS 18001

Clause # 4.3.1 of OHSAS 18001 mandates "Hazard Identification, Risk Assessment & Determining Controls" as an essential part of planning stage of any Occupational Health & Safety Management System (OHSMS). Various techniques explained above are utilized to ensure hazards are recognized, associated risks assessed and controls determined to reduce risks to an acceptable level.

Individual Roles & Responsibilities

The success of all the techniques described above depends on the competency (knowledge, skill and experience) of the personnel involved in the process. An active monitoring by supervision and management is a basic requirement.

Conclusion

HSE Risk Management is a significant component of any HSSE Management System. KNPC's HSSE Management System is not only in full compliance with the international standard requirements but goes beyond standard requirements in its quest to achieve continual improvement.

Persistent efforts by all stakeholders (management, employees, contractors) in reducing risks posed by various activities will result in continual improvement of HSE performance.


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