

Technological Evaluation of the Implementation of Advanced Process Control at the RFCC Unit of PT Kilang Pertamina Internasional

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Abstract

The RFCC (Resid Fluid Catalytic Cracking) unit at PT Kilang Pertamina Internasional RU IV Cilacap has a design capacity of 62 MBSD, using Low Sulphur Wax Residue (LSWR) from CDU II and Vacuum Gas Oil from HVU I/II as feedstock. In this unit, heavy hydrocarbon feed is cracked using a fluidized catalyst to produce lighter and higher-value products. The main RFCC products include propylene, RFCC naphtha, LPG, Light Cycle Oil (LCO), Decant Oil (DCO), and Heavy Cycle Oil (HCO). Propylene is produced in Unit 104, Propylene Recovery, as the overhead product of the C3 Splitter after further treatment through the propylene drier and propylene treater. RFCC naphtha from Units 101/102 is treated in Unit 105 Gasoline Hydrotreating (Prime-G) to remove sulphur contaminants and produce desulphurized RFCC gasoline as a high-octane blending component. LPG is produced through gas concentration, LPG Merox treatment, and separation in Unit 104. Meanwhile, LCO and DCO may be sent to product tanks or used as refinery fuel oil blending components, while HCO can be recycled to the reactor as heat carrier or feed under certain operating conditions. Current RFCC operation still faces several challenges, including reactor outlet temperature fluctuations affecting conversion stability, main column temperature profile fluctuations influencing valuable product yield, and prolonged operating-condition tuning in Unit 104 to maintain high-purity propane while keeping propylene on specification. Therefore, the implementation of Advanced Process Control (APC) is considered a strategic optimization approach to improve operating stability, maximize valuable product recovery, increase efficiency, and support energy savings in the RFCC unit.

Keywords: APC; Advanced Process Control; optimization

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INTRODUCTION

PT Kilang Pertamina Internasional (KPI) RU IV Cilacap is one of seven oil and gas processing units and other materials in the country with a production capacity of 348,000 barrels/day or 348 MBSD [1]. This refinery has an area of approximately 200 hectares and supplies 33.2% of national fuel needs or 60% of fuel needs on the island of Java. PT KPI RU IV Cilacap is Pertamina's largest oil processing unit with an NCI (Number Complexity Index) value of 7.4 and the highest avtur producer in Indonesia. In addition, this refinery is the only refinery in the country that currently produces asphalt and base oil for infrastructure development needs in Indonesia [2].

PT KPI Unit IV Cilacap has a very strategic role in maintaining the security of supply of oil products including Pertamax, Premium, Solar, Dexlite, Avtur, and LPG (LPG) which are distributed to the Central and Eastern Java areas as well as surrounding areas in the territory of the Republic of Indonesia [3]. Over time and the need for the supply of petroleum processing products is getting bigger, PT KPI Unit IV Cilacap has experienced revamp projects, capacity additions and installation of new units which of course have an impact on changes in the mode and operational pattern of the refinery itself [4]. The latest is the completion of the Cilacap Blue Sky Project (PLBC) in October 2018 so that it can increase the operational capacity of RU IV Cilacap [5], [6].

As a refinery that processes petroleum, the PT KPI Unit IV Cilacap Oil Refinery has a variety of products [7]. The main business process is to process petroleum (crude oil) and intermediate raw materials into products with high selling value [8]. The products produced include:

1. Fuels are Pertamax, Premium, Solar, Dexlite, Avtur, IDO, MFO, LPG [9]
2. Petrochemical yaitu Parafinik Oil, Paraxylene, Benzene, Propylene, Asphalt, Exdo-4, Minarex, Slack Wax, Sulfur [10]
3. Lube base yaitu HVI-60, HVI-95, HVI-160s, HVI-650

The process of processing raw materials in the refinery in the form of petroleum (crude oil) into derivative products, namely in the form of Pertamax, Premium, Solar, Dexlite, Avtur, IDO, MFO, LPG, Propylene, Paraxylene, Benzene, Asphalt, Lube Base and Sulfur is presented in the form of a block flow diagram [11]

One of the refineries in RU IV Cilacap, namely the RFCC (Resid Fluid Catalytic Cracking) Unit, has a design capacity of 62 MBSD, with raw oil feed coming from Low Sulphur Wax Residue (LSWR) ex CDU II and Vacuum Gas Oil ex-HVU I/II [12]. Feed raw oil will go through the cracking process using a fluidized catalyst into a lighter and more valuable product, including:

- a. Propylene products are produced in unit 104, Propylene Recovery as an overhead product C3 Splitter, after going through the advanced treatment process of moisture removal in the propylene drier and COS and metal removal in the propylene treater.
- b. RFCC naphtha derived from unit 101/102 removed sulphur contaminants and ditreated external diolefin fraction in unit 105 Gasoline Hydrotreating (Prime-G) produces desulphurized RFCC gasoline. Ex-RFCC gasoline products are high octane blending (HOMC) components, flowed to the RFCC gasoline tank.
- c. LPG (mixed C3/C4) products are produced in unit 104, Propylene Recovery after going through the process of treating and separating in unit 102, Gas Concentration

and unit 103, LPG Merox. In unit 104, LPG is produced as the bottom product of C3/C4 Splitter and C3 Splitter.

- d. Light Cycle Oil (LCO) received from the LCO Product Coalescer at RFCC Unit 101 will be delivered to the existing MFO header or LCO Tank and can also be delivered to the Fuel Oil Tank as a blending component of the refinery fuel oil (RFO).
- e. Decant Oil (DCO) is the bottom distillate of RFCC products. Before going to the product tank, the fine catalyst is first separated using an automatic backwash filter. Some DCO can also be sent to the Fuel Oil Tank as a blending component of the refinery fuel oil (RFO).
- f. Heavy Cycle Oil (HCO) is an intermediate product that is used to circulate back to the reactor to be used for heat, besides that HCO can also be reused as reactor feed, under certain conditions.

There is still room for improvement in the RFCC unit to get more optimal operating conditions so that it is able to produce products to the maximum, one of the optimization efforts that can be done is to implement APC in the RFCC unit.

The problems that occur in the operation of RFCC are as follows:

1. Fluctuations in reactor outlet temperature that have an impact on fluctuations in RFCC conversion
2. The fluctuation in the temperature profile in the main column has an impact on the suboptimal value of the products produced.
3. Tuning operating conditions that take a long time in Unit 104 to obtain high purity propane under conditions while maintaining on-spec propylene quality

To improve the stability of operating conditions at RFCC PT KPI RU IV Cilacap through the implementation of Advanced Process Control (APC) process control and optimization, the use of which has been widely applied to increase profits through optimization of valuable products, efficiency, and energy savings.

LITERATURE REVIEW

Advanced Process Control (APC) is a technology used for process control and optimization, APC is widely used in the refinery industry and is proven to provide benefits through valuable product optimization, efficiency and energy savings [13].

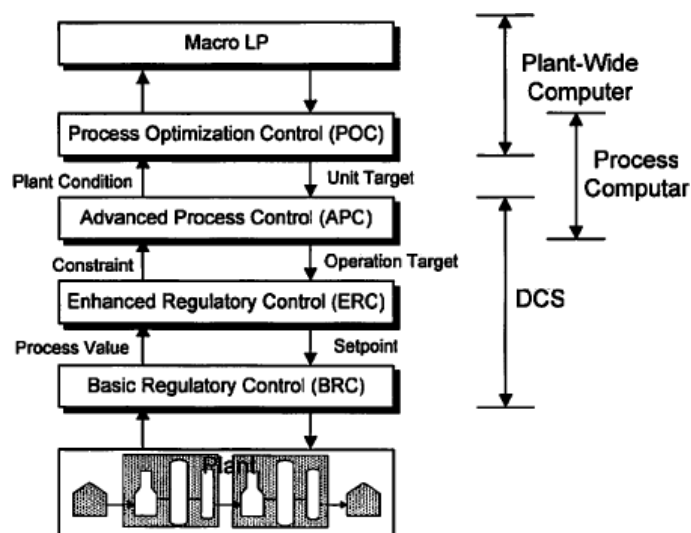


Figure 1. Process Control Hierarchy

In the APC operating system, there are 3 types of variable processes including:

a. Controlled Variable (CV)

CV is a variable of the process that wants to be controlled because disturbance at all times has a great effect on this variable. Controlled variables can be in the form of critical operating conditions such as: reactor top temperature, reactor conversion, and product quality.

b. Manipulated Variabel (MV)

MV is a variable of the process that is arranged in such a way that it affects the CV value with the aim that the CV value remains within the target range. Manipulated variables are usually set points of the control valve which philosophically control can affect the controlled variable.

c. Disturbance Variabel (DC)

DV is a variable of the process that is a disturbance and can affect the process.

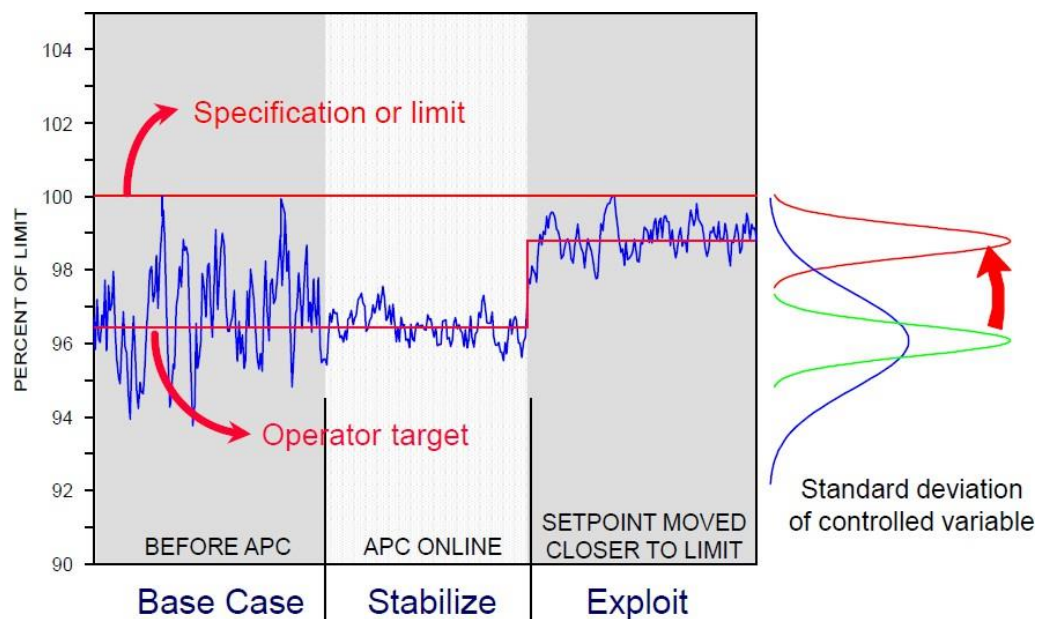


Figure 2. Philosophy Control APC

METHODS

Advanced Process Control

The main goal of the implementation of APC is to increase profitability by reducing the variation of operating variables so that it can increase profitability/profit [14]. In general, APC profits are derived from:

a. Maximizing feed

The operation of the APC can encourage the process unit to operate more efficiently so that it can operate at a higher capacity.

b. Maximizing product value

In the operation of a process unit, there are one or more products with a higher economic value than other products. By using APC, products with higher economic value can be maximized so that they produce higher profits.

c. Reduce product quality giveaway

Through good control, the quality of the products produced can be maintained at the value according to the specifications, thereby reducing the quality of excess products.

d. Stable operation

APCs are designed to quickly identify and respond to disturbances that arise, by setting all MVs at a certain magnitude after a disturbance is detected, so that they can be eliminated.

In addition, there are intangible benefits from the implementation of APC such as:

- a. Response to optimization is done quickly and in real time 24 hours
- b. Assisting panelists for multi monitoring process variables so that the potential of off-spec products is minimized
- c. Help each shift perform uniform optimization actions
- d. Can be a learning medium / reference for new panelists and operators

Implementation of APC at Refinery Unit IV Cilacap

PT Pertamina RU IV Cilacap has APC that has been implemented in CDU I, CDU II, and Existing Boiler units[15], with a summary according to the following table:

No	APC Parameter	APC CDU I	APC CDU II	Existing APC Boiler
1	Technology	Azbil	Honeywell	Azbil
2	Implementation	2015	2018	2017
3	Status	Idle	Sustain optimized	Idle (after DCS upgrade in 2019)
4	Objective	•Maximize production of more valuable products (kerosene draw-out)	•Maximize production of more valuable products (kerosene, LDO, and HDO)• Stabilize heater pass balance	• Reduce CO ₂ emissions• Improve boiler efficiency• Maximize fuel gas consumption
5	Benefit	USD 780,000 per year	USD 62,175 per day	Decrease in CO ₂ emissions by 34,957 tons; reduction in TSRF by 43.46 TSRF/day; reduction in EII by 1,427

Objectives of APC Implementation in the RFCC RU IV Cilacap Unit

The objectives of implementing APC in RFCC units by considering room for improvement to increase the profitability of RFCC units are:

- a. The implementation of the APC controller in the 101 Reactor RFCC unit (101-R-501), the main purpose of the APC controller is to stabilize the reactor temperature and improve the reactor conversion.
- b. The implementation of the APC controller in the Main Fractionating Column unit (101-C-521), the main purpose of the APC controller is to maintain the reliability of the main column and optimize the operating conditions to maximize high valuable products according to specifications. One of the optimizations is to increase LCO production from shifting DCO and or HCO products.
- c. The implementation of the APC controller in the 104 Propylene Recovery unit, the main purpose of the APC controller is to maintain the reliability and optimization of

the recovery of propylene products in accordance with the required quality and optimization of the carry over of propylene ex 104-C-502.

- d. The implementation of APC for energy efficiency purposes includes but not limited to regenerator equipment, and other potential equipment for energy efficiency optimization.

APC Implementation Target at the RFCC RU IV Cilacap Unit

No	Equipment	Parameter	UoM	Target
1.	Reactor 101-R-501	ROT	degC	527-538
		Konversi	%-wt	Min 78.08
		Yield	% % % % % %	Offgas: 3.13 LPG: 11.85 Propylene: 4.81 Gasoline: 48.5 LCO: 15.04 DCO: 6.88 Coke: 9.64
2.	Main Fractionating Column	Temperature Bottom	degC	Max. 345
		Temperature Top	degC	Min. 120
		LCO Quality	degC mm ² /s degC ppm ppm degC degC degC degC	Cetane Index: Min 21.95 Flash Point PMCC: min 70 Kinematic Visc 40 deg C: min 2.98 Pour point: Max -14 SG (60/60 deg F): Min 0.9682 Sulfur Content: Max 6500 Water Content: 890 – 1300 Cetane Index: Min. 21.95 Cloud Point: Max. 24 Distillation : 10% recovery: Max. 208 50% recovery: Max. 266 90% recovery: Max. 340
		DCO Quality:	%-wt	pH 9.2 – 10.5 Sulphur Content: max. 1.5
		Temperature bottom	degC	Max. 41
		Propylene Quality:	% ppm-wt ppm-wt ppm-wt %-vol	Purity: Min 99.60 Total Sulfur: Max. 1 CO ₂ : Max. 1 Water Content: Max. 1 Propylene carry over: 5-8
3.	Propylene Recovery Unit 104-C-502			

*The target parameters in the table above adjust to the optimization during the implementation of the APC RFCC RU IV Cilacap.

Advantages of APC Implementation of the RFCC RU IV Cilacap Unit

In general, the advantages of APC implementation in RFCC units are classified into tangible benefits and intangible benefits.

The calculation was carried out using a statistical-based price difference approach between LCO and DCO, by analyzing the decrease in standard deviation using historical process data and operating conditions.

Method of calculating the APC RFCC benefit:

1. LCO Production Data

Min	39.66	m ³ /hour
Max	53.00	m ³ /hour
Average	48.17	m ³ /hour

2. Product Price Base

The economics of APC are evaluated by shifting LCO products from DCO with the basis of calculation is LCO and DCO prices refer to September Price Recap:

LCO	140.06 USD/bbl
DCO	71.77 USD/Bbl

3. Laboratory Analysis Data

Min	288.00
Max	326.00
Average	305.49
Standard Deviation	6.0164

4. APC Benefit Calculation Statistical Approach Method

By using the Final percentage rule method to calculate delta x (the average value of the target difference between baseline and final conditions after APC implementation).

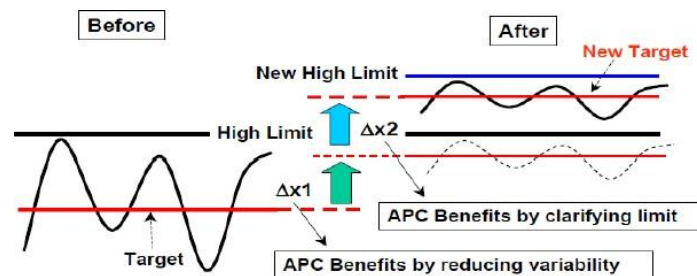


Figure 3. APC calculation with a statistical approach

The final percentage rule method is used to anticipate the distribution of data that deviates from the specification with stricter control, with this method the use of APC can reduce data that is scattered outside the distribution curve. In this method, a z value is required which is based on the assumption of the percentage of error, the z value is determined based on the basic statistical formula according to the following table:

Z	Percentage Violation
1.280	10.0
1.645	5.0
1.960	2.5
2.330	1.0

Assumption:

- Standard deviation decreased by up to 70% after APC implementation
- Percentage violation is 5% data exceeding spec $Z = P(5\%) = 1.65$ (final percentage method)

The calculation of ΔX is carried out by the following formula:

$$\Delta X = Z \times \text{Standar deviasi} \times 0,70$$

Standard Deviation	6.016
$Z = P(5\%)$	1.650
ΔX	6.949

With delta X of 6,949 deg C, calculate the increase in LCO volume with an average increase of 90 % recovery to 312.44 °C

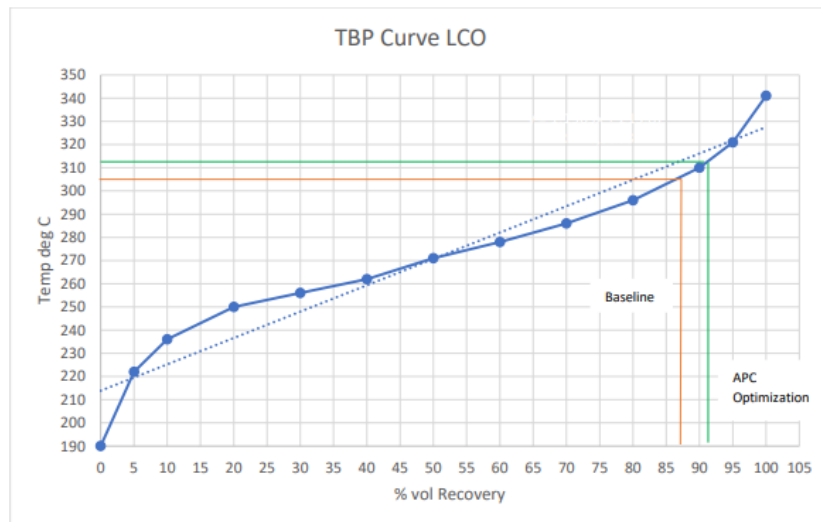


Figure 4. TBP Curve LCO

Delta volume LCO	%Vol recovery
Baseline	86.25
APC Optimization	91.25

5% vol recovery equivalent to 2.41 m³/h LCO, Potential impact:

LCO Optimization	2.41	m ³ /hour
LCO Optimization	358.39	bbl/day
Advantage	50,196.42	USD/day

With an increase in LCO, there will be a decrease in DCO products, so for benefits it is necessary to calculate the difference between the increase in LCO production and the decrease in DCO, based on the following operating condition data and the correlation between LCO and DCO products:

LCO (m ³ /hour)	DCO (kg/hour)
45.92	34,226.67
46.09	34,552.63

An increase of 1 m³/h of LCO led to a decrease in DCO of 1,839 kg/h.

DCO Decline	4,429.32	kg/hour
DCO Decline	106,303.76	kg/day
Disadvantage	45,702.48	USD/day

The APC benefit is the difference between LCO optimization and DCO reduction in the following table:

LCO Optimization	358.39	bbl/day
Advantage LCO	50,196.41	USD/day
DCO Decline	4,429.32	kg/hour
Disadvantage DCO	45,702.48	USD/day
Benefit	4,493.93	USD/day
Benefit	1,640,285.36	USD/year
Benefit	25,672,106,279	IDR/year
Safety factor 50%	818,182.02	USD/year

Safety factor 50%	12,805,366,876	IDR/year
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Calculation basis:

15,651	USD to IDR
Operating day	365 day / year

Based on the above evaluation, the value of benefits obtained from the optimization of LCO products through the implementation of APC RFCC RU IV Cilacap is 12,805,366,876 IDR / year.

Economics of APC Implementation

Economic calculation is carried out using capital budgeting, which is by calculating projected cash flow during implementation, during the economic life until it is implemented [16]. With the following economic indicators:

No.	Economic Indicators	Eligibility Criteria	Information
1.	NPV = \$3,157,822	Positive NPV	The projected revenue generated exceeds the projected investment costs incurred.
2.	Payback period = 0.39 years	< 3 years	The investment cost return period is 0.39 years
3.	IRR = 259%	IRR > 10.9%	IRR > hurdle rate of this investment has very favorable prospects
4.	ROI = 159.46%	Positive ROI	The return on investment made is positive
5.	Profitability Index = 9	PI > 1	Investment needs to be a priority

So it can be concluded that the implementation of the APC RFCC in terms of economic aspects is attractive and feasible to be implemented.

RESULTS

The Performance Test Advanced Process Control (APC) RFCC unit can be conveyed as follows:

1. Performance Test Advance Process Control (APC) of the RFCC unit by having been held on April 15 – 24, 2025
2. The scope of performance test evaluation includes the following job acceptance criteria:
 - a. Minimum Benefit Realization of 2,000,000 USD / year (Two Million US Dollars per year)
 - b. Uptime minimum 90%
 - c. Inferential models or soft sensors have an accuracy of $\pm 3 - 5\%$ for each property
3. Highlights during the APC RFCC performance test period are as follows:
 - a. There was an obstacle to the increase in the temperature bottom main column from 342°C to 344.8 °C so that the flow of LCO products was lowered from 40 m³/hour to 32 m³/hour which had an impact on LCO production loss.

- b. There is an upset problem in the Debutanizer which causes high pressure on the Debutanizer overhead so it is necessary to flaring which has an impact on gasoline production loss.

Note : The conditions mentioned above are upset conditions so all data during that period will not be used in the evaluation.

4. Taking into account the Highlights during the Performance Test period in point 3 above, the results of the APC RFCC Performance Test are as follows:

Date	Potential Benefit (Million USD/year)	APC Uptime (%)	Remarks
15 April 2025	11.85	100%	On target
16 April 2025	4.92	100%	On target
17 April 2025	7.26	100%	On target
18 April 2025	14.85	100%	On target
21 April 2025	6.05	100%	On target
22 April 2025	3.26	100%	On target
23 April 2025	5.23	100%	On target
Average	7.63	100%	On target

No	Inferential	%Deviation	Note
1	Gasoline RON	0.44%	On target
2	Gasoline End Point	1.31%	On target
3	LCO End Point	2.89%	On target
4	C5 in LPG	36.88%	Off target
5	Gasoline RVP	9.24%	Off target
6	%C3 in C4	31.73%	Off target
7	Propane in Propylene	21.01%	Off target
8	Propylene in Propane	16.55%	Off target

5. The improvement of the inferential model/soft sensor Advanced Process Control (APC) of the RFCC unit was carried out on May 20-21, 2025 with the following results:

No	Inferential	%Deviation Before Improvement	%Deviation After Improvement	Note
1	Gasoline RON	0.44%	0.44%	On target
2	Gasoline End Point	1.31%	1.31%	On target
3	LCO End Point	2.89%	2.89%	On target
4	C5 in LPG	36.88%	9.36%	Off target
5	Gasoline RVP	9.24%	3.97%	On target
6	%C3 in C4	31.73%	24.60%	Off target
7	Propane in Propylene	21.01%	32.25%	Off target
8	Propylene in Propane	16.55%	8.57%	Off target

After the improvement of the model, there are still 4 inferential parameters that have an accuracy of >5%.

6. Based on the results of the performance test, the following conclusions were concluded:
 - a. Parameters of Realization of On Target benefits with potential benefits of 7.63 million USD/year vs min 2 million USD/year
 - b. Uptime parameter reaches On Target with uptime reaching 100% vs min 90%
 - c. Inferential Parameters of the Model / Soft Sensor there are 4 Off Target parameters, namely C5 in LPG (deviation 9.36%), %C3 in C4 (deviation of 24.6%), Propane in Propylene (deviation of 32.25%), and Propylene in Propane (deviation of 8.57%) vs max 5%.

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REFERENCES

1. Engineering. CRUDE DISTILLATION. 2009.
2. UOP Training Services. Line Sizing and Hydraulics. 2000.
3. Refinery Business & Optimization. Overview RU IV Cilacap 1974. 2024.
4. Business Planning & development Directorate. Focus Group Discussion (FGD) Persiapan FID New DHT RU IV Cilacap. 2023.
5. Pertamina RU IV Cilacap. General Operating Manual for Unit 101, Unit 102, Unit 103 & Unit 104. 2011.
6. Honeywell. General Operating Manual for Advanced Process Control (APC). n.d.
7. Oil refineries in the 21st century : energy efficient, cost effective, environmentally benign. Wiley-VCH. 2005.
8. Waheed MA, Oni AO. Performance improvement of a crude oil distillation unit. *Applied Thermal Engineering*. 2015;75:315-324. doi:10.1016/j.applthermaleng.2014.10.078.
9. Chevron. pascagoula_TDR. 2025. Available from: <https://Pascagoula.Chevron.Com/What-We-Do/Refining-Crude-Oil>.
10. Exxon Mobile. Rotterdam_ALC Mix. 2019. Available from: <https://www.Exxonmobil.Be/En-Be/Company/Locations/Netherlands/Rotterdam-Refinery>.
11. Saudi Arabia Oil C. Rastanura_ALC Aramco. 2025. Available from: <https://www.aramco.com/en/what-we-do/energy-products/refined-products/base-oils>.
12. Reliance. Reliance-Jamnagar. 2024. Available from: <https://www.ril.com/businesses/energy/refining-marketing>.
13. Process Control RU IV Cilacap Roadmap. Process Control RU IV Cilacap Roadmap. n.d.
14. Kawai E, Sato H, Furuichi K, Toru T, Yoshioka T. Maximizing margins and optimizing operational conditions for residue fluid catalytic cracking with an artificial intelligence hybrid reaction model. *Journal of Advanced Manufacturing and Processing*. 2022;4(3). doi:10.1002/amp2.10118.
15. Amec Foster Wheller. Amec Foster Wheeler Study Report. 2016.
16. PT Kilang Pertamina Internasional. A. Finansial. 2024.
17. Moshgbar M, Hammond S. Advanced process control. *Quality Assurance Journal*. 2010;13(3-4):62-66. doi:10.1002/qaj.472.