

INTRODUCTION:

National Refinery Limited (NRL) was incorporated on August 19, 1963. NRL is engaged in the manufacturing, production and sale of large range of petroleum products. The refinery complex comprises of three refineries i.e. two lube refineries and one fuel refinery having a total crude oil refining capacity of 24,570,000 Bbl per annum. Two Lube refineries process reduced crude to produce LBO, Bitumen, Wax and other specialty products.

NRL commissioned UOP licensed Diesel Hydrotreater Unit having capacity to process 29,765 BPSD of HSD in June 2017, the unit was designed to hydro treat a feed blend containing straight run distillates, naphtha from the Uniflex Unit (Note that Uniflex unit will be installed in future), and distillates from the Uniflex Unit. DHT unit was designed to reduce the sulfur content of the diesel product (150°C+) to less than 50 wppm and increase the cetane number to 51(minimum). The diesel product meet Euro IV specifications.

1. DESIGN BASIS

The feeds have the following composition depend on different phases as follows:

- Phase 0 (UOP Uniflex unit not installed, current case)
- Phase 1 (UOP Uniflex unit installed, future case)
- Phase 2 (Unicracker unit installed, future case)

PHASE 0

Type	Blend	HSD AL	HSD Local	Kero AL	Kero Local	LVGO AL	Diesel (New VDU)
Flow rate, BPD	22700	14161	1879	4323	1237	700	400
Vol%	100	62.4	8.3	19	5.4	3.1	1.8

PHASE 1

Type	Blend	HSD AL	HSD Local	Kero AL	Kero Local	LVGO AL	Uniflex Naphtha	Uniflex Kero	Uniflex Diesel	Diesel (New VDU)
Flow rate, BPD	29765	14161	1879	4323	1237	700	1924	2558	2583	400
Vol%	100	47.6	6.3	14.5	4.2	2.4	6.5	8.6	8.7	1.8

PHASE 2

Type	Blend	HSD AL	HSD Local	Kero AL	Kero Local	LVGO AL	Uniflex Naphtha	Uniflex Kero	Uniflex Diesel	Diesel (New VDU)
Flow rate, BPD	29722	14161	1879	4323	1237	700	1937	2544	2541	400
Vol%	100	47.6	6.3	14.5	4.2	2.4	6.5	8.6	8.5	1.3

1.1 Feed Specification

The properties and test methods for the design oil feedstock blend is listed below:

Property	Value			The method
	Phase 0	Phase 1	Phase 2	
API	35.96	36.95	36.95	ASTM D1298
Specific Gravity@15.6°C	0.845	0.840	0.840	ASTM D4052
Sulfur, wt%	1.08	1.06	1.07	ASTM D1552
Nitrogen, wppm	466	466	494	ASTM D4629
Si, wppm	0.0	1.5	1.5	ASTM D5184
Distillation, °C				ASTM D86
IBP	189	88	88	
10	206	188	188	
30	269	230	230	
50	287	282	282	
70	304	303	303	
90	343	343	343	
EP	359	365	365	

1.2 Makeup Gas Specifications

Makeup gas to the diesel hydrotreating unit will be hydrogen rich gas from CCR platforming process unit, the properties are tabulated below:

Component	Value
Hydrogen, mole%	92.2
Methane, mole%	2.3
Ethane, mole%	2.3
Propane, mole%	1.7
Butane, mole%	0.7
C5 +, mole%	0.8
CO + CO ₂ , ppm mol	20 max
Chloride, ppm	1 max

However, the current makeup gas (hydrogen) source is from HPU, properties as below:

Component	Value
Hydrogen, mole%	99.9
Methane, mole%	0.1

1.3 Product Specification

DHT unit was designed to produce Euro IV diesel, however, naphtha is also produced and sent to downstream as raw material. The products properties list as below:

Property	Value			The method
	Phase 0	Phase 1	Phase 2	
API	37.7	37.3	37.3	ASTM D1298
Specific Gravity@15.6°C	0.836	0.838	0.838	ASTM D4052
Sulfur, wppm	<50	<50	<50	ASTM D5453
Nitrogen, wppm	32	25	25	ASTM D4629
Cetane Number	55	53	53	ASTM D613
Cetane Index	55	54	54	ASTM D4737
Flash point, °C	65.5	62.8	62.8	ASTM D93
Viscosity@40°C,cSt	3.4	3.6	3.6	ASTM D445
Water, wppm	<200	<200	<200	ASTM D6304
Distillation, °C				ASTM D86
IBP	188	176	176	
10	206	202	202	
30	265	244	244	
50	286	286	286	
70	304	306	306	
90	340	342	342	
EP	350	353	353	

1.4 Reactor / Catalyst Details

306-R02	Dia * Height 3050*22745 mm
Fixed Bed reactor	Operation Pres: Top 6.38Mpa(G)
	Operation Temp: 400 °C
	Design pres: 7.86 Mpa(G) FV@177 °C
	Design Temp: 430 °C
	Insulation: HC
	Catalyst Volume Loaded: 142.0276 m3
	Inert ceramic balls: 4.41 m3

2. CURRENT REQUIREMENT:

NRL intends to procure one fill of Hydrotreating catalyst for Diesel Hydrotreater (DHT) Reactor (306-R02) the reactor consist of three beds. NRL requires sufficient desulfurization activity of the new catalyst to achieve a minimum cycle length of 04 years while meeting **Euro V diesel specification:**

- To produce diesel with sulfur content of ≤ 10 wt-ppm, flash point $\geq 66^\circ\text{C}$, & cetane index of ≥ 46
- Produce diesel with density ≥ 820 kg/m³ with naphtha end point 180 °C max.
- Maximize diesel yield %
- Minimize naphtha yield %

2.1 CURRENT OPERTAING CONDITIONS

Feed component	Unit		Feed 1	Feed 2	Feed 3	Feed 4	Feed 5
Stream Type		Blended Feed	HSD AL	HSD Local	Kero AL	Kero Local	LVGO AL
Flow Rate	BPSD	22,700	14,161	1,879	4,725	1,237	700
	m ³ /hr	150.4	93.8	12.5	31.3	8.2	4.6
Percent of blend	wt.-%		63.53	8.33	19.76	5.17	3.2
Percent of blend	vol.-%		62.4	8.28	20.81	5.45	3.08
API		39.03	35.96	37.96	48.02	48.02	32.73
Specific Gravity	g/cc	0.8298	0.845	0.835	0.7882	0.7882	0.8616
Total sulfur (max)	wt.-%	1.1	1.37	0.09	0.13	0.04	1.87
Total Nitrogen	wt.-ppm	99	95	290	1	20	400
Aromatic							
• Mono	wt.-%	14.2	12.4	10.51	21.2	16.80	13.8
• Di	wt.-%	3.9	4.7	3.96	1	1	8.8
• Tri	wt.-%	4.1	5.6	4.76	0	0	2.5
Bromine No		1	1	1	1	1	1
Metals in Feed							
• Silicon Si	Wt.-ppb		200	370	330	295	
• Arsenic	wt.-ppm		< 10	< 10	< 10	< 10	
• Ca, Na, Mg, P	wt.-ppb		< 100	< 100	< 100	< 100	
• Cu	wt.-ppb		< 5	< 5	< 5	< 5	
Cetane Index D4737-A		54	60	64	47	47	
Distillation Type		D-86	D-86	D-86	D-86	D-86	D-86
IBP	°C	144	253	253	152	152	148
5%	°C	185	265	265	165	165	195
10%	°C	197	272	272	170	170	226
30%	°C	253	278	278	181	181	255
50%	°C	272	293	293	190	190	278
70%	°C	298	317	317	200	200	293
90%	°C	348	354	354	216	216	323
95%	°C	364	368	368	222	222	329
FBP	°C	380	380	380	243	243	339

2.2 HIGH SPEED DEISEL (Euro V) PRODUCT SPECIFICATIONS

SR.NO.	TEST	TEST METHOD	SPEC. LIMIT
1	Density @ 15 °C, Kg/Lit	ASTM D-1298 / D4052	0.82 - 0.86
2	Colour, ASTM	ASTM D-1500	Max. 2.5
3	Flash Point, (PMCC), °C	ASTM D-93	Min. 66
4	Distillation:	ASTM D-86	Report
	50% vol. recovery at °C		
	95% vol. recovery at °C		Max. 360
5	Sulphur content, ppm	ASTM D-2622 ASTM D-4294 / D-1552	Max. 10
6	Copper strip corrosion 3 Hrs. at 100 °C	ASTM D-130	Max. No. 1
7	Viscosity Kinematic at 40 °C, cSt	ASTM D-445	Min. 1.6 Max. 5.5
8	CFPP, °C Summer grade (March – Oct.) Winter grade (Nov. – Feb.)	ASTM D-6371 / IP309	Max. + 3 Max. - 3
9	Cloud Point, °C Summer grade (March – Oct.) Winter grade (Nov. – Feb.)	ASTM D-2500	Max + 11 Max. + 5
10	Conradson carbon residue on 10% Distillation residue, % wt.	ASTM D-189/4530	Max. 0.1
11	A s h, % Wt.	ASTM D-482	Max. 0.01
12	Sediment, % Wt.	ASTM D-473	Max. 0.01
13	Water, % Vol.	ASTM D-95	Max. 0.05

14	Cetane Index (Calculated)	ASTM D-976 / D-4737	Min. 46
15	Strong acid No. mgKOH/g	ASTM D-974	Nil
16	Total acid No. mgKOH/g	ASTM D-974	Max. 0.5
17	Electrical Conductivity pS/m	ASTM D-2624	Min. 50
18	Lubricity Corrected Wear Scar diameter (WSD 1.4) at 60 °C	ASTM D-6079	Max. 460

3. SUMMARY:

Keeping in view the current operating conditions which is straight run feed case having flowrate of 22,700 BPSD refer section 2.1, the Catalyst supplier shall propose the appropriate type and quantity of catalyst / support media to meet Euro V Diesel specification mentioned above.