Reference WBS: R14677

TECHNICAL REPORT N°: 2021/	ISSUE DATE: 28/10/2021

BALDER Crude Oil
Quality evaluation
October 2021 Update

AUTHORS	**COLLABORATORS**
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REVISOR

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SUMMARY AND CONCLUSION

A quality evaluation of North Sea production, Balder crude, and a quality comparison of this crude with various reference crudes has been requested, for marketing purposes, by Var Energi.

Main chemical-physical parameters of analysed Balder sample, received on September 2021, are reported in Tab.1

TAB.1	BALDER Refining Characteristics
	Production Country: NORWAY
Whole crude	The crude, 29,1°API, 0,53 %m/m S, is Low Sulfur , Medium, Intermediate. Acidity is high.
	It gives 51,5 %m/m yield in fractions until 370°C and 77,3 %m/m yield in fractions until 530°C
	Main fractions slate:
	• **C5-160 Light Distillates**: 12 %m/m
	• **160-370 Middle Distillates**: 38,4 %m/m
	• **370-530 Vacuum Distillates**: 25,8 %m/m
	• **370+ Atmospheric Resid**: 48,5 %m/m
Light distillates	**80-160°C heavy naphtha fraction** yield is 8,9 %m/m, 74,2 %m/m of C5-160 light distillates.
	80-160°C heavy naphtha (N+2A = 69,2 %v/v), is a good feedstock to catalytic reforming for gasoline production.
Middle distillates	**160-230°C kero cut**: fraction yield is 8,79 %m/m, 22,9 %m/m of 160-370 middle distillates. Good combustion properties (smoke point), and good cold properties (freezing point)
	230-370°C atmospheric gasoil cut: fraction yield is 29,58 %m/m, 77 %m/m of 160-370 middle distillates. Poor combustion properties (cetane index), and good cold properties (cloud point and pour point). Acidity is high.
Vacuum distillates	**370-530° vacuum distillate cut**: high sulfur, high acidity content. UOP K factor = 11,7, resulting in discrete feedstock for catalytic cracker or hydrocracker, taking into account acidity management.
Vacuum resid	**530+°C vacuum resid:** Ni+V metal content = 61 ppm; low asphaltene content

Balder crude assay summary table is reported in APPENDIX 1

BALDER shows similarities with LS medium density acid crudes from North Sea, (Johan Sverdrup, Grane blend) and West Africa (Mondo, Antan, Mandji, Djeno). Other comparisons can be made with medium density HS crudes (e.g. Norne, Catcher) taking into account differences in terms of acidity content.

In comparison with previous reference crude quality (2019) 28°API, 0.57 %m/m S, the actual quality is lighter, and shows a decrease in resid yields: -2.3 %m/m 370+°C resid yield, with a consequent yield increase distillates both C5-180°C light distillates (+1.1 pts %m/m) and 230-370°C gasoil cut (+1.9 pts. %m/m).

INTRODUCTION AND SCOPE OF WORK

A quality evaluation of North Sea production, Balder crude, has been requested by Var Energi.

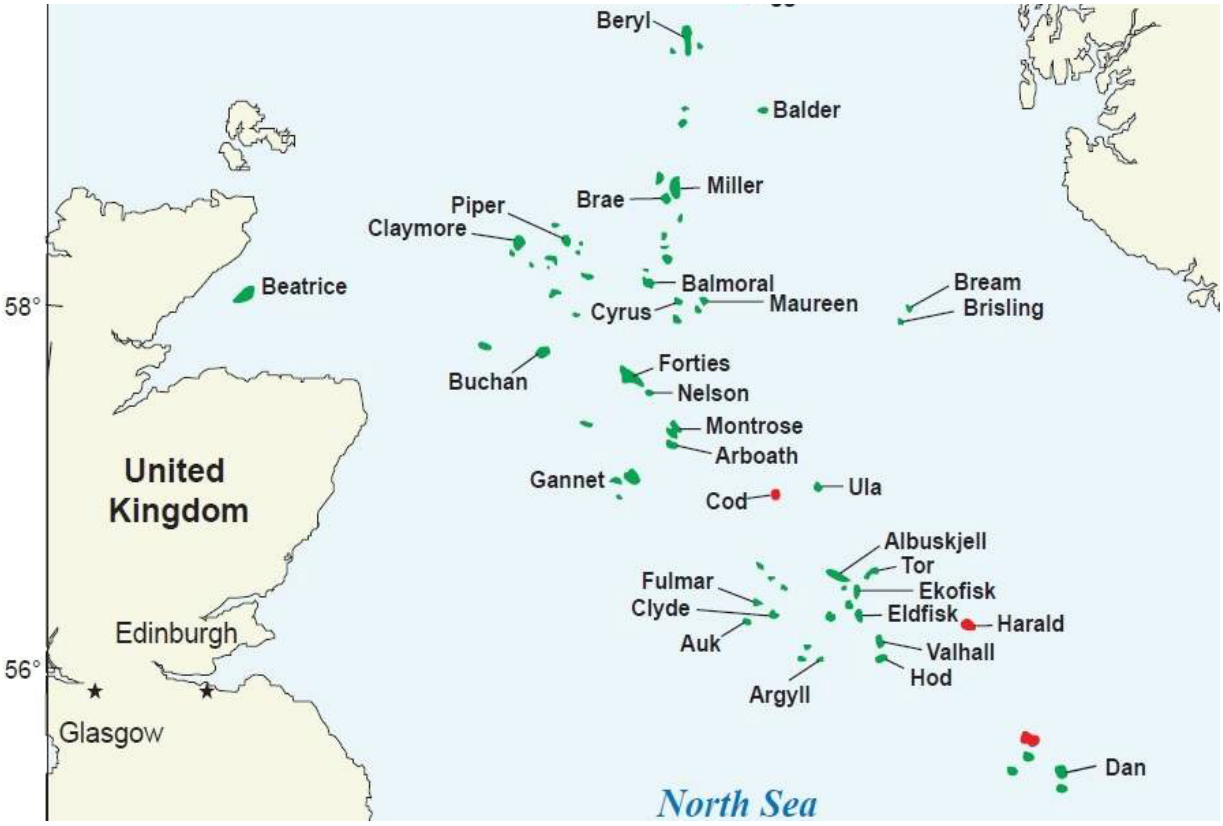


Fig.1 - OCTP Location Map

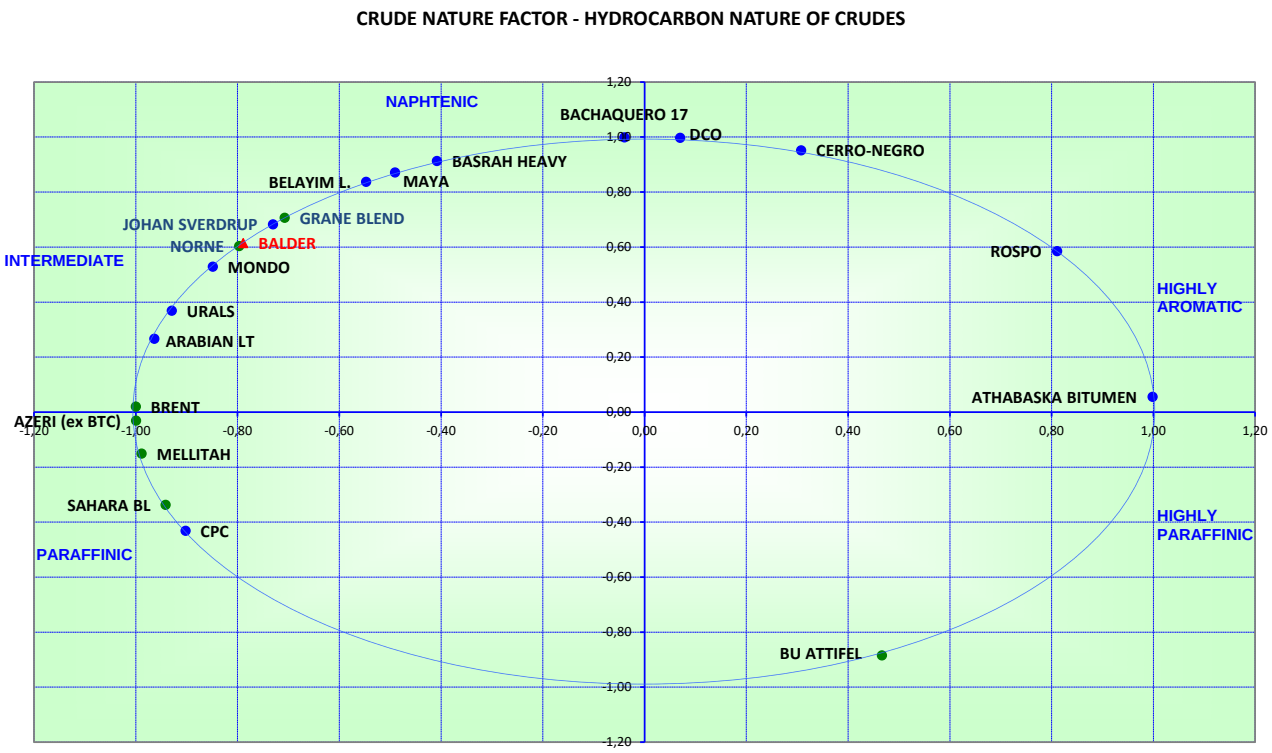
In this report results of evaluation are reported.

QUALITY OF BALDER CRUDE OIL

BALDER, 29,1°API, 0.53 %m/m S, is a medium density, low sulphur, intermediate crude with high acidity and a low content in mercaptan compounds.

In Fig.2 a comparison of BALDER hydrocarbon nature (paraffinic, naphtenic, aromatic) with other reference crudes is reported.

Fig.2



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Sankofa crude assay summary table is reported in APPENDIX 1

SIMILARITY OF BALDER CRUDE WITH OTHER REFERENCE CRUDES

Quality has been compared, in order to verify its similarity (from their hydrocarbon nature point of view) with other crudes, by mean of a similarity analysis tool for supporting preliminary crudes evaluations/selections, built at eni DOW R&D laboratories in San Donato Milanese.

Global similarity index (from 1 to 7) gives an indication about the quality nearness of a crude to other to be compared: the lower the value the higher the similarity.

Analysis has been performed on crudes from various areas.

Output values with similarity between 1 and 3 are reported in Tab.2.

BALDER shows similarities with LS medium density acid crudes from North Sea, (Johan Sverdrup, Grane blend) and West Africa (Mondo, Antan, Mandji, Djeno). Other comparisons can be made with medium density HS crudes (e.g. Norne, Catcher) taking into account differences in terms of acidity content.

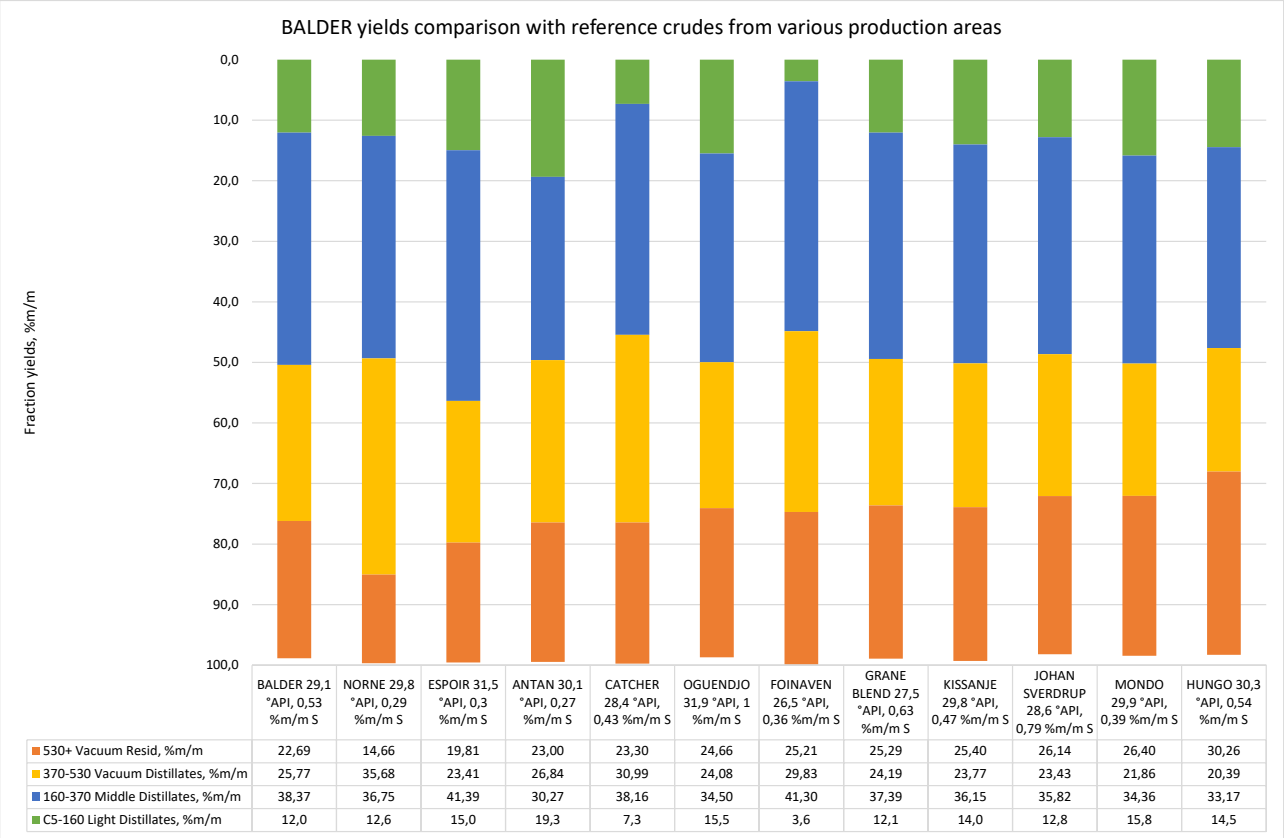
Output values with similarity between 1 and 3 are reported in Tab.2.

Tab.2 – Similarity of BALDER with other crudes

Global Similarity	Country	Crude	API	S, %m/m	Viscosity @ 20°C, cSt	Pour P., °C	TAN, mg KOH/g	Ni, ppm	V, ppm	n-C7 Asphaltenes, %m/m	CCR, %m/m
1 *(Rif)*	NORVEGIA	**BALDER**	**29,1**	0,53	21,08	-18	**1,11**	3,43	10,30	0,47	3,46
1	NORVEGIA	**NORNE**	**29,8**	0,29	17,64	-6	0,20	2,59	2,16	0,48	1,89
2	NIGERIA	**ANTAN**	**30,1**	0,27	15,61	-6	**0,54**	19,92	5,43	0,18	3,37
2	NORVEGIA	**JOHAN SVERDRUP**	**28,6**	0,79	21,30	0	**0,55**	4,52	14,01	1,98	5,14
2	ANGOLA	**HUNGO**	**30,3**	0,54	16,92	-9	0,42	22,57	19,81	1,20	5,59
2	ANGOLA	**MONDO**	**29,9**	0,39	19,32	<-36	**0,75**	24,00	6,98	1,63	5,47
2	NORVEGIA	**GRANE BLEND**	**27,5**	0,63	28,17	0	**1,18**	3,96	13,19	0,84	4,16
2	ANGOLA	**KISSANJE**	**29,8**	0,47	21,30	-18	0,47	17,23	8,84	0,62	3,99
2	ANGOLA	**GIRASSOL**	**29,9**	0,37	24,20	3	0,34	12,19	14,45	0,45	3,40
2	NIGERIA	**OKORO**	**29,6**	0,15	12,92	<-36	0,34	4,96	0,38	< 0,05	3,41
2	GABON	**MANDJI**	**29,2**	1,02	38,04	9	**0,52**	65,56	49,79	1,04	4,93
3	REGNO UNITO	**FOINAVEN**	**26,5**	0,36	57,92	9	0,27	3,88	5,82	0,22	2,13
3	RUSSIA	**URAL NOVOROSSISK**	**30,2**	1,71	17,83	-6	0,11	13,99	70,85	1,31	4,79
3	COSTA D'AVORIO	**ESPOIR**	**31,5**	0,30	14,49	-12	0,19	4,94	1,90	0,19	2,07
3	CONGO	**DJENO MELANGE**	**28,0**	0,50	45,88	-21	**0,86**	41,41	21,46	1,40	5,45
3	ANGOLA	**SANGOS**	**32,7**	0,39	13,65	-21	0,39	20,69	6,33	0,93	4,22
3	NORVEGIA	**ALVHEIM**	**33,3**	0,21	11,93	-24	**0,57**	1,19	1,58	0,12	1,11
3	BRASILE	**LULA**	**30,6**	0,33	25,12	-18	0,36	10,45	9,50	0,31	3,43
3	GABON	**OGUENDJO**	**31,9**	1,00	18,36	9	**1,04**	37,25	24,28	0,92	4,27
3	NIGERIA	**BONGA**	**27,6**	0,26	14,54	<-36	**0,66**	3,77	0,63	0,09	1,40
3	REGNO UNITO	**CATCHER**	**28,4**	0,43	192,82	<-36	0,27	3,35	10,05	0,14	2,27

Yields comparison of Sankofa with some of selected West African and reference crudes is reported in Fig.3

Fig.3

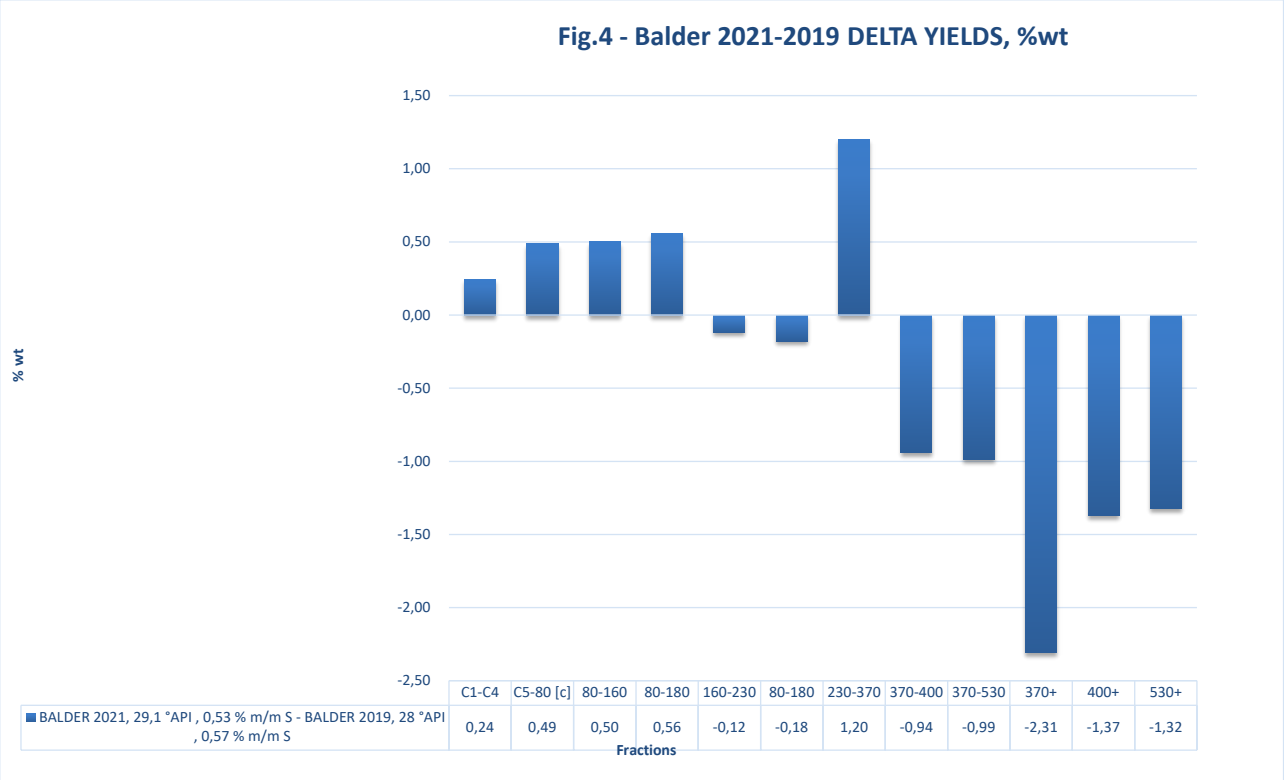


	BALDER 29,1 °API, 0,53 %m/m S	NORNE 29,8 °API, 0,29 %m/m S	ESPOIR 31,5 °API, 0,3 %m/m S	ANTAN 30,1 °API, 0,27 %m/m S	CATCHER 28,4 °API, 0,43 %m/m S	OGUENDJO 31,9 °API, 1 %m/m S	FOINAVEN 26,5 °API, 0,36 %m/m S	GRANE BLEND 27,5 °API, 0,63 %m/m S	KISSANJE 29,8 °API, 0,47 %m/m S	JOHAN SVERDRUP 28,6 °API, 0,79 %m/m S	MONDO 29,9 °API, 0,39 %m/m S	HUNGO 30,3 °API, 0,54 %m/m S
530+ Vacuum Resid, %m/m	22,69	14,66	19,81	23,00	23,30	24,66	25,21	25,29	25,40	26,14	26,40	30,26
370-530 Vacuum Distillates, %m/m	25,77	35,68	23,41	26,84	30,99	24,08	29,83	24,19	23,77	23,43	21,86	20,39
160-370 Middle Distillates, %m/m	38,37	36,75	41,39	30,27	38,16	34,50	41,30	37,39	36,15	35,82	34,36	33,17
C5-160 Light Distillates, %m/m	12,0	12,6	15,0	19,3	7,3	15,5	3,6	12,1	14,0	12,8	15,8	14,5

Comparison with previous crude assay

In comparison with previous reference crude quality (2019) 28°API, 0.57 %m/m S, the actual quality is lighter, and shows a decrease in resid yields: -2.3 %m/m 370+°C resid yield, with a consequent yield increase distillates both C5-180°C light distillates (+1.1 pts %m/m) and 230-370°C gasoil cut (+1.9 pts. %m/m). (Fig.4).

Fig.4 -



APPENDIX 1 – EXPERIMENTAL DATA

Eni S.p.A Downstream R&D
Centro ricerche di San Donato Milanese (MI) R&D-D
Via Felice Maritano 26, 20097 San Donato Milanese

		CRUDE OIL	YIELDS AND CHARACTERISTICS OF PRODUCTS											
			GAS	NAPHTHAS			KEROSENES		GASOILS		V.DIST	RESIDUES		
TBP Range :			C1-C4	C5-80 [c]	80-160	80-180	160-230	180-230	230-370	370-400	370-530	370+	400+	530+
TBP Yield	%m/m		1,12	3,14	8,91	11,31	8,79	6,39	29,58	5,53	25,77	48,46	42,93	22,69
TBP Yield	%v/v		1,81	4,10	10,34	13,00	9,52	6,86	29,96	5,38	24,50	44,37	38,99	19,87
Density @15°C	Kg/l	0,8812	0,5483	0,6747	0,7591	0,7667	0,8139	0,8208	0,8701	0,9053	0,9269	0,9624	0,9703	1,0062
API Gravity @ 60°F		29,1												
Viscosity @ 20°C	mm²/s	21,08												
Viscosity @ 50°C	VBN						2,83	4,09	16,56	25,74	31,40	38,47	40,11	46,50
Sulphur	%m/m	0,53		0,0003	0,0005	0,0006	0,0166	0,0229	0,26	0,53	0,63	0,93	0,98	1,26
Mercaptan Sulphur	ppm	8		1		2		3						
Hydrogen Sulphide	%m/m	<1												
Acidity	mgKOH/g	1,11					0,06	0,06	0,52	1,52	1,59			
Paraffins	%v/v			75,8	42,4	46,4								
Naphthenes	%v/v			22,7	46,0	40,3								
Aromatics	%v/v			1,5	11,6	13,4	23,4	24,7						
N+2A				25,8	69,2	67,0								
Smoke Pt.	mm						25	24						
Freezing Pt.	°C						-67	-62						
Cloud Pt.	°C								-8	+21				
Pour Pt.	°C	-18							-9	+18		+24	+27	+51
Cetane Index									47,1	60,1				
Total Nitrogen	%m/m									431	0,09	0,37	0,41	0,69
Basic Nitrogen	ppm									147	287	1182	1334	2234
Nickel	ppm	3									< 1 [c]	7	8	15
Vanadium	ppm	10,3									< 2 [c]	21	24	45
P.Value													4,5	
Asphaltenes in NC7	%m/m	0,5										0,95	1,10	2,10
R.C.C.	%m/m	3,5									0,2	7,1	8,1	15,1
Penetration @ 25°C	dmm													
UOP K Factor		11,8									11,7	11,7	11,7	

TBP Distillation

Cut Point	%m/m Cum
C1	0,00
C2	0,03
C3	0,32
IC4	0,56
NC4	1,12
IC5	1,53
NC5	2,09
80	4,26
100	6,67
120	8,75
140	10,92
160	13,17
180	15,57
210	18,96
230	21,96
250	25,58
270	30,41
290	33,33
320	40,32
350	47,54
370	51,54
400	57,07
530	77,31
550	79,65

NB: see corresponding tabs for notes associated to each cut.

[c] calculated value

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Eni S.p.A
Downstream R&D
Centro ricerche di San Donato Milanese (MI)

	BALDER				29,1
State	NORVEGIA	Report	2-GR-202	Record	BAL12.2021.10.ET