another shutdown test was conducted to get a more accurate estimate of gas hold-up. The shutdown test indicated a gas hold-up of 8 vol%.

As planned, the unit was shutdown after completing the baseline condition. As the slurry had degraded through the run, perhaps due to carbon formation, it was no longer a representative slurry. Hence, it was decided not to conduct the tracer or the filter work with this slurry. The reactor was cooled to 125°C and the slurry was transferred to the preparation tank, and subsequently drained. The slurry appeared a bit thicker than typical oxygenate slurry, but much thinner compared to the earlier spent slurry.

Mass Balance

Some simplifying assumptions were made for mass and elemental balance. The 22.18 Separator hydrocarbon to aqueous phase ratio was assumed to be constant during the run. An aqueous fraction of 0.542 by volume was estimated from the hydrocarbon and aqueous phase collected in the 22.16 Tank during the entire run. The 22.18 Separator hydrocarbon and aqueous phase flows were assumed to be constant at constant operating conditions.

A run-time table, which summarizes the cross-reference between run numbers, actual times and on-stream times, is given in Table 13. Analysis of liquid samples taken during the run are compiled in Appendix E. This includes both the hydrocarbon and aqueous phases. The analysis was performed by DOE-PETC. No wax samples were available as no significant amount of wax was produced during the run. The product distribution was calculated based on amounts and analysis of liquid collected as well as measured gas flows and analysis.

The mass balance was in the 95-97% range while the elemental balance ranged from 92 to 105%. This closure is considered good at the pilot scale given the number of components involved in some of the streams. A typical mass and elemental balance is given in Table 14. Mass balances for each data period are included in Appendix F. A summary of the results for each data period is given in Table 15.

Alpha Estimate

Alpha (α) was estimated for conditions at which liquid sample analysis was available. A typical α plot is shown in Figure 35. Additional α plots are included with respective mass balances in Appendix F. Generally, an excellent straight line fit was obtained for a single α in the C_1-C_{16} range. Also, a peak corresponding to presence of Drakeol-10 was observed in C_{20}-C_{27} range. The value of α declined from around 0.65 to 0.5 towards the end of F-T IIA operation.

Reactor Temperature Profile

Reactor temperature profile during the high productivity condition (Run No. AF-R12.2A) is shown in Figure 36. The reactor was essentially isothermal in the liquid phase with only a 1.7°C (3°F) variation along the height of the reactor. The temperature of the gas phase in the vapor disengagement zone was significantly lower due to heat losses.

Pilot Plant Results from Literature

Slurry thickening similar to the current run was experienced by Farley and Ray (6) in a pilot plant run at Fuel Research Station, Greenwich, UK in the 1950s. Gas hold-up in the reactor was found to decrease with increasing slurry viscosity due to formation of finely divided carbon. A plot of gas hold-up and viscosity as a function of free carbon in wax from this paper is shown in Figure 37. A constant gas hold-up of 45 vol% was observed for carbon under 1 wt%. Rapid drop in the hold-up was observed for higher carbon content. The hold-up drop coincided with the viscosity rise. At higher temperatures, excessive build-up of carbon increased viscosity substantially, leading to gelation of the reactor contents.

Heat Transfer Coefficients Estimate

Heat transfer calculations were made to check the performance of the new internal heat exchanger in comparison to its design basis. Overall heat transfer coefficients were calculated based on data from Runs AF-R12.1A and 12.2A. The "measured" coefficients were calculated using data from actual utility oil flow rate, temperature rise, reactor temperature and predicted utility oil heat capacity. Measured shell-side (slurry-side) coefficients were then backed out from measured overall coefficients using predicted tube-side coefficients from Sieder-Tate equation.

The measured coefficients are compared with predicted, as well as design, coefficients in Table 16. The predicted coefficients are based on Sieder-Tate equation for tube-side and Deckwer correlations (7) on the slurry-side. For design, a safety factor of 0.85 was used for the tube side (inside) coefficient and 0.75 for the slurry-side (outside) coefficient. The measured overall coefficients were within 6% of the predicted values and 11-22% higher than the design numbers. The measured slurry-side coefficients were within 15% of the predicted value and 14-35% higher than the design numbers. Hence, the data validate current design methods. Since significantly higher amount of heat was transferred during Run No. 12.2A compared to previous operations with the old heat exchanger, the results also indicate successful scale-up.

The new heat exchanger was designed to remove the entire heat of reaction. Considering heat removal with gas flow as well as heat leak through reactor walls, the reactor has significantly higher capacity for additional reactor productivity. As expected, the reactor temperature control needed manual intervention at high productivity conditions. A realignment of the utility oil system is planned to improve the control.

CONCLUSIONS AND RECOMMENDATIONS

- A very high level of reactor productivity (more than five times the F-T I productivity) was demonstrated for slurry phase Fischer-Tropsch synthesis. Reactor productivity of 136 grams of HC/hr - liter of slurry volume was achieved, which was within the target of 120-150. The productivity was constrained by mass transfer limitations, perhaps due to slurry thickening. With a cobalt catalyst or an improved iron catalyst, if carbon formation can be avoided, there is significant room for further improvements.

- The demonstration was conducted at a pilot scale of 5 T/D. An initial attempt with 44 wt% catalyst concentration had to be aborted as excessive slurry thickening was experienced due to carbon formation and particle agglomeration. A second test with 29 wt% catalyst concentration was successful. The catalyst activation with CO/N_2 proceeded well. The initial catalyst activity was close to the expectations from the CAER autoclave runs. CO conversion of about 85% was obtained at the baseline condition. The catalyst also showed good water-gas shift activity and a low α.

- Mass transfer limitations were observed during the high productivity runs. To alleviate these limitations and prevent excessive thickening, the slurry was diluted during the run. This enabled operations under kinetic control later in the run. However, the dilution resulted in lower conversion and reactor productivity. The catalyst activity declined steadily during the run, with carbon formation suspected to be the cause.

- Gas hold-up declined significantly earlier in the run and was much lower than expected (~ 10 vol%) during most of the run. Slurry thickening with time on-stream appeared to be the reason for the low gas hold-up. The gas hold-up estimates were confirmed by shutdown tests.

- The new reactor internal heat exchanger performed well above design, and the system never limited the performance. As expected, the reactor temperature control needed manual intervention. The control can be improved by realigning the utility oil system.

FUTURE PLANS

Additional Fischer-Tropsch runs are planned during a new "Alternative Fuels and Chemicals from Synthesis Gas" program which began late 1994. Further slurry-phase F-T runs are needed to demonstrate high levels of productivity with highly selective (high wax producing) catalysts. The high productivity of the slurry-bubble-column reactor can be used to improve the economics of the process. The improved catalyst source could be either an industrial partner or a DOE-sponsored contractor. The LaPorte AFDU will be modified to install best available catalyst-wax separation technology. The newly installed heat exchanger has already been proven for its capacity to handle high heats of reaction, enabling operation at significantly higher productivity. The slurry-phase reactor can directly use synthesis gas from coal without the need for a separate shift reactor. However, a majority of the newly-developed cobalt-based catalysts which have been primarily focused for natural gas derived synthesis gas, do not have water-gas shift activity. In such cases, a demonstration is needed involving use of a mixture of a shift catalyst with a cobalt-based F-T catalyst to handle coal derived synthesis gas in a single reactor.

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ƎLE 1

Iron Fischer-Tropsch Developmental Preparations
Air Products & Chemicals, Inc.

Identification	% Fe_2O_3	% CuO	% K_2O	% Binder	Calc. T, °C	Average Particle Size, µ, 120x325 Mesh	FBAT[+] % 15 Hr	Activity	Bulk Density, g/cc	Comments
1185-43	65.9	4.91	1.17	28.0 Silica	Uncalc					22.0% LOI, 1000°F
					370	7.6	1.0	**	0.63	#3
					600	7.1	1.1		0.62	#4
Nominal	64.0	5.0	1.0	30						
1185-54	62.9	5.53	0.098	31.5 Silica	Uncalc					14.8% LOI, 1000°F
					370	23.8	0.6		1.23	#1
					600	10.5	0.2		0.63	#2
Nominal	64.9	5.0	0.1	30						
1185-55	61.8	6.25	1.78	30.2 Silica	Uncalc					23.1% LOI, 1000°F
					370	24.2	1.0	**	0.65	#7
					600	12.9	0.1		0.67	#12
Nominal	63.0	5.0	2.0	30						
1185-56	65.9	5.65	0.092	28.6 Kaolin	Uncalc					15.6% LOI, 1000°F
					370	8.0	0.01		1.09	#10
					600	5.8	0.1		1.07	#5
Nominal	64.9	5.0	0.1	30						
1185-57	62.3	5.58	0.93	31.2 Kaolin	Uncalc					16.1% LOI, 1000°F
					370	4.3	0.01	**	1.09	#11
					600	11.3	0.1		1.10	#6
Nominal	64.0	5.0	1.0	30						
1185-61	90.0	7.97	0.19	No Binder	Uncalc					14.6% LOI, 1000°F
					370	66.0	0.01	**	1.16	#8
					600	62.1	0.01		1.18	#9
Nominal	92.75	7.15	0.1							

/slo FLT-240 4/19/93

+ FBAT - Fluid Bed Attrition Test
** Selected for Activity Testing

TABLE 2

FISCHER-TROPSCH II CATALYST (FIRST 500 LBS BATCH)

	Specifications	L-3950 (1185-149) (500 lb composite)
Composition at 1000°F:		
Fe_2O_3 (wt%)	87.9 ± 2	86.6
CuO (wt%)	11.1 ± 1	12.5
K_2O (wt%)	0.052 ± 0.01	0.05
Particle Size (D50), Microns:		
	77 ± 10	D10: 40 μ
	≥ 80% above 20 μ	D50: 92 μ
	≤ 3% below 5 μ	D90: 137 μ
FBAT, % 15 Hrs:	< 1.5	0.2
Density, g/cc oxides:	1.09 ± 0.1	1.305
Surface Area, m^2/g oxides:	27 ± 5	40

TABLE 3

PHYSICAL AND CHEMICAL DATA FROM UCI ON PRODUCTION CATALYST

CATALYST # 1185-149	CALCINATN TEMP, °C	% LOI @ 538°C	PARTICLE SIZE DISTRIBUTION (MICRONS)			COMPACTED DENSITY G/ML	SURFACE AREA M^2/G	FBAT ATTRITION % (15 HRS)	WT% Fe_2O_3	WT% CuO	WT% K_2O
			D10%	D50%	D90%						
1st 500 lbs	350	1.9	40	92	137	1.305	40	0.2	86.6	12.5	0.05
2nd 500 lbs	350		42	88	132	1.130		1.0	86.4	12.0	0.05
3rd 500 lbs	350		53	101	148	1.107		2.8	87.3	11.7	0.05

TABLE 4

START-UP WAX FOR LAPORTE F-T II

TMC 24810, EX HPS 9/8, HT 95-3, ZP (V-650)

CARBON DISTRIBUTION BY HIGH TEMPERATURE GLC

Carbon No	Pct w	Carbon No	Pct w
09	0.53	26	2.56
10	1.88	27	2.44
11	3.02	28	2.30
12	3.56	29	2.18
13	3.78	30	2.07
14	3.91	31	2.05
15	3.92	32	1.87
16	3.90	33	1.78
17	3.84	34	1.69
18	3.72	35	1.65
19	3.77	36	1.47
20	3.43	37	1.47
21	3.27	38	1.38
22	3.13	39	1.31
23	2.98	40	1.23
24	2.84		
25	2.69		

Carbon No range	Pct w
09-10	2.41
11-20	36.85
21-30	26.46
31-40	15.90
41-50	9.25
51-60	5.05
61-70	2.26
71-80	1.10
81-90	0.50
91 +	0.22

Average composition:

normal paraffins: 93 %w
isoparaffins: 7%w

TABLE 5

					FT II RUN PLAN						
RUN NO.	DESCRIPTION	SPACE VELOCITY SL/HR KG-FE	REACTOR PRESS., PSIG	REACTOR TEMP., DEG C	NO. OF DAYS ON-STREAM	LIN GAS VEL (IN), FT/SEC	SYNGAS FLOW LBMOL/HR	CO CONV., MOLE%	LIGHT WAX PRODTN GPD	HC PRODTN GPD	WATER PRODTN GPD
AF-A7	ACTIVATION	2000	150	270	1	0.38	54				
AF-R11.1	TIE-IN WITH F-T I	2500	200	265	2	0.36	66	80	51.4	496.3	142
AF-R11.2	NEW BASE LINE	3000	400	270	2	0.23	80	80	106.5	609.6	174.8
AF-R11.3	HIGH PRODUCTIVITY	5600	750	300	5	0.24	150	83	286.6	1117.6	343.1
AF-R11.4	HIGH LIN. VELOCITY	5600	400	300	3	0.45	150	50	65.7	690.8	203.1
AF-R11.5	RETURN TO BASELINE	3000	400	270	2	0.23	80	80	106.5	609.6	174.8
AF-R11.6A	TRACER STUDY	2500	200	265	0.5	0.36	66	80	51.4	496.3	142.0
AF-R11.6B	TRACER STUDY	5600	750	300	0.5	0.24	150	83	286.6	1117.6	343.1
AF-R11.7	FILTRATION TESTS				3						
	TOTAL				19				2328	12147	3551

TABLE 6

FISCHER-TROPSCH II ACTIVATION CONDITIONS

- TRANSFER SLURRY FROM PREP TANK TO REACTOR AT ~200°F
- REACTOR PRESSURE AT 150 PSIG

INITIAL HEAT UP UNDER NITROGEN

- 16°F/HR FROM ~200°F TO 302°F (~ 6 HRS)
- N2 FLOW = 12,500 SCFH (LIN. VEL = 0.15 - 0.18 FT/SEC)

ACTIVATION WITH 75% CO, 25% N2

- 12°F/HR FROM 302°F TO 518°F (~18 HRS)
- CO + N2 FLOW = 20,900 SCFH (LIN. VEL = 0.30 - 0.38 FT/SEC)

HOLD TEMPERATURE AT 518°F FOR 12 HOURS MAX

MONITOR CO2 CONC. IN EFFLUENT &
CUMULATIVE CO2 PRODUCTION

ACTIVATION CHEMISTRY:

$$Fe_2O_3 + 4.6CO \longrightarrow 0.4Fe_5C_2 + 3.8CO_2$$

$$CuO + CO \longrightarrow Cu + CO_2$$

ACTIVATION TARGET:

CO2 CONC. IN EFFLUENT BACK AT BASELINE AFTER PEAK &
TOTAL CO2 PRODUCTION > 100% THEORETICAL

DO NOT EXCEED 120% OF THEORETICAL CO2 PRODUCTION OR
12 HOURS AT 518°F

TABLE 7

FISCHER-TROPSCH (II) DEMONSTRATION RESULTS

- INITIAL PERFORMANCE **LOWER**
  - CO CONVERSION **35% VS. 80%** IN AUTOCLAVE
- CONFIRMED EXPECTED **LOW** α

OPERATING PARAMETERS VARIED IN ATTEMPT TO IMPROVE PERFORMANCE:

CONDITION CHANGE	RESULT
REACTOR TEMP INCREASED FROM 265°C TO 270°C	LITTLE IMPROVEMENT IN PERFORMANCE UNSTEADY NUCLEAR DENSITY READINGS AND REACTOR TEMPERATURES
INCREASED GAS VELOCITY BY REDUCING REACTOR PRESSURE AND INTRODUCING ADDITIONAL NITROGEN (TO IMPROVE SLURRY MIXING)	REACTOR TEMPERATURE MORE STABLE LARGER SWINGS IN NUCLEAR DENSITY READINGS
SLURRY DILUTED TO MAXIMUM HEIGHT (TO REDUCE MASS TRANSFER LIMITATIONS), GAS VELOCITY REDUCED BY BACKING OUT N2 AND INCREASING PRESSURE (TO REDUCE GAS SLUGGING AND CHANNELING)	BOTH REACTOR TEMP AND N. D. READINGS STEADIER PERFORMANCE LOWER (26% CO CONV.)
H2/CO RATIO INCREASED FROM 0.7 TO 2.0 IN FEED GAS (TO REMOVE CARBON DEPOSITED ON CATALYST)	NO IMPROVEMENT IN PERFORMANCE HIGHER CH_4, LOWER CO_2
REACTOR TEMP INCREASED TO 288°C	NO IMPROVEMENT IN PERFORMANCE

TABLE 9

START-UP CONDITIONS & ACTIVATION PROCEDURE FOR FISCHER-TROPSCH (IIA)

START-UP CONDITIONS:

- 29 WT% SLURRY
- START-UP MEDIUM: STRIPPED WAX @ CAER
  DRAKEOL-10 @ LAPORTE

ACTIVATION PROCEDURE:

- 75 PSIG
- HEAT UP TO 428°F UNDER 100% N_2
- SWITCH TO 75% CO/ 25% N_2 AT 428°F
  (SPACE VEL. = 2.0 NL/HR-KG FE)
- HEAT UP TO 518°F AT 30°F/HR
- START H_2 BLENDING AT 100% OF THEORETICAL ACTIVATION
- SLOWLY BLEND H_2 AT ACTIVATION CONDITION TO REACH H_2/CO = 0.7
- CHANGE TO F-T CONDITION

TABLE 10

FISCHER-TROPSCH (IIA) DEMONSTRATION RESULTS

RUN NO.	SPACE VEL., SL/HR-KG FE	REACTOR PRESS., PSIG	REACTOR TEMP., °C	CO CONV., %	CO_2 SELECT., MOLE% C	C_1-C_5 SELECT., MOLE% C (CO_2 FREE)	REACTOR PROD., GM HC/HR - LIT. RXT VOL	GAS HOLD-UP, VOL%	SLURRY CONC., WT%
AF-12.1	2534	175	270	84.7	44.9	64.7	41.4	23.5 7-10	25
AF-12.2	12266	750	302	54.2	43.7	62.6	136.4	9	23

TABLE 11

FISCHER-TROPSCH IIA AT LAPORTE AFDU

RUN NO.	REACTOR TEMPERATURE, DEG F	REACTOR PRESSURE, PSIG	INLET FLOW RATE, MSCFH	H2/CO RATIO, INLET	EXPANDED SLURRY HEIGHT., FT	CO CONVERSION, MOLE %	CO2 SELECTIVITY, MOLE %	REACTOR PRODUCTIVITY GM HC/HR-LIT RXT
AF-R12.3A	592.9	750.1	57.8	0.70	17.8	52.4	42.0	136.1
AF-R12.3B	567.1	749.9	58.4	0.72	17.8	42.0	48.4	97.6
AF-R12.3C	570.9	749.5	73.5	1.27	17.8	40.9	34.7	114.9
AF-R12.3D	573.9	749.9	56.8	0.69	17.8	40.3	41.7	104.3
AF-R12.3E	571.6	750.0	58.1	0.70	20.3	48.0	41.2	111.7

TABLE 12

FISCHER-TROPSCH (IIA) DEMONSTRATION RESULTS

RUN NO.	SPACE VEL., SL/HR-KG FE	REACTOR PRESS., PSIG	REACTOR TEMP., °C	CO CONV., %	CO_2 SELECT, MOLE% C	GAS HOLD-UP, VOL%	SLURRY CONC., WT%
AF-R12.3F	18529	750	303	24.6 (30 - 21)	28.5	8.9	14.4
AF-R12.4	18682	500	303	15.6	20	13	15
AF-R12.5A	3665	175	270	10	22.4	6.7	13.8
AF-R12.5B	3771	175	310	43.6	46.1	6.1	14.1

7 .E 13

RUN TIME TABLES

RUN F-T II: ACTIVATION START 10-May-94 14:30
RUN START 11-May-94 21:00

RUN NO.	AVG TIME ON-STR, HRS	START DATE	START TIME	TIME ON-STR, HRS	END DATE	END TIME	TIME ON-STR, HRS	TIME PERIOD, HRS
R11.1A	10	12-May	4:00	7	12-May	10:00	13	6
R11.1B	33	13-May	4:00	31	13-May	8:00	35	4

RUN F-T IIA: ACTIVATION START 26-May-94 20:30
RUN START 27-May-94 12:00

RUN NO.	AVG TIME ON-STR, HRS	START DATE	START TIME	TIME ON-STR, HRS	END DATE	END TIME	TIME ON-STR, HRS	TIME PERIOD, HRS
R12.1A	9	27-May	17:00	5	28-May	1:00	13	8
R12.2A	30.5	28-May	13:00	25	29-May	0:00	36	11
R12.3A	41.8	29-May	3:00	39	29-May	8:30	44.5	5.5
R12.3B	45.5	29-May	8:50	44.8	29-May	10:15	46.3	1.4
R12.3C	48.3	29-May	11:50	47.8	29-May	12:45	48.8	0.9
R12.3D	50.7	29-May	14:00	50	29-May	15:20	51.3	1.3
R12.3E	56.3	29-May	16:40	52.7	30-May	0:00	60	7.3
R12.3F	84	30-May	16:00	76	31-May	8:00	92	16
R12.4	100.5	31-May	10:00	94	31-May	23:00	107	13
R12.5A	116	1-Jun	2:00	110	1-Jun	14:00	122	12
R12.5B	129.5	1-Jun	18:00	126	2-Jun	1:00	133	7

TABLE 14

MASS / ELEMENTAL BALANCE

RUN NO. AF-R12.3F

	TOTAL LB/HR	C LB/HR	H LB/HR	O LB/HR	N LB/HR
REACTOR FEED GAS	2674.7	1051.7	118.3	1401.1	103.5
MAIN GAS OUTLET	2421.1	964.9	100.0	1252.7	103.5
27.10 REACTOR WAX	0	0	0	0	0
22.14 LIGHT WAX	0	0	0	0	0
22.18 HC PHASE	46.9	38.5	6.9	1.5	0
22.18 AQ PHASE	78.8	12.3	8.9	57.6	0
TOTAL OUT	2546.8	1015.7	115.8	1311.8	103.5
% BALANCE	95.2	96.6	97.9	93.6	100.0

TABI 5 (p. 1/3)

		SUMMARY OF RESULTS FOR FT-II / IIA DEMONSTRATION RUN AT LAPORTE								
RUN NO.	ON-STREAM TIME HRS	TEMPERATURE DEG F	PRESSURE PSIG	SPACE VELOCITY SL/KG-FE HR	SUPERFICIAL GAS VEL- INLET, FT/SEC	CATALYST IN REACTOR LBS	SLURRY CONC. WT%	GAS HOLD-UP VOL%	CO CONV. MOLE%	H2 CONV. MOLE%
AF-R11.1A	10	508.2	200.1	2440	0.35	985	43.5	18.7	34.7	37.9
AF-R11.1B	33	521	300	2433	0.24	985	41.1	24.5	25.7	27.5
AF-R12.1A	9	517.9	175	2534	0.19	445	25.0	23.5	84.7	79.6
AF-R12.2A	30.5	576	750	12266	0.24	445	23.0	9.0	54.2	56.3
AF-R12.3F	84	577.5	750	18529	0.24	297	14.4	8.9	24.6	32.2
AF-R12.4	100.5	577.9	500	18682	0.36	297	15.0	13.0	15.6	18.6
AF-R12.5A	116	517.8	175	3665	0.18	297	13.8	6.7	10.0	11.7
AF-R12.5B	129.5	589.4	175	3771	0.20	297	14.1	6.1	43.6	41.7

TABLE 15 (p. 2/3)

		SUMMARY OF RESULTS FOR F-T II / IIA DEMONSTRATION RUN AT LAPORTE											
RUN	CO+H2	CO CONV	H2/CO USAGE	H2/CO IN	CO2	<———HC Selectivity (CO2 free) mole % C———>							
NO.	CONV.	RATE	RATIO	OUTLET	SELECT.	CH4	C2H6	C2H4	C3H8	C3H6	C4H10	C4H8	C5H11
	MOLE%	GMOLE/KG-FE HR	MOLE/MOLE	MOLE/MOLE	MOLE%						SUM	SUM	SUM
AF-R11.1A	36	21.5	0.76	0.66	48.6	19.2	14.8	0.62	15.1	5.74	7.44	7.53	8.51
AF-R11.1B	26.4	15.9	0.74	0.68	34.8	12.7	9.83	0.44	11.1	2.31	5.80	3.56	2.54
AF-R12.1A	82.5	53.1	0.70	1.00	44.9	13.4	11.7	0.49	13.3	4.65	7.46	5.69	7.92
AF-R12.2A	55.0	172.2	0.71	0.65	43.7	11.8	12.0	0.39	14.5	3.66	8.16	3.96	8.45
AF-R12.3F	27.6	118.7	0.88	0.60	28.5	5.52	5.59	3.13	3.42	11.2	2.16	8.49	6.24
AF-R12.4	16.8	75.4	0.82	0.66	20	5.55	4.44	4.72	2.23	11.1	1.38	7.68	5.09
AF-R12.5A	10.7	9.5	0.79	0.64	22.4	3.87	3.00	5.24	1.26	10.0	0.83	6.47	5.33
AF-R12.5B	42.8	41.2	0.70	0.76	46.1	10.4	11.3	3.96	7.86	13.2	3.27	10.41	7.33