RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: . . 1991

Tests No.	S_1-b_3	Temp.	95 ℃	Additives Conc.	0 mg/l μl/l	Oil Conc.	100 mg/l μl/l	♯ Note

No.	Subjects	Sym.	Measuring items	Unit	Results	♯ Note
1		V_B	V. of filtrate	l	0.488	change into
2		pH_F	pH of filtrate	25℃	8.567 @ 22.2	25 ℃
3		Ak_F	m-Alk of filtrate	mg/l	179.4 @pH=4.17	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	30,745	
5		Ca_s	Ca ion before heat'g	mg/l	630	
6	Quantity	Ca_F	Ca ion in filtrate	mg/l	288	
7	of	Ca_{P1}	$Ca_s - Ca_F$	mg/l	342	
8	Ca^{2+} Mg^{2+}	Wl_{Ca}	$2.5(Ca_{P1})(V_B)$	mg	428	$CaCO_3$
9	in	Mg_s	Mg ion before heat'g	mg/l	1967	
10	filtrate	Mg_F	Mg ion of filtrate	mg/l	1937	
11		Mg_{P1}	$Mg_s - Mg_F$	mg/l	40	
12		Wl_{Mg}	$2.4(Mg_{P1})(V_B)$	mg	48	$Mg(OH)_2$
13		Wl_s	W. of ppt. after dry'g	mg	475	
14	Quantity	Wl_{Cl}	W. of Cl^Na after dry'g	mg	9.3	
15	of	Wl_{NC}	W. of NaCl	mg	24	
16	$CaCO_3$ & $Mg(OH)_2$	$W2_s$	W. of actual ppt	mg	451	$Wl_s - Wl_{NC}$
17	in		W. of Ca	mg	S 270 A 74	
18	ppt	$W2_{Ca}$	W. of $CaCO_3$	mg	430	
19			W. of Mg	mg	S 28 A 8	
20		$W2_{Mg}$	W. of $Mg(OH)_2$	mg	43	

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: 15 Dec 1991

Tests No.	S-154	Temp.	95 ℃	Additives Conc.	0 mg/l μl/l	Oil Conc.	0 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results			* Note
1	Formation of p.p.t	pH_S	pH before heating	25℃*	7.653 @ 23.1			change into 25 ℃
2		pH_F	pH of filtrate	25℃*	8.509 @ 22.1			
3		Ak_S	m-Alk before heating	mg/l*	181.7 @ pH = 4.16			as $CaCO_3$
4		Ak_A	m-Alk added	mg/l*	1000			as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l*	131.1 @ pH = 4.15			as $CaCO_3$
6		t_o	Oil bath temperature	℃	110			
7		t_B	Brine temperature	℃	95			
8		Δt	Temp. difference	℃	15			$=t_o-t_B$
9		T_S	Starting time	hr	1°00'	$t=t_B$		
10		T_M	Time after X min.	hr	1°30'	X=30 min		
11		T_F	Time after Y min.	hr	2°07'	Y=17 min		
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.01			
13		V_B	V. of filtrate	l	0.495			
14		W_S	W. of ppt. after dry'g	g	0.578			
15			Results of observation by eyes	—	Sharp	Round	S+R	Adhere
					✓			✓

(NOTE)
- $Ak_A = (53)(0.94)(10^3)V_{NA}/0.8$ [mg/l as $CaCO_3$]
- Cocentration of Na_2CO_3 solution: 1N
- To dry at 105℃

COMMENTS	ppt particles are mixture of fine and large particles

Singnature

wt of #5 filter paper = 1.141 g
" " " " + ppt = 1.707 g → 0.566
" " millipore = 0.087 g
" " + ppt = 0.099 g → 0.012
wt of ppt for $CaCO_3$ = 0.00359

RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: . . 1991

Tests No.	S 1-4	Temp.	95℃	Additives Conc.	○ mg/l μl/l	Oil Conc.	○ mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	0.495	change into 25 ℃
2		pH_F	pH of filtrate	25℃	8.509 @22.1	
3		Ak_F	m-Alk of filtrate	mg/l	131.1 @pH=4.15	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	30,400	
5		Ca_s	Ca ion before heat'g	mg/l	630	
6	Quantity	Ca_F	Ca ion in filtrate	mg/l	278	
7	of	Ca_{P1}	$Ca_s - Ca_F$	mg/l	352	
8	Ca^{2+} Mg^{2+}	Wl_{Cs}	$2.5(Ca_{P1})(V_B)$	mg	440	$CaCO_3$
9	in	Mg_s	Mg ion before heat'g	mg/l	1967	
10	filtrate	Mg_F	Mg ion of filtrate	mg/l	1908	
11		Mg_{P1}	$Mg_s - Mg_F$	mg/l	59	
12		Wl_{Ms}	$2.4(Mg_{P1})(V_B)$	mg	71	$Mg(OH)_2$
13		Wl_s	W. of ppt. after dry'g	mg	578	
14	Quantity	Wl_{cl}	W. of NaCl after dry'g	mg	12.4	
15	of	Wl_{NC}	W. of NaCl	mg	31	
16	$CaCO_3$ & $Mg(OH)_2$	$W2_s$	W. of actual ppt	mg	363	$Wl_s - Wl_{NC}$
17	in		W. of Ca	mg	S 286 A 59	
18	ppt	$W2_{Cs}$	W. of $CaCO_3$	mg	431	
19			W. of Mg	mg	S 38 A 7	
20		$W2_{Ms}$	W. of $Mg(OH)_2$	mg	54	

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: 20. Nov. 1991

Tests No.	S 1-1	Temp.	95 ℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	0 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results		* Note
1	Formation of p.p.t	pH_S	pH before heating	25℃*	7.598 @ 24.9		change into 25 ℃
2		pH_F	pH of filtrate	25℃*	8.893 @ 23.3		
3		Ak_S	m-Alk before heating	mg/l*	154.1 @ pH = 4.16		as $CaCO_3$
4		Ak_A	m-Alk added	mg/l*	996.4		as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l*	98.9 @ pH = 4.05		as $CaCO_3$
6		t_o	Oil bath temperature	℃	106		
7		t_B	Brine temperature	℃	96		
8		Δt	Temp. difference	℃	15		$=t_o-t_B$
9		T_S	Starting time	hr	8°00'	$t=t_B$	
10		T_M	Time after X min.	hr	8°30'	X=30min	
11		T_F	Time after Y min.	hr	9°30''	Y=60min	
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.01		
13		V_B	V. of filtrate	l	0.492		
14		W_S	W. of ppt. after dry'g	g	0.718		

15	Results of observation by eyes	—	Sharp	Round	S+R	Adhere
				Y		Y

(NOTE)
- $Ak_A = (53)(0.94)(10^3)V_{NA} / 0.8$ [mg/l as $CaCO_3$]
- Cocentration of Na_2CO_3 solution: 1N
- To dry at 105℃

COMMENTS	Volume of sample is 500 ml.

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RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: . . 1991

Tests No.	S1-1	Temp.	95 ℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	0 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	0.492	change into 25 ℃
2		pH_F	pH of filtrate	25℃*	8.893 @ 23.3	
3		Ak_F	m-Alk of filtrate	mg/l*	98.96 @ pH=4.05	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	21,743	
5	Quantity of Ca^{2+} Mg^{2+} in filtrate	Ca_s	Ca ion before heat'g	mg/l	630	
6		Ca_F	Ca ion in filtrate	mg/l	278	
7		Ca_{PI}	$Ca_s - Ca_F$	mg/l	352	
8		Wlc_a	$2.5(Ca_{PI})(V_B)$	mg*	440	$CaCO_3$
9		Mg_s	Mg ion before heat'g	mg/l	1967	
10		Mg_F	Mg ion of filtrate	mg/l	1792	
11		Mg_{PI}	$Mg_s - Mg_F$	mg/l	175	
12		Wl_{Ms}	$2.4(Mg_{PI})(V_B)$	mg*	210	$Mg(OH)_2$
13	Quantity of $CaCO_3$ & $Mg(OH)_2$ in ppt	Wl_S	W. of ppt. after dry'g	mg	718	
14		Wl_{cl}	W. of NaCl after dry'g	mg	25.5	
15		Wl_{NC}	W. of NaCl	mg	65	
16		$W2_S$	W. of actual ppt	mg*	653	$Wl_S - Wl_{NC}$
17			W. of Ca	mg	S 327 | A 23	
18		$W2_{Ca}$	W. of $CaCO_3$	mg	437	
19			W. of Mg	mg	S 78 | A 85	
20		$W2_{Ms}$	W. of $Mg(OH)_2$	mg	196	

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: 20, Nov. 1991

Tests No.	S-2	Temp.	℃ 30	Additives Conc.	mg/l 5 μl/l	Oil Conc.	mg/l 1 μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results		* Note
1	Formation of p.p.t	pH_S	pH before heating	25℃*	7.598 @ 24.9		change into 25 ℃
2		pH_F	pH of filtrate	25℃*	8.333 @ 23.7		
3		Ak_S	m-Alk before heating	mg/l*	154.1 @ pH=4.16		as $CaCO_3$
4		Ak_A	m-Alk added	mg/l*	996.4		as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l*	151.8 @ pH=4.16		as $CaCO_3$
6		t_o	Oil bath temperature	℃	98		
7		t_B	Brine temperature	℃	81		
8		Δt	Temp. difference	℃	17		$=t_o-t_B$
9		T_S	Starting time	hr	12° 35'	t=t_B	
10		T_M	Time after X min.	hr	1° 5'	X=30min	
11		T_F	Time after Y min.	hr	2° 5'	Y=60min	
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.01		
13		V_B	V. of filtrate	l	0.497		
14		W_S	W. of ppt. after dry'g	g	0.546		
15			Results of observation by eyes	—	Sharp / Round / S+R / Adhere: Round = Y, Adhere = Y		

(NOTE) ・$Ak_A=(53)(0.94)(10^3)V_{NA}/0.8$ [mg/l as $CaCO_3$]
・Cocentration of Na_2CO_3 solution: 1N
・To dry at 105℃

COMMENTS	
	Singnature

F=0.945

RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: . . 1991

Tests No.	S -	Temp.	℃	Additives Conc.	mg/l μl/l	Oil Conc.	mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	0.497	change into 25 ℃
2		pH_F	pH of filtrate	25℃	8.733 @ 23.7	
3		Ak_F	m-Alk of filtrate	mg/l	151.8 @ pH = 4.16	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	33,614	
5	Quantity of Ca^{2+} Mg^{2+} in filtrate	Ca_s	Ca ion before heat'g	mg/l	630	
6		Ca_F	Ca ion in filtrate	mg/l	270	
7		Ca_{PI}	$Ca_s - Ca_F$	mg/l	360	
8		Wl_{Ca}	$2.5(Ca_{PI})(V_B)$	mg	450	$CaCO_3$
9		Mg_s	Mg ion before heat'g	mg/l	1967	
10		Mg_F	Mg ion of filtrate	mg/l	1665	
11		Mg_{PI}	$Mg_s - Mg_F$	mg/l	302	
12		Wl_{Mg}	$2.4(Mg_{PI})(V_B)$	mg	362	$Mg(OH)_2$
13	Quantity of $CaCO_3$ & $Mg(OH)_2$ in ppt	Wl_s	W. of ppt. after dry'g	mg	546	
14		Wl_{Cl}	W. of Cl after dry'g	mg	63	
15		Wl_{NC}	W. of NaCl	mg	161	
16		$W2_s$	W. of actual ppt	mg	385	$Wl_s - Wl_{NC}$
17			W. of Ca	mg	S 131 | A 215	
18		$W2_{Ca}$	W. of $CaCO_3$	mg	433	
19			W. of Mg	mg	S 127 | A 159	
20		$W2_{Mg}$	W. of $Mg(OH)_2$	mg	343	

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: 5 Nov. 1991

Tests No.	S_{1-2}	Temp.	95 ℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	1 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results			* Note
1	Formation of p.p.t	pH_S	pH before heating	25℃*	7.598 @ 24.9			change into 25 ℃
2		pH_F	pH of filtrate	25℃*	8.917 @ 23.3			
3		Ak_S	m-Alk before heating	mg/l*	154.1 @ pH: 4.16			as $CaCO_3$
4		Ak_A	m-Alk added	mg/l*	996.4			as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l*	108.1 @ pH = 4.10			as $CaCO_3$
6		t_o	Oil bath temperature	℃	105			
7		t_B	Brine temperature	℃	95			
8		Δt	Temp. difference	℃	10			$=t_o-t_B$
9		T_S	Starting time	hr	10° 30′	$t=t_B$		
10		T_M	Time after X min.	hr	11° 00′	X= 30min		
11		T_F	Time after Y min.	hr	12° 00′	Y=60min		
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.01			
13		V_B	V. of filtrate	l	0.490			
14		W_S	W. of ppt. after dry'g	g	0.852			
15			Results of observation by eyes	—	Sharp	Round	S+R	Adhere
						Y		Y

(NOTE)
- $Ak_A = (53)(0.94)(10^3)V_{NA}/0.8$ [mg/l as $CaCO_3$]
- Cocentration of Na_2CO_3 solution: 1N
- To dry at 105℃

COMMENTS	
	Singnature

RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: . . 1991

Tests No.	S 1 - 2	Temp.	95 ℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	1 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	0.490	change into 25 ℃
2		pH_F	pH of filtrate	25℃*	5.717 @ 23.3	
3		Ak_F	m-Alk of filtrate	mg/l*	to 5.8 @ pH = 4.10	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	29,709	
5	Quantity of Ca^{2+} Mg^{2+} in filtrate	Ca_s	Ca ion before heat'g	mg/l	630	
6		Ca_F	Ca ion in filtrate	mg/l	272	
7		Ca_{P1}	$Ca_s - Ca_F$	mg/l	358	
8		Wlc_a	$2.5(Ca_{P1})(V_B)$	mg *	448	$CaCO_3$
9		Mg_s	Mg ion before heat'g	mg/l	1967	
10		Mg_F	Mg ion of filtrate	mg/l	1766	
11		Mg_{P1}	$Mg_s - Mg_F$	mg/l	201	
12		Wl_{Ms}	$2.4(Mg_{P1})(V_B)$	mg *	241	$Mg(OH)_2$
13	Quantity of $CaCO_3$ & $Mg(OH)_2$ in ppt	Wl_s	W. of ppt. after dry'g	mg	852	
14		Wl_{c1}	W. of ~~Ca~~ Na after dry'g	mg	31.3	
15		Wl_{NC}	W. of NaCl	mg	80	
16		$W2_s$	W. of actual ppt	mg *	772	$Wl_s - Wl_{NC}$
17			W. of Ca	mg	S 368 A 10	
18		$W2_{Ca}$	W. of $CaCO_3$	mg	472	
19			W. of Mg	mg	S 85 A 91	
20		$W2_{Ms}$	W. of $Mg(OH)_2$	mg	211	

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: 2 Dec. 1991

Tests No.	S 1 ~ 4	Temp.	95 ℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	100 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results		* Note
1	Formation of p.p.t	pH_S	pH before heating	25℃*	7.598 @ 24.9		change into 25 ℃
2		pH_F	pH of filtrate	25℃*	8.726 @ 22.0		
3		Ak_S	m-Alk before heating	mg/l*	154.1 @ pH = 4.16		as $CaCO_3$
4		Ak_A	m-Alk added	mg/l*	498.2		as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l*	96.6 @ pH = 4.14		as $CaCO_3$
6		t_o	Oil bath temperature	℃	109		
7		t_B	Brine temperature	℃	95		
8		Δt	Temp. difference	℃	14		$= t_o - t_B$
9		T_S	Starting time	hr	10°15'	t = t_B	
10		T_M	Time after X min.	hr.	10°45'	X = 30 min	
11		T_F	Time after Y min.	hr	11°45'	Y = 60 min	
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.008		
13		V_B	V. of filtrate	l	0.393		
14		W_S	W. of ppt. after dry'g	g	0.627		
15			Results of observation by eyes	—	Sharp	Round	S+R	Adhere
						✓		✓

(NOTE) · $Ak_A = (53)(0.94)(10^3)V_{NA} / 0.8$ [mg/l as $CaCO_3$]
· Cocentration of Na_2CO_3 solution: 1N.
· To dry at 105℃

COMMENTS	Volume of sample = 400 ml, additive = 2 μl, oil = 40 μl very very little adhere.

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RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: 5. Dec. 1991

Tests No.	S 1 - 4	Temp.	95℃	Additives Conc.	5 mg/l 5 μl/l	Oil Conc.	100 mg/l 100 μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	0.393	change into 25 ℃
2		pH_F	pH of filtrate	25℃*	8.726 @ 22.0	
3		Ak_F	m-Alk of filtrate	mg/l*	96.6 @ pH 4.14	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	30,443	
5	Quantity of Ca^{2+} Mg^{2+} in filtrate	Ca_s	Ca ion before heat'g	mg/l	630	
6		Ca_F	Ca ion in filtrate	mg/l	266	
7		Ca_{P1}	Ca_s-Ca_F	mg/l	364	
8		Wl_{Ca}	$2.5(Ca_{P1})(V_B)$	mg*	364	$CaCO_3$
9		Mg_s	Mg ion before heat'g	mg/l	1967	
10		Mg_F	Mg ion of filtrate	mg/l	1900	
11		Mg_{P1}	Mg_s-Mg_F	mg/l	67	
12		Wl_{Mg}	$2.4(Mg_{P1})(V_B)$	mg*	64	$Mg(OH)_2$
13	Quantity of $CaCO_3$ & $Mg(OH)_2$ in ppt	Wl_S	W. of ppt. after dry'g	mg	627	
14		Wl_{C1}	W. of ~~Cl~~ No after dry'g	mg	18	
15		Wl_{NC}	W. of NaCl	mg	45	
16		$W2_S$	W. of actual ppt	mg*	582	Wl_S-Wl_{NC}
17			W. of Ca	mg	S 376 A 5	
18		$W2_{Ca}$	W. of $CaCO_3$	mg	381	
19			W. of Mg	mg	S 78 A 131	
20		$W2_{Mg}$	W. of $Mg(OH)_2$	mg	87	

wt of filter paper #5 = 1.103 g
wt of " " " + ppt = 1.716 g → wt of ppt = 0.613 g

wt of 0.4 millipore filter = 0.089 g
wt of " " + ppt = 0.103 g → 0.014

wt of ppt for Ca & Mg = 0.627 − 0.014 = 0.613 g

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: . . 1991

Tests No.	S_1 ~ 5	Temp.	95 ℃	Additives Conc.	10 mg/l (μl/l)	Oil Conc.	100 mg/l (μl/l)	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results			* Note
1	Formation of p.p.t	pH_S	pH before heating	25℃*	7.598 @ 24.9			change into 25 ℃
2		pH_F	pH of filtrate	25℃*	8.715 @ 21.9			
3		Ak_S	m-Alk before heating	mg/l*	154.1 @ pH=4.16			as $CaCO_3$
4		Ak_A	m-Alk added	mg/l*	1000			as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l*	140.3 @ pH=4.15			as $CaCO_3$
6		t_o	Oil bath temperature	℃	105			
7		t_B	Brine temperature	℃	95			
8		Δt	Temp. difference	℃	10			$=t_o-t_B$
9		T_S	Starting time	hr	9 ° 40 '	$t=t_B$		
10		T_M	Time after X min.	hr.	10 ° 10 '	X=30 min		
11		T_F	Time after Y min.	hr	11 ° 10 '	Y=60 min		
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.008			
13		V_B	V. of filtrate	l	0.385			
14		W_S	W. of ppt. after dry'g	g	0.503			
15			Results of observation by eyes	—	Sharp	Round	S+R	Adhere
						✓		✗

(NOTE) • $Ak_A=(53)(0.94)(10^3)V_{NA}/0.8$ [mg/l as $CaCO_3$]
• Cocentration of Na_2CO_3 solution: 1N
• To dry at 105℃

COMMENTS	
	Singnature

RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: . . 1991

Tests No.	S-5	Temp.	95 ℃	Additives Conc.	10 mg/l (10 μl/l)	Oil Conc.	100 mg/l (100 μl/l)	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	0.385	change into 25 ℃
2		pH_F	pH of filtrate	25℃	8.715@21.9	
3		Ak_F	m-Alk of filtrate	mg/l	140.3@pH=4.15	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	30,443	
5		Ca_s	Ca ion before heat'g	mg/l	630	
6	Quantity of Ca^{2+} Mg^{2+} in filtrate	Ca_F	Ca ion in filtrate	mg/l	330	
7		Ca_{PI}	$Ca_s - Ca_F$	mg/l	300	
8		Wlc_a	$2.5(Ca_{PI})(V_B)$	mg	300	$CaCO_3$
9		Mg_s	Mg ion before heat'g	mg/l	1967	
10		Mg_F	Mg ion of filtrate	mg/l	1807	
11		Mg_{PI}	$Mg_s - Mg_F$	mg/l	160	
12		Wl_{Ms}	$2.4(Mg_{PI})(V_B)$	mg	154	$Mg(OH)_2$
13	Quantity of $CaCO_3$ & $Mg(OH)_2$ in ppt	Wl_s	W. of ppt. after dry'g	mg	503	
14		Wl_{cl}	W. of ~~Cl~~ Na after dry'g	mg	12	
15		Wl_{NC}	W. of NaCl	mg	31	
16		$W2_s$	W. of actual ppt	mg	472	$Wl_s - Wl_{NC}$
17			W. of Ca	mg	S 307 | A 6	
18		$W2_{Ca}$	W. of $CaCO_3$	mg	313	
19			W. of Mg	mg	S 68 | A 80	
20		$W2_{Ms}$	W. of $Mg(OH)_2$	mg	142	

wt of filter paper #5 = 1.101 g
" " " " + ppt = 1.594 g
wt of millipore = 0.091 g
" " " + ppt = 0.101 g

wt of ppt for Ca & Mg = .00495

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: . . 1991

Tests No.	S 1 ~ 6	Temp.	95 ℃	Additives Conc.	5 mg/l 5 μl/l	Oil Conc.	0 mg/l 0 μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results			* Note
1		pH_S	pH before heating	25℃	7.595@24.9			change into 25 ℃
2		pH_F	pH of filtrate	25℃	7.850@22.1			
3		Ak_S	m-Alk before heating	mg/l	154.1@4.16			as $CaCO_3$
4		Ak_A	m-Alk added	mg/l	1000			as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l	515.2@pH=4.18			as $CaCO_3$
6	Formation	t_o	Oil bath temperature	℃	96			
7	of	t_B	Brine temperature	℃	96			
8	p.p.t	Δt	Temp. difference	℃	10			$=t_o-t_B$
9		T_S	Starting time	hr	8°30'	$t=t_B$		
10		T_M	Time after X min.	hr.	9°00'	X=30min		
11		T_F	Time after Y min.	hr	9°5'	Y=5min		
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.005			
13		V_B	V. of filtrate	l	0.392			
14		W_S	W. of ppt. after dry'g	g	0.496			
15			Results of observation by eyes	—	Sharp	Round	S+R	Adhere
					✓			✗

(NOTE) ・$Ak_A=(53)(0.94)(10^3)V_{NA}/0.8$ [mg/l as $CaCO_3$]
・Cocentration of Na_2CO_3 solution: 1N
・To dry at 105℃

COMMENTS	
	Singnature

wt of #5 filter paper = 1.126 g ? 0.469
" " " " + ppt = 1.595
wt of millipore filter paper = 0.092 g .027
" " " + ppt = 0.119 g
wt of ppt for Ca & Mg = 0.00205

RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: . . 1991

Tests No.	S_1-6	Temp.	95 ℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	0 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	0.392	change into
2		pH_F	pH of filtrate	25℃	7.850 @ 25.1	25 ℃
3		Ak_F	m-Alk of filtrate	mg/l*	515.2 @pH=4.18	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	30,616	
5	Quantity of Ca^{2+} Mg^{2+} in filtrate	Ca_s	Ca ion before heat'g	mg/l	630	
6		Ca_F	Ca ion in filtrate	mg/l	400	
7		Ca_{P1}	$Ca_s - Ca_F$	mg/l	230	
8		Wl_{Ca}	$2.5(Ca_{P1})(V_B)$	mg	230	$CaCO_3$
9		Mg_s	Mg ion before heat'g	mg/l	1967	
10		Mg_F	Mg ion of filtrate	mg/l	1704	
11		Mg_{P1}	$Mg_s - Mg_F$	mg/l	263	
12		Wl_{Mg}	$2.4(Mg_{P1})(V_B)$	mg	252	$Mg(OH)_2$
13	Quantity of $CaCO_3$ & $Mg(OH)_2$ in ppt	Wl_s	W. of ppt. after dry'g	mg	496	
14		Wl_{Cl}	W. of NaCl after dry'g	mg	35	
15		Wl_{NC}	W. of NaCl	mg	89	
16		$W2_s$	W. of actual ppt	mg	407	$Wl_s - Wl_{NC}$
17			W. of Ca	mg	S 79 | A 142	
18		$W2_{Ca}$	W. of $CaCO_3$	mg	221	
19			W. of Mg	mg	S 217 | A 8	
20		$W2_{Mg}$	W. of $Mg(OH)_2$	mg	216	

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: 10 Dec. 1991

Tests No.	S1-7	Temp.	95 ℃	Additives Conc.	5 mg/l (μl/l)	Oil Conc.	1 mg/l (μl/l)	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results			* Note
1	Formation of p.p.t	pH_S	pH before heating	25℃*	7.653 @ 23.1			change into 25 ℃
2		pH_F	pH of filtrate	25℃*	7.882 @ 22.4			
3		Ak_S	m-Alk before heating	mg/l*	181.7 @ pH=4.16			as $CaCO_3$
4		Ak_A	m-Alk added	mg/l*	996.4			as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l*	388.7 @ pH=4.15			as $CaCO_3$
6		t_o	Oil bath temperature	℃	111			
7		t_B	Brine temperature	℃	95			
8		Δt	Temp. difference	℃	16			$=t_o-t_B$
9		T_S	Starting time	hr	8°5'	t=t_B		
10		T_M	Time after X min.	hr.	8°35'	X=30min		
11		T_F	Time after Y min.	hr	8°40'	Y=5 min		
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.01			
13		V_B	V. of filtrate	l	0.490			
14		W_S	W. of ppt. after dry'g	g	0.573			
15			Results of observation by eyes	—	Sharp	Round	S+R	Adhere
						✓		—

(NOTE) • $Ak_A=(53)(0.94)(10^3)V_{NA}/0.8$ [mg/l as $CaCO_3$]
• Cocentration of Na_2CO_3 solution: 1N
• To dry at 105℃

COMMENTS	No adhere

Singnature

wt of [illegible] = 1.145 g
[illegible] = 1.642 g → 0.497

[illegible] = 0.087 g
[illegible] = 0.163 g → 0.076

[illegible] = 0.0015.7 g

RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: , , 1991

Tests No.	S_1-7	Temp.	95 ℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	1 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	0.490	change into
2		pH_F	pH of filtrate	25℃	7.882 @ 22.4	25 ℃
3		Ak_F	m-Alk of filtrate	mg/l	388.7 @ pH = 4.15	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	30,875	
5	Quantity of Ca^{2+} Mg^{2+} in filtrate	Ca_s	Ca ion before heat'g	mg/l	630	
6		Ca_F	Ca ion in filtrate	mg/l	378	
7		Ca_{P1}	$Ca_s - Ca_F$	mg/l	252	
8		Wlc_a	$2.5(Ca_{P1})(V_B)$	mg	315	$CaCO_3$
9		Mg_s	Mg ion before heat'g	mg/l	1967	
10		Mg_F	Mg ion of filtrate	mg/l	1767	
11		Mg_{P1}	$Mg_s - Mg_F$	mg/l	200	
12		Wl_{Mg}	$2.4(Mg_{P1})(V_B)$	mg	240	$Mg(OH)_2$
13	Quantity of $CaCO_3$ & $Mg(OH)_2$ in ppt	Wl_s	W. of ppt. after dry'g	mg	573	
14		Wl_{Cl}	W. of Cl after dry'g	mg	47	
15		Wl_{NC}	W. of NaCl	mg	118	
16		$W2_s$	W. of actual ppt	mg	455	$Wl_s - Wl_{NC}$
17			W. of Ca	mg	S 73 A 173	
18		$W2_{Ca}$	W. of $CaCO_3$	mg	307	
19			W. of Mg	mg	S 186 A 11	
20		$W2_{Mg}$	W. of $Mg(OH)_2$	mg	236	

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: Dec. 1991

Tests No.	S1-8	Temp.	95℃	Additives Conc.	5 mg/l (5 μl/l)	Oil Conc.	100 mg/l (100 μl/l)	

No.	Subjects	Sym.	Measuring items	Unit	Results			* Note
1	Formation of p.p.t	pH_S	pH before heating	25℃*	7.653 @ 22.1			change into 25 ℃
2		pH_F	pH of filtrate	25℃*	7.938 @ 22.6			
3		Ak_S	m-Alk before heating	mg/l*	181.7 @ pH=4.16			as $CaCO_3$
4		Ak_A	m-Alk added	mg/l*	1000			as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l*	2139 @ pH=4.15			as $CaCO_3$
6		t_o	Oil bath temperature	℃	110			
7		t_B	Brine temperature	℃	95			
8		Δt	Temp. difference	℃	15			$=t_o-t_B$
9		T_S	Starting time	hr	12°30'	$t=t_S$		
10		T_M	Time after X min.	hr	1°00'	$X=30$ min		
11		T_F	Time after Y min.	hr	1°05'	$Y=5$ min		
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.01			
13		V_B	V. of filtrate	l	0.492			
14		W_S	W. of ppt. after dry'g	g	0.575			
15			Results of observation by eyes	—	Sharp	Round	S+R	Adhere
						✓		—

(NOTE)
- $Ak_A=(53)(0.94)(10^3)V_{NA}/0.8$ [mg/l as $CaCO_3$]
- Cocentration of Na_2CO_3 solution: 1N
- To dry at 105℃

COMMENTS	very little adhere

Singnature

wt of 5 filter paper = 1.122 g
" " " + ppt = 1.674 g → 0.552
" " middle piece = 0.085 g
" " " + ppt = 0.108 g → 0.023
wt of ppt from Ca^{++} & Ba^{++} = 0.00180 g

RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: . . 1991

Tests No.	S1 - 8	Temp.	95 ℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	100 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	1.492	change into 25 ℃
2		pH_F	pH of filtrate	25℃	7.9-38 @ 22.6	
3		Ak_F	m-Alk of filtrate	mg/l	213.9 @pH:4.5	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	30,659	
5	Quantity of Ca^{2+} Mg^{2+} in filtrate	Ca_s	Ca. ion before heat'g	mg/l	630	
6		Ca_F	Ca ion in filtrate	mg/l	358	
7		Ca_{P1}	$Ca_s - Ca_F$	mg/l	272	
8		Wl_{Cs}	$2.5(Ca_{P1})(V_B)$	mg	340	$CaCO_3$
9		Mg_s	Mg ion before heat'g	mg/l	1967	
10		Mg_F	Mg ion of filtrate	mg/l	1693	
11		Mg_{P1}	$Mg_s - Mg_F$	mg/l	274	
12		Wl_{MS}	$2.4(Mg_{P1})(V_B)$	mg	329	$Mg(OH)_2$
13	Quantity of $CaCO_3$ & $Mg(OH)_2$ in ppt	Wl_S	W. of ppt. after dry'g	mg	575	
14		Wl_{C1}	W. of ~~Cl~~ Na after dry'g	mg	43	
15		Wl_{NC}	W. of NaCl	mg	108	
16		$W2_S$	W. of actual ppt	mg	467	$Wl_S - Wl_{NC}$
17			W. of Ca	mg	S 115 | A 145	
18		$W2_{Cs}$	W. of $CaCO_3$	mg	325	
19			W. of Mg	mg	S 173 | A 100	
20		$W2_{MS}$	W. of $Mg(OH)_2$	mg	328	

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: 9 Dec 1991

Tests No.	S_1-9	Temp.	95 ℃	Additives Conc.	5 mg/l 5 μl/l	Oil Conc.	0 mg/l 0 μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results		* Note
1	Formation of p.p.t	pH_S	pH before heating	25℃*	7.653 @ 23.9		change into 25 ℃
2		pH_F	pH of filtrate	25℃*	8.195 @ 22.4		
3		Ak_S	m-Alk before heating	mg/l*	1817 @ pH=4.16		as $CaCO_3$
4		Ak_A	m-Alk added	mg/l*	996.4		as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l*	218.05 @ pH=4.17		as $CaCO_3$
6		t_o	Oil bath temperature	℃	110		
7		t_B	Brine temperature	℃	95		
8		Δt	Temp. difference	℃	15		$=t_o-t_B$
9		T_S	Starting time	hr	11°40'	t=t_B	
10		T_M	Time after X min.	hr.	12°10'	X=30min	
11		T_F	Time after Y min.	hr	12°27'	Y=17min	
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.01		
13		V_B	V. of filtrate	l	0.485		
14		W_S	W. of ppt. after dry'g	g	0.623		
15			Results of observation by eyes	—	Sharp: ✓	Round:	S+R:	Adhere: —

(NOTE) • $Ak_A=(53)(0.94)(10^3)V_{NA}/0.8$ [mg/l as $CaCO_3$]
• Cocentration of Na_2CO_3 solution: 1N
• To dry at 105℃

COMMENTS	Almost, no adhere.

Singnature

wt of #5 Filter paper = 1.125 g
" " " + ppt = 1.669 g
→ 0.544

" " millipore = 0.083 g
" " + ppt = 0.162 g
→ 0.079

wt of ppt. for $CaSiO_3$ = 0.00262 g

RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: . . 1991

Tests No.	S 1-9	Temp.	95 ℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	0 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	0.485	change into
2		pH_F	pH of filtrate	25℃	8.195 @ 22.4	25 ℃
3		Ak_F	m-Alk of filtrate	mg/l	218.5 @ pH = 4.17	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	30.745	
5	Quantity of Ca^{2+} Mg^{2+} in filtrate	Ca_s	Ca ion before heat'g	mg/l	630	
6		Ca_F	Ca ion in filtrate	mg/l	304	
7		Ca_{P1}	$Ca_s - Ca_F$	mg/l	326	
8		Wlc_s	$2.5(Ca_{P1})(V_B)$	mg	395	$CaCO_3$
9		Mg_s	Mg ion before heat'g	mg/l	1967	
10		Mg_F	Mg ion of filtrate	mg/l	1724	
11		Mg_{P1}	$Mg_s - Mg_F$	mg/l	243	
12		Wl_{Ms}	$2.4(Mg_{P1})(V_B)$	mg	292	$Mg(OH)_2$
13	Quantity of $CaCO_3$ & $Mg(OH)_2$ in ppt	Wl_s	W. of ppt. after dry'g	mg	623	
14		Wl_{c1}	W. of Cl after dry'g	mg	79	
15		Wl_{NC}	W. of NaCl	mg	200	
16		$W2_s$	W. of actual ppt	mg	423	$Wl_s - Wl_{NC}$
17			W. of Ca	mg	S 140 | A 137	
18		$W2_{Cs}$	W. of $CaCO_3$	mg	346	
19			W. of Mg	mg	S 104 | A 110	
20		$W2_{Ms}$	W. of $Mg(OH)_2$	mg	257	

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: [illegible] 1991

Tests No.	S1-8	Temp.	95 ℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	100 mg/l μl/l	

No.	Subjects	Sym.	Measuring items	Unit	Results			* Note
1	Formation of p.p.t	pH_S	pH before heating	25℃*	7.653 @ [illegible]			change into 25 ℃
2		pH_F	pH of filtrate	25℃*	7.938@ 22.6			
3		Ak_S	m-Alk before heating	mg/l*	1617 @ pH=4.16			as $CaCO_3$
4		Ak_A	m-Alk added	mg/l*	1000			as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l*	2139 @ pH=4.15			as $CaCO_3$
6		t_o	Oil bath temperature	℃	110			
7		t_B	Brine temperature	℃	95			
8		Δt	Temp. difference	℃	15			$=t_o-t_B$
9		T_S	Starting time	hr	12°30'	$t=t_B$		
10		T_M	Time after X min.	hr	1°00'	$X=30$ min		
11		T_F	Time after Y min.	hr	1°05'	$Y=5$ min		
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.01			
13		V_B	V. of filtrate	l	0.492			
14		W_S	W. of ppt. after dry'g	g	0.575			
15			Results of observation by eyes	—	Sharp	Round	S+R	Adhere
						✓		—

(NOTE)
- $Ak_A=(53)(0.94)(10^3)V_{NA}/0.8$ [mg/l as $CaCO_3$]
- Cocentration of Na_2CO_3 solution: 1N
- To dry at 105℃

COMMENTS	very little odour

Singnature

wt of filter paper = 1.122 g
" " + ppt = 1.674 g → 0.552
" " + milliporer = 0.085 g
" " + ppt = 0.108 g → 0.023
wt of ppt after dry'g = 0.0150 g

RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: . . 1991

Tests No.	S_1 - S	Temp.	95 ℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	100 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	1.492	change into 25 ℃
2		pH_F	pH of filtrate	25℃	7.938 @ 22.6	
3		Ak_F	m-Alk of filtrate	mg/l	213.9 @pH=4.15	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	30,659	
5	Quantity of Ca^{2+} Mg^{2+} in filtrate	Ca_s	Ca. ion before heat'g	mg/l	630	
6		Ca_F	Ca ion in filtrate	mg/l	358	
7		Ca_{P1}	$Ca_s - Ca_F$	mg/l	272	
8		Wl_{Ca}	$2.5(Ca_{P1})(V_B)$	mg	340	$CaCO_3$
9		Mg_s	Mg ion before heat'g	mg/l	1967	
10		Mg_F	Mg ion of filtrate	mg/l	1693	
11		Mg_{P1}	$Mg_s - Mg_F$	mg/l	274	
12		Wl_{Mg}	$2.4(Mg_{P1})(V_B)$	mg	329	$Mg(OH)_2$
13	Quantity of $CaCO_3$ & $Mg(OH)_2$ in ppt	Wl_s	W. of ppt. after dry'g	mg	575	
14		Wl_{Cl}	W. of ~~Cl~~ Na after dry'g	mg	43	
15		Wl_{NC}	W. of NaCl	mg	108	
16		$W2_s$	W. of actual ppt	mg	467	$Wl_s - Wl_{NC}$
17			W. of Ca	mg	S 115 A 145	
18		$W2_{Ca}$	W. of $CaCO_3$	mg	325	
19			W. of Mg	mg	S 173 A 100	
20		$W2_{Mg}$	W. of $Mg(OH)_2$	mg	328	

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: 9 Dec 1991

Tests No.	S_1-9	Temp.	95 ℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	6 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results		* Note
1	Formation of p.p.t	pH_S	pH before heating	25℃	7.653 @ 23.9		change into 25 ℃
2		pH_F	pH of filtrate	25℃	8.195 @ 22.4		
3		Ak_S	m-Alk before heating	mg/l	181.7 @ pH=4.16		as $CaCO_3$
4		Ak_A	m-Alk added	mg/l	996.4		as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l	218.5 @ pH=4.17		as $CaCO_3$
6		t_o	Oil bath temperature	℃	110		
7		t_B	Brine temperature	℃	95		
8		Δt	Temp. difference	℃	15		$=t_o-t_B$
9		T_S	Starting time	hr	11°40'	$t=t_B$	
10		T_M	Time after X min.	hr.	12°10'	X=30min	
11		T_F	Time after Y min.	hr	12°27'	Y=17min	
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.01		
13		V_B	V. of filtrate	l	0.485		
14		W_S	W. of ppt. after dry'g	g	0.623		

15	Results of observation by eyes	—	Sharp	Round	S+R	Adhere
			✓			—

(NOTE) · $Ak_A=(53)(0.94)(10^3)V_{NA}/0.8$ [mg/l as $CaCO_3$]
· Cocentration of Na_2CO_3 solution: 1N
· To dry at 105℃

COMMENTS	Almost, no adhere.

Singnature

wt of #5 filter paper = 1.125 g
" " " + ppt = 1.669 g
" " = 0.544 g
" " + ppt = 1.623 g
" " = 0.079 g
" " ppt. for $CaCO_3$ = 0.465 g

RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: , , 1991

Tests No.	S 1~9	Temp.	95 ℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	0 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	0.485	change into 25 ℃
2		pH_F	pH of filtrate	25℃*	8.195 @ 22.4	
3		Ak_F	m-Alk of filtrate	mg/l*	218.5 @ pH = 4.17	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	30.745	
5	Quantity of Ca^{2+} Mg^{2+} in filtrate	Ca_s	Ca ion before heat'g	mg/l	630	
6		Ca_F	Ca ion in filtrate	mg/l	304	
7		Ca_{PI}	$Ca_s - Ca_F$	mg/l	326	
8		Wlc_s	$2.5(Ca_{PI})(V_B)$	mg*	395	$CaCO_3$
9		Mg_s	Mg ion before heat'g	mg/l	1967	
10		Mg_F	Mg ion of filtrate	mg/l	1724	
11		Mg_{PI}	$Mg_s - Mg_F$	mg/l	243	
12		Wlm_s	$2.4(Mg_{PI})(V_B)$	mg	292	$Mg(OH)_2$
13	Quantity of $CaCO_3$ & $Mg(OH)_2$ in ppt	Wl_S	W. of ppt. after dry'g	mg	623	
14		Wl_{CI}	W. of CI after dry'g	mg	79	
15		Wl_{NC}	W. of NaCl	mg	200	
16		$W2_S$	W. of actual ppt	mg	423	$Wl_S - Wl_{NC}$
17			W. of Ca	mg	S 140 | A 137	
18		$W2_{Cs}$	W. of $CaCO_3$	mg	346	
19			W. of Mg	mg	S 104 | A 110	
20		$W2_{Ms}$	W. of $Mg(OH)_2$	mg	257	

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: 10 · Dec 1991

Tests No.	S 1 - 10	Temp.	95 ℃	Additives Conc.	5 mg/l 5 μl/l	Oil Conc.	mg/l 1 μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results			* Note
1	Formation of p.p.t	pH_S	pH before heating	25℃*	7.653 @ 23.1			change into 25 ℃
2		pH_F	pH of filtrate	25℃*	7.976 @ 22.4			
3		Ak_S	m-Alk before heating	mg/l*	1817 @ pH = 4.16			as $CaCO_3$
4		Ak_A	m-Alk added	mg/l*	996.4			as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l*	174.8 @ pH = 4.13			as $CaCO_3$
6		t_o	Oil bath temperature	℃	112			
7		t_B	Brine temperature	℃	95			
8		Δt	Temp. difference	℃	17			$=t_o-t_B$
9		T_S	Starting time	hr	9°45'	$t=t_B$		
10		T_M	Time after X min.	hr.	19°15'	X=30 min		
11		T_F	Time after Y min.	hr	10°32'	Y=47 min		
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.01			
13		V_B	V. of filtrate	l	0.485			
14		W_S	W. of ppt. after dry'g	g	0.608			
15			Results of observation by eyes	—	Sharp	Round	S+R	Adhere
						/		—

(NOTE) · $Ak_A = (53)(0.94)(10^3)V_{NA}/0.8$ [mg/l as $CaCO_3$]
· Cocentration of Na_2CO_3 solution: 1N
· To dry at 105℃

COMMENTS	
	Singnature

wt of filter paper = 1.166 g
" " " + ppt = 1.716 g → 0.550
wt of millipore = 0.088 g
" " + ppt = 0.146 g → 0.058
wt of ppt for $CaSiO_3$ = 0.00280

RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: , , 1991

Tests No.	S 1-10	Temp.	95 ℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	1 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	0.485	change into 25 ℃
2		~~pH_F~~	~~pH of filtrate~~	~~25℃~~	~~7.976 @ 24~~	
3		Ak_F	m-Alk of filtrate	mg/l	174.8 @ pH=4.13	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	31,263	
5	Quantity of Ca^{2+} Mg^{2+} in filtrate	Ca_s	Ca ion before heat'g	mg/l	630	
6		Ca_F	Ca ion in filtrate	mg/l	356	
7		Ca_{PI}	$Ca_s - Ca_F$	mg/l	274	
8		Wlc_a	$2.5(Ca_{PI})(V_B)$	mg	342	$CaCO_3$
9		Mg_s	Mg ion before heat'g	mg/l	1967	
10		Mg_F	Mg ion of filtrate	mg/l	1673	
11		Mg_{PI}	$Mg_s - Mg_F$	mg/l	294	
12		Wl_{MH}	$2.4(Mg_{PI})(V_B)$	mg	353	$Mg(OH)_2$
13	Quantity of $CaCO_3$ & $Mg(OH)_2$ in ppt	Wl_S	W. of ppt. after dry'g	mg	608	
14		Wl_{CI}	W. of ~~Cl~~ Na Cl after dry'g	mg	64	
15		Wl_{NC}	W. of NaCl	mg	162	
16		$W2_S$	W. of actual ppt	mg	446	$Wl_S - Wl_{NC}$
17			W. of Ca	mg	S 73 | A 188	
18		$W2_{Ca}$	W. of $CaCO_3$	mg	326	
19			W. of Mg	mg	S 167 | A 116	
20		$W2_{MH}$	W. of $Mg(OH)_2$	mg	340	

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: 10, Dec 1991

Tests No.	S 1 - 11	Temp.	95 ℃	Additives Conc.	5 mg/l (μl/l)	Oil Conc.	100 mg/l (μl/l)	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results		* Note
1	Formation of p.p.t	pH_S	pH before heating	25℃*	7.653 @ 23.1		change into 25 ℃
2		pH_F	pH of filtrate	25℃*	8.028 @ 22.4		
3		Ak_S	m-Alk before heating	mg/l*	181.7 @ pH = 4.16		as $CaCO_3$
4		Ak_A	m-Alk added	mg/l*	1000		as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l*	186.3 @ pH = 4.13		as $CaCO_3$
6		t_o	Oil bath temperature	℃	110		
7		t_B	Brine temperature	℃	95		
8		Δt	Temp. difference	℃	25		$=t_o-t_B$
9		T_S	Starting time	hr	2°5'	$t=t_B$	
10		T_M	Time after X min.	hr	2°35'	X=30 min	
11		T_F	Time after Y min.	hr	2°52'	Y=17 min	
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.01		
13		V_B	V. of filtrate	l	0.485		
14		W_S	W. of ppt. after dry'g	g	0.756		

15	Results of observation by eyes	—	Sharp	Round	S+R	Adhere
				—		✓

(NOTE) • $Ak_A = (53)(0.94)(10^3)V_{NA} / 0.8$ [mg/l as $CaCO_3$]
• Cocentration of Na_2CO_3 solution: 1N
• To dry at 105℃

COMMENTS	little adhere

Singnature

wt of #5 filter paper = 1.133 g
" " " + ppt = 1.875 g → 0.742 g
" " millipore = 0.087 g
" " + ppt = 0.101 g → 0.014
wt of ppt for Card No. = 0.0039 g

RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: . . 1991

Tests No.	S1-11	Temp.	95 ℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	100 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	0.485	change into 25 ℃
2		pH_F	pH of filtrate	25℃	8.028@32.4	
3		Alk_F	m-Alk of filtrate	mg/l*	186.3 @pH:4.13	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	30,918	
5		Ca_s	Ca ion before heat'g	mg/l	630	
6	Quantity	Ca_F	Ca ion in filtrate	mg/l	328	
7	of	$Ca_{P.I}$	$Ca_s - Ca_F$	mg/l	302	
8	Ca^{2+} Mg^{2+}	Wl_{Cs}	$2.5(Ca_{P.I})(V_B)$	mg	378	$CaCO_3$
9	in	Mg_s	Mg ion before heat'g	mg/l	1967	
10	filtrate	Mg_F	Mg ion of filtrate	mg/l	1721	
11		$Mg_{P.I}$	$Mg_s - Mg_F$	mg/l	246	
12		Wl_{MS}	$2.4(Mg_{P.I})(V_B)$	mg	295	$Mg(OH)_2$
13	Quantity	Wl_S	W. of ppt. after dry'g	mg	756	
14	of	$Wl_{C.I}$	W. of V_B l after dry'g	mg	65	
15	$CaCO_3$	Wl_{NC}	W. of NaCl	mg	164	
16	&	$W2_S$	W. of actual ppt	mg	592	$Wl_S - Wl_{NC}$
17	$Mg(OH)_2$		W. of Ca	mg	S 206 | A 94	
18	in	$W2_{Cs}$	W. of $CaCO_3$	mg	375	
19	ppt		W. of Mg	mg	S 151 | A 78	
20		$W2_{MS}$	W. of $Mg(OH)_2$	mg	275	

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: 16 Dec. 1991

Tests No.	S 1 ~ 12	Temp.	℃ 95	Additives Conc.	mg/l 3 μl/l	Oil Conc.	mg/l 100 μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results			* Note
1	Formation of p.p.t	pH_S	pH before heating	25℃*	7.653 @ 23.1			change into 25 ℃
2		pH_F	pH of filtrate	25℃*	8.086 @ 22.5			
3		Ak_S	m-Alk before heating	mg/l*	181.7 @ pH=4.16			as $CaCO_3$
4		Ak_A	m-Alk added	mg/l*	1000			as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l*	216.2 @ pH=4.17			as $CaCO_3$
6		t_o	Oil bath temperature	℃	107			
7		t_B	Brine temperature	℃	95			
8		Δt	Temp. difference	℃	12			$=t_o-t_B$
9		T_S	Starting time	hr	9°55	$t=t_B$		
10		T_M	Time after X min.	hr.	10°25	X=30 min		
11		T_F	Time after Y min.	hr	10°30	Y=5 min		
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.01			
13		V_B	V. of filtrate	l	0.488			
14		W_S	W. of ppt. after dry'g	g	0.385			
15			Results of observation by eyes	—	Sharp	Round	S+R	Adhere
						✓		✓

(NOTE)
- $Ak_A=(53)(0.94)(10^3)V_{NA}/0.8$ [mg/l as $CaCO_3$]
- Cocentration of Na_2CO_3 solution: 1N
- To dry at 105℃

COMMENTS	
	Singnature

wt of #5 filter paper = 1.145 g → 0.328
" " " " + ppt = 1.473 g
" " millipore = 0.086 → 0.057
" " + ppt = 0.143 g
wt of ppt for $CaCO_3$ = 0.00290 g

RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: . . 1991

Tests No.	S_1-12	Temp.	95℃	Additives Conc.	3 mg/l μl/l	Oil Conc.	100 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	0.488	change into 25 ℃
2		pH_F	pH of filtrate	25℃	8.086@22.5	
3		Ak_F	m-Alk of filtrate	mg/l	216.2 @pH=4.17	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	30,961	
5	Quantity of Ca^{2+} Mg^{2+} in filtrate	Ca_s	Ca ion before heat'g	mg/l	630	
6		Ca_F	Ca ion in filtrate	mg/l	310	
7		Ca_{P1}	Ca_s-Ca_F	mg/l	320	
8		Wl_{Cs}	$2.5(Ca_{P1})(V_B)$	mg	400	$CaCO_3$
9		Mg_s	Mg ion before heat'g	mg/l	1967	
10		Mg_F	Mg ion of filtrate	mg/l	1794	
11		Mg_{P1}	Mg_s-Mg_F	mg/l	173	
12		Wl_{Ms}	$2.4(Mg_{P1})(V_B)$	mg	208	$Mg(OH)_2$
13	Quantity of $CaCO_3$ & $Mg(OH)_2$ in ppt	Wl_S	W. of ppt. after dry'g	mg	385	
14		Wl_{C1}	W. of ~~Cl~~ Na after dry'g	mg	38	
15		Wl_{NC}	W. of NaCl	mg	96	
16		$W2_S$	W. of actual ppt	mg	289	Wl_S-Wl_{NC}
17			W. of Ca	mg	S 65 | A 250	
18		$W2_{Cs}$	W. of $CaCO_3$	mg	394	
19			W. of Mg	mg	S 106 | A 58	
20		$W2_{Ms}$	W. of $Mg(OH)_2$	mg	197	

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: 16, Dec 1991

Tests No.	S_1-13	Temp.	95 ℃	Additives Conc.	10 mg/l μl/l	Oil Conc.	100 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results			* Note
1	Formation of p.p.t	pH_S	pH before heating	25℃*	7.653 @ 23.1			change into 25 ℃
2		pH_F	pH of filtrate	25℃*	8.008 @ 22.5			
3		Ak_S	m-Alk before heating	mg/l*	181.7 @ pH = 4.16			as $CaCO_3$
4		Ak_A	m-Alk added	mg/l*	1000			as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l*	216.2 @ pH = 4.18			as $CaCO_3$
6		t_o	Oil bath temperature	℃	110			
7		t_B	Brine temperature	℃	96			
8		Δt	Temp. difference	℃	12			$=t_o-t_B$
9		T_S	Starting time	hr	11°25'	$t=t_B$		
10		T_M	Time after X min.	hr.	11°55'	X=30 min		
11		T_F	Time after Y min.	hr	12°00'	Y=5 min		
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.01			
13		V_B	V. of filtrate	l	0.488			
14		W_S	W. of ppt. after dry'g	g	0.604			
15			Results of observation by eyes	—	Sharp	Round	S+R	Adhere
					✓			X

(NOTE) · $Ak_A = (53)(0.94)(10^3)V_{NA}/0.8$ [mg/l as $CaCO_3$]
· Cocentration of Na_2CO_3 solution: 1N
· To dry at 105℃

COMMENTS	
	Singnature

wt of #5 filter paper = 1.128 g
" " " + ppt = 1.626 g → 0.498
" " millipore = 0.087 g
" " " + ppt = 0.193 g → 0.106
wt of ppt for Ca & Mg = 0.00244

RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: , , 1991

Tests No.	S1-13	Temp.	95℃	Additives Conc.	mg/l / 10 μl/l	Oil Conc.	100 mg/l / μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	0.488	change into 25 ℃
2		pH_F	pH of filtrate	25℃*	8.008 @ 22.5	
3		Ak_F	m-Alk of filtrate	mg/l*	216.2 @ pH=4.15	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	30,961	
5	Quantity of Ca^{2+} Mg^{2+} in filtrate	Ca_s	Ca ion before heat'g	mg/l	630	
6		Ca_F	Ca ion in filtrate	mg/l	372	
7		Ca_{P1}	$Ca_s - Ca_F$	mg/l	258	
8		Wlc_a	$2.5(Ca_{P1})(V_B)$	mg	315	$CaCO_3$
9		Mg_s	Mg ion before heat'g	mg/l	1967	
10		Mg_F	Mg ion of filtrate	mg/l	1736	
11		Mg_{P1}	$Mg_s - Mg_F$	mg/l	231	
12		Wl_{Mg}	$2.4(Mg_{P1})(V_B)$	mg	277	$Mg(OH)_2$
13	Quantity of $CaCO_3$ & $Mg(OH)_2$ in ppt	Wl_S	W. of ppt. after dry'g	mg	604	
14		Wl_{Cl}	W. of Cl after dry'g	mg	41	
15		Wl_{NC}	W. of NaCl	mg	103	
16		$W2_S$	W. of actual ppt	mg	501	$Wl_S - Wl_{NC}$
17			W. of Ca	mg	S 126 | A 119	
18		$W2_{Ca}$	W. of $CaCO_3$	mg	306	
19			W. of Mg	mg	S 176 | A 26	
20		$W2_{Mg}$	W. of $Mg(OH)_2$	mg	242	

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: 17 .Nov. 1991

Tests No.	S2-1	Temp.	80 ℃	Additives Conc.	5 mg/l 5 μl/l	Oil Conc.	0 mg/l 0 μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results		* Note
1	Formation of p.p.t	pH_S	pH before heating	25℃*	7.685		change into 25 ℃
2		pH_F	pH of filtrate	25℃*	8.580 @ 22.7		
3		Ak_S	m-Alk before heating	mg/l*	154.1 @ EP pH = 4.17		as $CaCO_3$
4		Ak_A	m-Alk added	mg/l*	1027.5		as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l*	210.45 @ pH = 4.17		as $CaCO_3$
6		t_o	Oil bath temperature	℃	88		
7		t_B	Brine temperature	℃	75		
8		Δt	Temp. difference	℃	13		$=t_o-t_B$
9		T_S	Starting time	hr	1°00'	t=t_B	
10		T_M	Time after X min.	hr	1°37'	X=30min	
11		T_F	Time after Y min.	hr	2°37'	Y=60min	
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.0165		
13		V_B	V. of filtrate	l	0.815		
14		W_S	W. of ppt. after dry'g	g	0.576		

No.	Subjects	Measuring items		Sharp	Round	S+R	Adhere
15		Results of observation by eyes	—		Yes		No

(NOTE)
- $Ak_A = (53)(0.94)(10^3)V_{NA} / 0.8$ [mg/l as $CaCO_3$]
- Cocentration of Na_2CO_3 solution: 1N
- To dry at 105℃

COMMENTS	
	Singnature

RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: 17 Nov 1991

Tests No.	S 2-1	Temp.	80℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	0 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	0.815	change into 25 ℃
2		pH_F	pH of filtrate	25℃*	8.580 @ 22.7	
3		Ak_F	m-Alk of filtrate	mg/l*	210.45 @ pH=4.8	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	33,989	
5	Quantity of Ca^{2+} Mg^{2+} in filtrate	Ca_s	Ca ion before heat'g	mg/l	630	
6		Ca_F	Ca ion in filtrate	mg/l	286	
7		Ca_{P1}	$Ca_s - Ca_F$	mg/l	344	
8		Wl_{Ca}	$2.5(Ca_{P1})(V_B)$	mg *	688	$CaCO_3$
9		Mg_s	Mg ion before heat'g	mg/l	1967	
10		Mg_F	Mg ion of filtrate	mg/l	1664 1664	
11		Mg_{P1}	$Mg_s - Mg_F$	mg/l	300	
12		Wl_{Mg}	$2.4(Mg_{P1})(V_B)$	mg *	593	$Mg(OH)_2$
13	Quantity of $CaCO_3$ & $Mg(OH)_2$ in ppt	Wl_s	W. of ppt. after dry'g	mg	576	
14		Wl_{Cl}	W. of ~~Cl~~ Na after dry'g	mg	17	
15		Wl_{NC}	W. of NaCl	mg	43	
16		$W2_S$	W. of actual ppt	mg *	533	$Wl_s - Wl_{NC}$
17			W. of Ca	mg	S 141 | A 197	
18		$W2_{Ca}$	W. of $CaCO_3$	mg	676	
19			W. of Mg	mg	S 54 | A 212	
20		$W2_{Mg}$	W. of $Mg(OH)_2$	mg	510	

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: 26. Nov 1991

Tests No.	S2-b	Temp.	80 ℃	Additives Conc.	0 mg/l 0 μl/l	Oil Conc.	0 mg/l 0 μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results		* Note
1	Formation of p.p.t	pH_S	pH before heating	25℃*	7.598 @ 24.9		change into 25 ℃
2		pH_F	pH of filtrate	25℃*	8.551 @ 22.5		
3		Ak_S	m-Alk before heating	mg/l*	154.1 @ pH = 4.16		as $CaCO_3$
4		Ak_A	m-Alk added	mg/l*	996.4		as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l*	108.1		as $CaCO_3$
6		t_o	Oil bath temperature	℃	99		
7		t_B	Brine temperature	℃	81		
8		Δt	Temp. difference	℃	18		$=t_o-t_B$
9		T_S	Starting time	hr	7°35'	$t=t_B$	
10		T_M	Time after X min.	hr.	8°5'	X=30min	
11		T_F	Time after Y min.	hr	9°5'	Y=60min	
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.01		
13		V_B	V. of filtrate	l	0.490		
14		W_S	W. of ppt. after dry'g	g	0.341		
15			Results of observation by eyes	—	Sharp:	Round: ✓	S+R:	Adhere: ✓

(NOTE)
- $Ak_A = (53)(0.94)(10^3)V_{NA} / 0.8$ [mg/l as $CaCO_3$]
- Cocentration of Na_2CO_3 solution: 1N
- To dry at 105℃

COMMENTS	little adhere was noticed.

Singnature

RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: . . 1991

Tests No.	S -	Temp.	℃	Additives Conc.	mg/l μl/l	Oil Conc.	mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	9.490	change into 25 ℃
2		pH_F	pH of filtrate	25℃	8.551@ 22.5	
3		Ak_F	m-Alk of filtrate	mg/l	108.1	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	30,875	
5	Quantity of Ca^{2+} Mg^{2+} in filtrate	Ca_s	Ca ion before heat'g	mg/l	630	
6		Ca_F	Ca ion in filtrate	mg/l	242	
7		Ca_{P1}	$Ca_s - Ca_F$	mg/l	388	
8		Wl_{Cs}	$2.5(Ca_{P1})(V_B)$	mg	485	$CaCO_3$
9		Mg_s	Mg ion before heat'g	mg/l	1967	
10		Mg_F	Mg ion of filtrate	mg/l	1763	
11		Mg_{P1}	$Mg_s - Mg_F$	mg/l	204	
12		Wl_{Ms}	$2.4(Mg_{P1})(V_B)$	mg	245	$Mg(OH)_2$
13	Quantity of $CaCO_3$ & $Mg(OH)_2$ in ppt	Wl_s	W. of ppt. after dry'g	mg	341	
14		Wl_{cl}	W. of ~~Cl~~ Na after dry'g	mg	5	
15		Wl_{NC}	W. of NaCl	mg	13	
16		$W2_s$	W. of actual ppt	mg	328	$Wl_s - Wl_{NC}$
17			W. of Ca	mg	S 180 | A 181	
18		$W2_{Cs}$	W. of $CaCO_3$	mg	451	
19			W. of Mg	mg	S 14 | A 168	
20		$W2_{Ms}$	W. of $Mg(OH)_2$	mg	218	

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: 4 . Dec 1991

Tests No.	S 2-3	Temp.	80 ℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	10 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results				* Note
1	Formation of p.p.t	pH_S	pH before heating	25℃*	7.598 @ 24.9				change into 25 ℃
2		pH_F	pH of filtrate	25℃*	8.675 @ 22.5				
3		Ak_S	m-Alk before heating	mg/l*	1541 @ pH=4.16				as $CaCO_3$
4		Ak_A	m-Alk added	mg/l*	1000				as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l*	138 @ pH = 4.15				as $CaCO_3$
6		t_o	Oil bath temperature	℃	114				
7		t_B	Brine temperature	℃	80				
8		Δt	Temp. difference	℃	34				$=t_o-t_B$
9		T_S	Starting time	hr	11°55'	$t=t_B$			
10		T_M	Time after X min.	hr.	12°25'	X=30min			
11		T_F	Time after Y min.	hr	1°25'	Y=90min			
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.008				
13		V_B	V. of filtrate	l	0.390				
14		W_S	W. of ppt. after dry'g	g	0.564				
15			Results of observation by eyes	—	Sharp	Round	S+R	Adhere	
						✓		✓	

(NOTE) • $Ak_A=(53)(0.94)(10^3)V_{NA}/0.8$ [mg/l as $CaCO_3$]
• Cocentration of Na_2CO_3 solution: 1N
• To dry at 105℃

COMMENTS	

Singnature

RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: . . , 1991

Tests No.	S_{2-3}	Temp.	℃	Additives Conc.	mg/l μl/l	Oil Conc.	mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	0.390	change into 25 ℃
2		pH_F	pH of filtrate	25℃	~~8.675 @ 22.5~~	
3		Ak_F	m-Alk of filtrate	mg/l*	138 @ pH = 4.15	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	30,227	
5	Quantity of Ca^{2+} Mg^{2+} in filtrate	Ca_s	Ca ion before heat'g	mg/l	630	
6		Ca_F	Ca ion in filtrate	mg/l	258	
7		Ca_{P1}	$Ca_s - Ca_F$	mg/l	372	
8		Wlc_s	$2.5(Ca_{P1})(V_B)$	mg	372	$CaCO_3$
9		Mg_s	Mg ion before heat'g	mg/l	1967	
10		Mg_F	Mg ion of filtrate	mg/l	1726	
11		Mg_{P1}	$Mg_s - Mg_F$	mg/l	241	
12		Wl_{MS}	$2.4(Mg_{P1})(V_B)$	mg	231	$Mg(OH)_2$
13	Quantity of $CaCO_3$ & $Mg(OH)_2$ in ppt	Wl_S	W. of ppt. after dry'g	mg	564	
14		Wl_{Cl}	W. of ~~Cl~~ Na after dry'g	mg	8.5	
15		Wl_{NC}	W. of NaCl	mg	22	
16		$W2_S$	W. of actual ppt	mg	542	$Wl_S - Wl_{NC}$
17			W. of Ca	mg	S 395 A 14	
18		$W2c_s$	W. of $CaCO_3$	mg	409	
19			W. of Mg	mg	S 35 A 209	
20		$W2_{MS}$	W. of $Mg(OH)_2$	mg	234	

wt of filter paper + ppt = 1.1332

wt of filter paper = 0.0882

ppt = .9450

wt of ppt from $CaCO_3$ = ...

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: , , 1991

Tests No.	S_2-4	Temp.	80 ℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	100 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results			* Note
1		pH_S	pH before heating	25℃*	7.598@24.9			change into 25 ℃
2		pH_F	pH of filtrate	25℃*	8.230@22.5			
3		Ak_S	m-Alk before heating	mg/l*	154.1 @ pH = 4.16			as $CaCO_3$
4		Ak_A	m-Alk added	mg/l*	1000			as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l*	211.6@pH=4.16			as $CaCO_3$
6	Formation	t_o	Oil bath temperature	℃	95			
7	of	t_B	Brine temperature	℃	86			
8	p.p.t	Δt	Temp. difference	℃	15			$=t_o-t_B$
9		T_S	Starting time	hr	9°45'	$t=t_B$		
10		T_M	Time after X min.	hr.	10°15'	X=30min		
11		T_F	Time after Y min.	hr	11°15'	Y=60min		
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.01			
13		V_B	V. of filtrate	l	0.497			
14		W_S	W. of ppt. after dry'g	g	0.679			
15			Results of observation by eyes	—	Sharp	Round	S+R	Adhere
					✓			✓

(NOTE) ・$Ak_A=(53)(0.94)(10^3)V_{NA}/0.8$ [mg/l as $CaCO_3$]
・Cocentration of Na_2CO_3 solution: 1N
・To dry at 105℃

COMMENTS	ppt particles are very fine, forming a fine precipitate through filter paper. very little adhere

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RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: . . 1991

Tests No.	S-24	Temp.	℃	Additives Conc.	mg/l μl/l	Oil Conc.	mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	0.497	change into 25 ℃
2		pH_F	pH of filtrate	25℃*	8.230 @ 22.5	
3		Ak_F	m-Alk of filtrate	mg/l*	211.6 @ pH 4.16	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	30,054	
5	Quantity of Ca^{2+} Mg^{2+} in filtrate	Ca_s	Ca ion before heat'g	mg/l	630	
6		Ca_F	Ca ion in filtrate	mg/l	278	
7		Ca_{P1}	$Ca_s - Ca_F$	mg/l	352	
8		Wlc_a	$2.5(Ca_{P1})(V_B)$	mg*	440	$CaCO_3$
9		Mg_s	Mg ion before heat'g	mg/l	1967	
10		Mg_F	Mg ion of filtrate	mg/l	1604	
11		Mg_{P1}	$Mg_s - Mg_F$	mg/l	363	
12		Wlm_g	$2.4(Mg_{P1})(V_B)$	mg*	436	$Mg(OH)_2$
13	Quantity of $CaCO_3$ & $Mg(OH)_2$ in ppt	Wl_s	W. of ppt. after dry'g	mg	679	
14		Wl_{cl}	W. of Cl after dry'g	mg	66	
15		Wl_{NC}	W. of NaCl	mg	168	
16		$W2_s$	W. of actual ppt	mg*	511	$Wl_s - Wl_{NC}$
17			W. of Ca	mg	S 185 | A 160	
18		$W2_{Ca}$	W. of $CaCO_3$	mg	431	
19			W. of Mg	mg	S 108 | A ≈ 39	
20		$W2_{Mg}$	W. of $Mg(OH)_2$	mg	416	

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: 4 Nov 1991

Tests No.	S 25	Temp.	80 ℃	Additives Conc.	3 mg/l μl/l	Oil Conc.	0 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results		* Note
1	Formation of p.p.t	pH_S	pH before heating	25℃*	7.598@24.9		change into 25 ℃
2		pH_F	pH of filtrate	25℃*	8.626@22.7		
3		Ak_S	m-Alk before heating	mg/l*	154.1@pH=4.16		as $CaCO_3$
4		Ak_A	m-Alk added	mg/l*	210.2		as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l*	98.9@pH=4.08		as $CaCO_3$
6		t_o	Oil bath temperature	℃	T15		
7		t_B	Brine temperature	℃	83		
8		Δt	Temp. difference	℃	32		$=t_o-t_B$
9		T_S	Starting time	hr	9°5'	$t=t_B$	
10		T_M	Time after X min.	hr.	9°35'	X=30min	
11		T_F	Time after Y min.	hr	10°35'	Y=60min	
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.008		
13		V_B	V. of filtrate	l	0.390		
14		W_S	W. of ppt. after dry'g	g	0.569		

No.	Subjects	Measuring items	Sharp	Round	S+R	Adhere
15		Results of observation by eyes		✓		✓

(NOTE) ・$Ak_A=(53)(0.94)(10^3)V_{NA}/0.8$ [mg/l as $CaCO_3$]
・Cocentration of Na_2CO_3 solution: 1N
・To dry at 105℃

COMMENTS	little addition.

Singnature

RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: . . 1991

Tests No.	S_{2-5}	Temp.	℃	Additives Conc.	mg/l μl/l	Oil Conc.	mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	0.390	change into 25 ℃
2		pH_F	pH of filtrate	25℃	8.626 @ 22.7	
3		Ak_F	m-Alk of filtrate	mg/l	98.9 @ pH=4.05	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	29,925	
5	Quantity of Ca^{2+} Mg^{2+} in filtrate	Ca_s	Ca ion before heat'g	mg/l	630	
6		Ca_F	Ca ion in filtrate	mg/l	244	
7		Ca_{P1}	$Ca_s - Ca_F$	mg/l	386	
8		Wl_{Cs}	$2.5(Ca_{P1})(V_B)$	mg	386	$CaCO_3$
9		Mg_s	Mg ion before heat'g	mg/l	1967	
10		Mg_F	Mg ion of filtrate	mg/l	1629	
11		Mg_{P1}	$Mg_s - Mg_F$	mg/l	338	
12		Wl_{Ms}	$2.4(Mg_{P1})(V_B)$	mg	324	$Mg(OH)_2$
13	Quantity of $CaCO_3$ & $Mg(OH)_2$ in ppt	Wl_S	W. of ppt. after dry'g	mg	569	
14		Wl_{C1}	W. of ~~Cl~~ Na after dry'g	mg	9	
15		Wl_{NC}	W. of NaCl	mg	23	
16		$W2_S$	W. of actual ppt	mg	546	$Wl_S - Wl_{NC}$
17			W. of Ca	mg	S 404 | A 5	
18		$W2_{Cs}$	W. of $CaCO_3$	mg	409	
19			W. of Mg	mg	S 36 | A 278.	
20		$W2_{Ms}$	W. of $Mg(OH)_2$	mg	301	

wt. of filter paper #5 = 1.138 g

" " " " + ppt = 1.696 g

wt of Millipore = 0.088 g

" " + ppt = 0.099 g

wt of ppt for Ca : Mg = 1 : 0.836

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: 9 Dec. 1991

Tests No.	S-6	Temp.	80 ℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	0 mg/l μl/l	# Note

No.	Subjects	Sym.	Measuring items	Unit	Results				# Note
1	Formation of p.p.t	pH_S	pH before heating	25℃*	7.653 @23.1				change into 25 ℃
2		pH_F	pH of filtrate	25℃*	7.880 @22.7				
3		Ak_S	m-Alk before heating	mg/l*	181.7 @ pH=4.16				as $CaCO_3$
4		Ak_A	m-Alk added	mg/l*	996.4				as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l*	246.1 @pH=4.16				as $CaCO_3$
6		t_o	Oil bath temperature	℃	107				
7		t_B	Brine temperature	℃	80				
8		Δt	Temp. difference	℃	27				$=t_o-t_B$
9		T_S	Starting time	hr	1°15'	t=t_B			
10		T_M	Time after X min.	hr.	1°45'	X=30 min			
11		T_F	Time after Y min.	hr	1°50'	Y=5 min			
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.01				
13		V_B	V. of filtrate	l	0.490				
14		W_S	W. of ppt. after dry'g	g	0.459				
15			Results of observation by eyes	—	Sharp	Round	S+R	Adhere	
					✓			—	

(NOTE) • $Ak_A=(53)(0.94)(10^3)V_{NA}/0.8$ [mg/l as $CaCO_3$]
: Cocentration of Na_2CO_3 solution: 1N
• To dry at 105℃

COMMENTS	
	Singnature

wt of #5 filter paper = 1.154 g
" " + ppt = 1.591 g → 0.437
" " = 0.087 g
" " + ppt = 0.109 g → 0.022
wt of ppt = 0.00152 g

RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: . . 1991

Tests No.	S 2 6	Temp.	80 ℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	0 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	0.490	change into 25 ℃
2		pH_F	pH of filtrate	25℃	7.880@22.7	
3		Ak_F	m-Alk of filtrate	mg/l	246.1 @pH=4.16	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	30,443	
5	Quantity of Ca^{2+} Mg^{2+} in filtrate	Ca_s	Ca ion before heat'g	mg/l	630	
6		Ca_F	Ca ion in filtrate	mg/l	344	
7		Ca_{P1}	$Ca_s - Ca_F$	mg/l	286	
8		Wl_{Ca}	$2.5(Ca_{P1})(V_B)$	mg	358	$CaCO_3$
9		Mg_s	Mg ion before heat'g	mg/l	1967	
10		Mg_F	Mg ion of filtrate	mg/l	1708	
11		Mg_{P1}	$Mg_s - Mg_F$	mg/l	259	
12		Wl_{Ms}	$2.4(Mg_{P1})(V_B)$	mg	311	$Mg(OH)_2$
13	Quantity of $CaCO_3$ & $Mg(OH)_2$ in ppt	Wl_s	W. of ppt. after dry'g	mg	459	
14		Wl_{Cl}	W. of Na after dry'g	mg	38	
15		Wl_{NC}	W. of NaCl	mg	96	
16		$W2_s$	W. of actual ppt	mg	363	$Wl_s - Wl_{NC}$
17			W. of Ca	mg	S 66 A 216	
18		$W2_{Ca}$	W. of $CaCO_3$	mg	352	
19			W. of Mg	mg	S 149 A 108	
20		$W2_{Ms}$	W. of $Mg(OH)_2$	mg	308	

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: 10, Dec. 1991

Tests No.	S_2-7	Temp.	80℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	1 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results			* Note
1	Formation of p.p.t	pH_S	pH before heating	25℃*	7.653 @ 23.1			change into 25 ℃
2		pH_F	pH of filtrate	25℃*	7.984 @ 22.7			
3		Ak_S	m-Alk before heating	mg/l*	181.7 @ pH = 4.14			as $CaCO_3$
4		Ak_A	m-Alk added	mg/l*	1000			as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l*	262.2 @ pH = 4.16			as $CaCO_3$
6		t_o	Oil bath temperature	℃	104			
7		t_B	Brine temperature	℃	81			
8		Δt	Temp. difference	℃	23			$=t_o-t_B$
9		T_S	Starting time	hr	10°55'	$t=t_B$		
10		T_M	Time after X min.	hr	11°25'	X=?min		
11		T_F	Time after Y min.	hr	11°30'	Y=5min		
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.01			
13		V_B	V. of filtrate	l	0.490			
14		W_S	W. of ppt. after dry'g	g	0.654			
15			Results of observation by eyes	—	Sharp	Round	S+R	Adhere
						✓		—

(NOTE) • $Ak_A = (53)(0.94)(10^3)V_{NA} / 0.8$ [mg/l as $CaCO_3$]
• Cocentration of Na_2CO_3 solution: 1N
• To dry at 105℃

COMMENTS	
	Singnature

wt of #5 filter paper = 1.133 g
" " " + ppt = 1.670 g → 0.537
" - millipore = 0.0583 g
" " + ppt = 0.2353 g → 0.147
wt of ppt for Ca & Mg = 0.00182

RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: . . 1991

Tests No.	S_2-7	Temp.	80℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	1 mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1	—	V_B	V. of filtrate	l	0.490	change into 25 ℃
2	—	pH_F	pH of filtrate	25℃	7.489 @22.7	25 ℃
3	—	Ak_F	m-Alk of filtrate	mg/l*	262.2 @pH=4.16	as $CaCO_3$
4	—	Cl_F	Cl ion in filtrate	mg/l	30,572	
5	Quantity of Ca^{2+} Mg^{2+} in filtrate	Ca_s	Ca ion before heat'g	mg/l	630	
6		Ca_F	Ca ion in filtrate	mg/l	358	
7		Ca_{P1}	Ca_s-Ca_F	mg/l	272	
8		$W1_{Cs}$	$2.5(Ca_{P1})(V_B)$	mg	340	$CaCO_3$
9		Mg_s	Mg ion before heat'g	mg/l	1967	
10		Mg_F	Mg ion of filtrate	mg/l	1660	
11		Mg_{P1}	Mg_s-Mg_F	mg/l	307	
12		$W1_{Ms}$	$2.4(Mg_{P1})(V_B)$	mg	368	$Mg(OH)_2$
13	Quantity of $CaCO_3$ & $Mg(OH)_2$ in ppt	$W1_s$	W. of ppt. after dry'g	mg	684	
14		$W1_{cl}$	W. of ~~21~~ after dry'g	mg	170	
15		$W1_{NC}$	W. of NaCl	mg	434	
16		$W2_s$	W. of actual ppt	mg	250	$W1_s$-$W1_{NC}$
17			W. of Ca	mg	S 88 | A 174	
18		$W2_{Cs}$	W. of $CaCO_3$	mg	328	
19			W. of Mg	mg	S 217 | A 60	
20		$W2_{Ms}$	W. of $Mg(OH)_2$	mg	332	

RECORDING SHEET FOR TEST(1) OF M-1 EXPERIMENT Date: 11 Dec. 1991

Tests No.	S_2-8	Temp.	80℃	Additives Conc.	5 mg/l μl/l	Oil Conc.	100 mg/l μl/l	

No.	Subjects	Sym.	Measuring items	Unit	Results			* Note
1	Formation of p.p.t	pH_S	pH before heating	25℃*	7.653 @23.1			change into 25 ℃
2		pH_F	pH of filtrate	25℃*	8.039 @22.9			
3		Ak_S	m-Alk before heating	mg/l*	181.7 @pH=4.16			as $CaCO_3$
4		Ak_A	m-Alk added	mg/l*	446.2 @ pH=4.18			as $CaCO_3$
5		Ak_F	m-Alk of filtrate	mg/l*	446.2			as $CaCO_3$
6		t_o	Oil bath temperature	℃	104			
7		t_B	Brine temperature	℃	81			
8		Δt	Temp. difference	℃	23			$=t_o-t_B$
9		T_S	Starting time	hr	8°15'	$t=t_B$		
10		T_M	Time after X min.	hr	8°45'	X=30 min		
11		T_F	Time after Y min.	hr	8°50'	Y=35 min		
12		V_{NA}	V. of Na_2CO_3 sol. added	l	0.01			
13		V_B	V. of filtrate	l	0.490			
14		W_S	W. of ppt. after dry'g	g	0.367			
15			Results of observation by eyes	—	Sharp	Round	S+R	Adhere
						✓		✓

(NOTE) • $Ak_A=(53)(0.94)(10^3)V_{NA}/0.8$ [mg/l as $CaCO_3$]
• Cocentration of Na_2CO_3 solution: 1N
• To dry at 105℃

COMMENTS	
	Singnature

wt of filter paper #5 = 1.180 g
" " " + ppt = 1.411 g
wt of millipore = 0.055 g
" " + ppt = 0.164 g
wt of ppt for $CaCO_3$ = 0.00291 g

RECORDING SHEET FOR TEST(2) OF M-1 EXPERIMENT Date: . . 1991

Tests No.	S -	Temp.	℃	Additives Conc.	mg/l μl/l	Oil Conc.	mg/l μl/l	* Note

No.	Subjects	Sym.	Measuring items	Unit	Results	* Note
1		V_B	V. of filtrate	l	0.490	change into 25 ℃
2		pH_F	pH of filtrate	25℃	8.039 @ 22.9	
3		Ak_F	m-Alk of filtrate	mg/l	446.2 (@ pH = 4.18	as $CaCO_3$
4		Cl_F	Cl ion in filtrate	mg/l	30,875	
5	Quantity of Ca^{2+} Mg^{2+} in filtrate	Ca_s	Ca ion before heat'g	mg/l	630	
6		Ca_F	Ca ion in filtrate	mg/l	299	
7		Ca_{P1}	$Ca_s - Ca_F$	mg/l	331	
8		Wl_{Cs}	$2.5(Ca_{P1})(V_B)$	mg	414	$CaCO_3$
9		Mg_s	Mg ion before heat'g	mg/l	1967	
10		Mg_F	Mg ion of filtrate	mg/l	1623	
11		Mg_{P1}	$Mg_s - Mg_F$	mg/l	344	
12		Wl_{Ms}	$2.4(Mg_{P1})(V_B)$	mg	413	$Mg(OH)_2$
13	Quantity of $CaCO_3$ & $Mg(OH)_2$ in ppt	Wl_s	W. of ppt. after dry'g	mg	367	
14		Wl_{Cl}	W. of ~~Cl~~ Na after dry'g	mg	78	
15		Wl_{NC}	W. of NaCl	mg	199	
16		$W2_s$	W. of actual ppt	mg	168	$Wl_s - Wl_{NC}$
17			W. of Ca	mg	S 59 | A 252	
18		$W2_{Cs}$	W. of $CaCO_3$	mg	388	
19			W. of Mg	mg	S 116 | A 209	
20		$W2_{Ms}$	W. of $Mg(OH)_2$	mg	390	

2. M4 添付資料（多段フラッシュ法プラントの熱放出部における海水淡水化中の分散油の分析実験）

4.2 Influence on Quality of Product Water

In as much as there is a complete difference in behavior of oil components in the sea water desalination process between the case where oil and water are simply mixed each other (two-liquid phase) and the case where oil is dissolved in water (single liquid phase), it is necessary to consider the behavior separately.

4.2.1 Behavior of Volatile Components During Sea Water Desalination Process (Two-Liquid Phase)

According to the report [18] concerning the behavior of oil components during the sea water desalination process, the vapor pressure of a water and oil mix vapor shows a similar value to that of the independent water and oil vapors.

When these two liquid phases are evaporated, the weight ratio of water to oil in the gaseous phase may be expressed by the following Equation:

$$W_O/W_W = (M_O \cdot P_O)/(M_W \cdot P_W) \qquad (4.2.1)$$

Where, W_O and W_W are the weight of the oil and water in the gaseous phase, and P_O and P_W are the vapor pressure, and M_O and M_W are their molecular weights. From this Equation, if the molecular weight and the vapor pressure are known, the composition of distillates at various temperatures can be calculated.

When oil contaminated raw sea water is drawn into the desalination plant which employs the evaporation process, the oil component is evaporated in the evaporation chamber by a kind of steam distillation pursuant to Equation (4.2.1), along with almost all of the light component, high vapor pressure distilled from the brine.

4.2.2. Study of Numerical Simulation (Two-Liquid Phase)

4.2.2.1 Simulation Model

Nakazawa, et al.[19] have designed a computer simulation program using a mathematical model in order to study the behavior of hydrocarbons in the evaporator under operating conditions where raw sea water is contaminated with oil.

In this study, some improvements were made to the actual conditions of the subject plant. Simulated calculations of the evaporation rate of oil at each stage of the evaporator process, using various oil concentrations, were conducted. The flow of the simulated calculation is shown in Fig. 4.2.1.

First, the following constants and given conditions were inputted in order to conduct the calculation: The hydrocarbon composition as a component of crude oil; each factor contained in Antoine's formula (Fig. 4.2.2) to obtain the vapor pressure of hydrocarbon and water; the normal probability to calculate the retention time of brine in the evaporation chamber; and, equipment data (number of stages, temperature at each stage, quantity of make-up sea water, and quantity of product water at each stage).

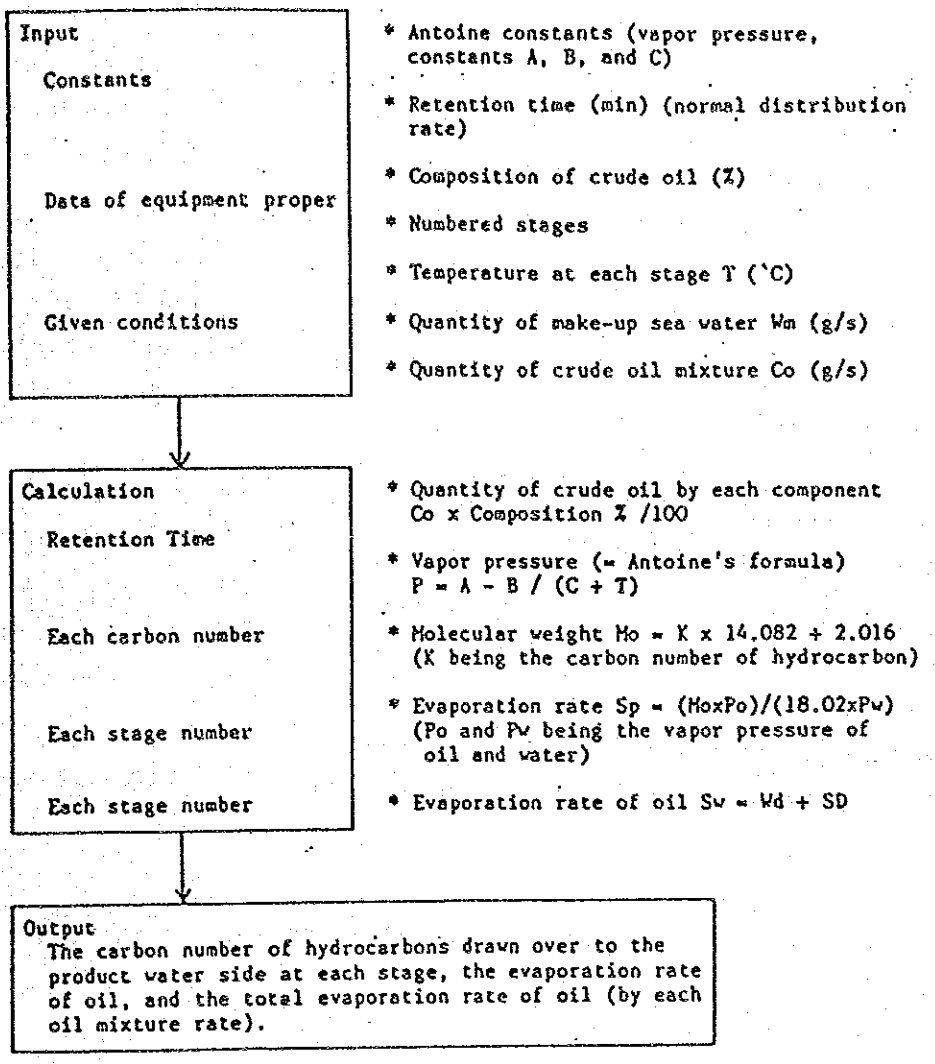

Fig. 4.2.1: Flow of Simulated Calculation for Behavior of Oil Components in MSF Evaporator

The retention time of the oil was calculated by assuming that the evaporation rates of hydrocarbons are proportional to the retention time of the brine in each evaporation chamber. As part of this calculation, the retention time of the brine at each evaporation chamber was assumed to be relative to the normal distribution of each portion of the brine in an average retention time. Then the crude oil mixture rate was inputted.

When the two kinds of parameters mentioned above were inputted, the retention time of oil in each evaporation chamber, the evaporation rate of each component of the crude oil at each stage, and the transfer rate of oil to the next stage were calculated then in accordance with the program.

Hydrocarbons with a carbon number up to 10 were regarded as gasoline components, carbon numbers 11 to 14 as kerosene components, carbon numbers 15 to 20 as gas oil components and carbon numbers 21 and above as heavy oil components.

For the purposes of simplification, only straight-chain compounds with up to carbon number 5 were evaporated, having been previously introduced into the plant and compounds with carbon numbers from 6 to 30 were considered to be present at the rate indicated in Fig. 4.2.3. Further, it was considered that in the evaporation chamber, distillation starts with the component with the lowest boiling point and continues successively through to the component with the highest boiling point. This curved line fits the oil components of both Kuwait and Kafuji.

Input conditions for simulation on Al Jubail Phase I and II plants (AJ-I and AJ-II) are shown in Table 4.2.1.

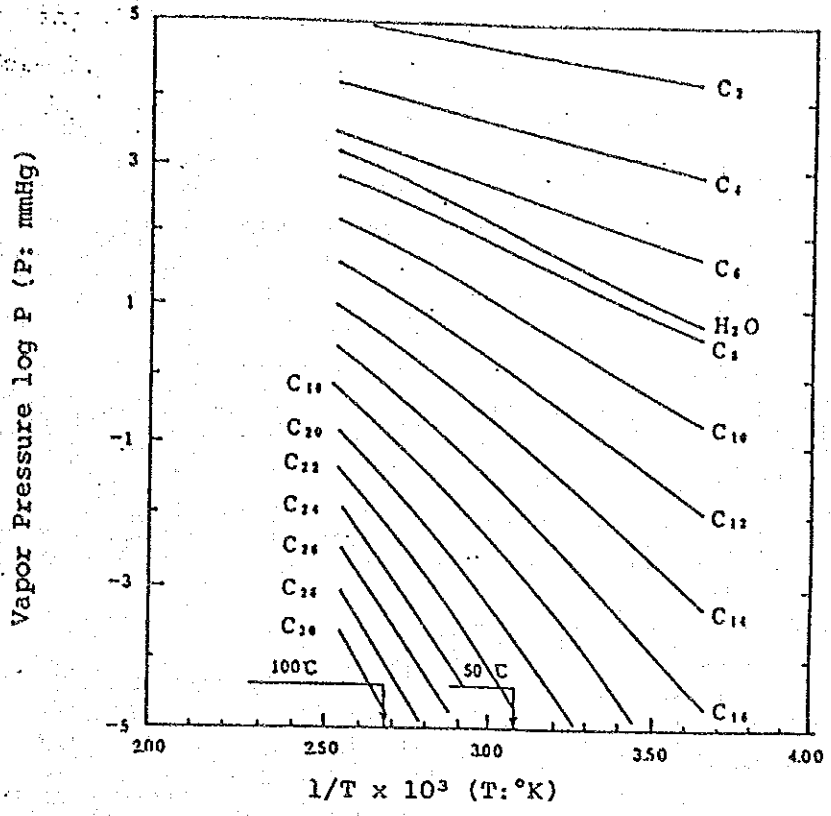

Fig. 4.2.2: Arrhenius Plot of Water and Hydrocarbon Vapor Pressure

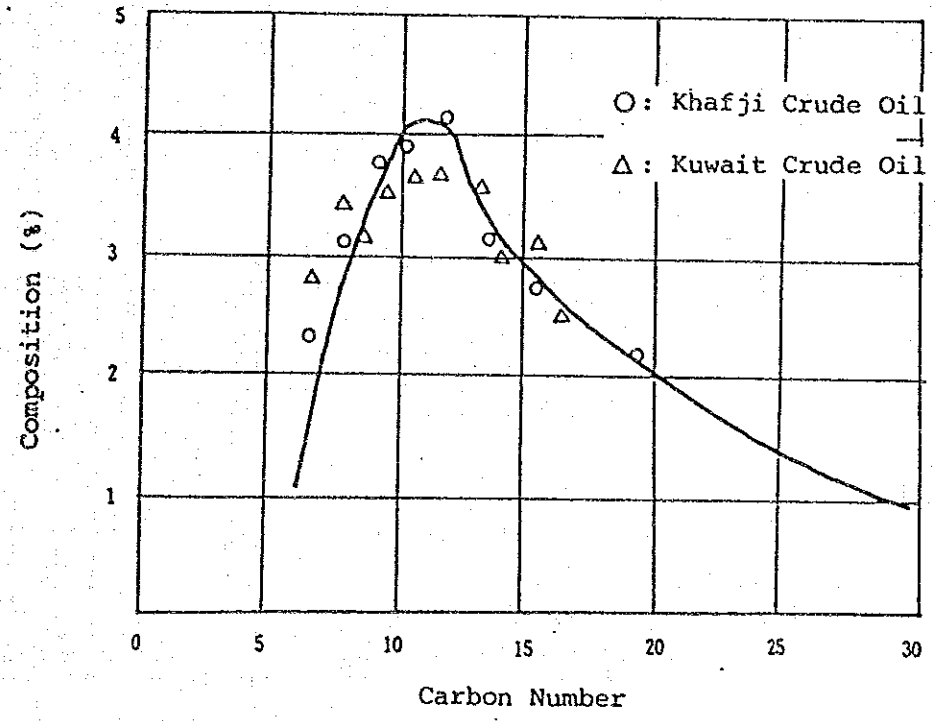

Fig. 4.2.3: Composition Model of Crude Oil used in Simulation

Table 4.2.1: Heat/Mass Balance of MSF Plants in Al Jubail

PLANT NAME		AJ-I	AJ-II.			NOTE
CONSTRACTOR		SK/MHI	SK-MHI	IHI	HZ	
1. OPERATING CONDITION						
1.1 Capacity	kg/h	948,800.0	979,000.0			
	t/d	22,771.2	23,500.0			
	kg/s	263.5	272.0			
1.2 Performance Ratio		8 lb/1000BTU	0.00344 KG/KJ			
1.3 Concentration Ratio		1.44	1.395			
1.4 Sea Water Temp.	℃	35.0	35.0			
1.5 Blow Down Temp.	℃	41.0	43.3			
1.6 Brine Max. Temp.	℃	90.56	90.6			
1.7 TDS in Sea Water	ppm	45,000.0	46,500.0			
1.8 TDS in Rec. brain	ppm	64,800.0	65,000.0			
2. INPUT CONDITION						
2.1 Feed Sea Water	kg/h	2,631,000.0	2,908,000.0			
	kg/s (l/s)	730.8(711.6)	807(785.8 at D=1.027kg/l in 40 ‰ 30 ℃)			
2.2 Product Water	kg/h	948,800.0	979,000.0			
	kg/s	263.5	272.0			

2.3 Oil Concent.	mg/l	0.1	1.0	10	50	100	0.10	1.0	10.0	50	100
2.4 Oil Content	g/s	0.07	0.71	7.12	36.5	71.2	0.08	0.79	7.85	39.25	78.58

3. Temp., Evaporation Rate in Deaeration Part & Each Stage	Eva. Part	Temp. (℃)	Eva. Rate (t/h)	Temp. (℃)	Eva. Rate (t/h)	Temp. (℃)	Eva. Rate (t/h)	Temp. (℃)	Eva. Rate (t/h)	NOTE
	Dea. P	41.0	1.28 a)	43.3	4.0 b)	43.3	4.0 b)	43.74	3.0 b)	
	1st'g	90.56	50.0	90.6	52.0	90.6	59.84	90.60	48.36	
	2	88.1	49.5	88.3	51.4	87.9	59.84	85.08	48.96	
	3	85.7	48.8	85.9	50.8	85.3	59.84	82.74	48.78	
	4	83.3	48.4	83.6	50.1	82.7	59.84	80.49	48.66	
	5	80.9	47.7	81.3	49.4	80.2	54.40	78.26	48.30	
	6	78.5	47.1	79.0	48.8	77.6	57.12	76.01	47.88	
	7	76.1	46.6	76.7	48.1	75.1	54.40	73.77	47.58	
	8	73.8	45.9	74.5	47.4	72.6	51.68	71.53	47.16	
	9	71.4	45.3	72.2	46.7	70.1	54.40	69.29	46.74	
	10	69.1	44.7	70.0	46.0	67.6	48.96	67.06	46.32	
	11	66.8	44.1	67.8	45.2	65.2	51.68	64.83	45.90	
	12	64.5	43.4	65.6	44.6	62.8	48.96	62.60	44.46	
	13	62.2	43.1	63.4	43.9	60.4	46.24	60.38	45.00	
	14	59.9	42.4	61.3	43.6	58.0	43.52	58.17	44.52	
	15	57.6	41.5	59.1	42.7	55.6	43.52	56.00	44.10	
	16	55.4	40.8	57.0	41.8	53.3	46.24	53.76	43.56	
	17	53.2	40.0	54.9	40.8	51.0	43.52	51.57	43.08	
	18	51.0	39.1	52.9	39.8	48.7	46.24	49.39	39.66	
	19	48.8	38.3	50.9	38.8	46.3	48.96	47.22	36.60	
	20	46.7	34.6	48.9	31.0	43.3(OL)	----	45.19	27.42	
	21	44.8	34.9	47.3	35.8	----	----	43.74	39.60	
	22	42.9	32.6	45.5	40.3	----	----	41.59	46.80	OL: Outlet
	TOTAL	41.0(OL)	950.1	43.3(OL)	983.0	----	983.20	38.7(OL)	982.44	

NOTE · a) :Final Stage Deaeration, b):Vaccum Deaeration
· SK :Sasakura Engineering Co.,Ltd
· MHI :Mitsubishi Heavy Industries,Ltd
· IHI :Isikawajima-Harima Heavy Industries Co.,Ltd
· HZ :Hitachi Zohsen Co.,Ltd

4.2.2.2 Results of Simulated Calculation (Two-Liquid Phase)

The behavior, of crude oil when mixed with sea water at the rates of 100, 10, 1, 0.1 mg/l and the amount of product water transported to by each plant are shown in Figs. 4.2.4(1) to (10) and Tables 4.2.2(1) to (10) with the results for the AJ-I and AJ-II plants constructed by Sasakura Engineering Co., Ltd. and Mitsubishi Heavy Industries, Ltd., Ishikawajima-Harima Heavy Industries Co., Ltd. and Hitachi Zosen Corporation.

According to the results of the simulated calculation, it is clear that the low boiling point components of crude oil evaporate very easily and so move readily to the product water. If a deaerator is installed like in the AJ-II Plant, most of the oil components will evaporate in the deaerator when the raw sea water is contaminated by only a small amount of crude oil (an oil concentration of about 0.1 mg/l). (refer to Fig. 4.2.4(6))

Even if the sea water is contaminated by oil with a concentration of 100 mg/l, the gasoline components will evaporate in the deaerator and both the kerosene and gas oil components will mostly evaporate between the first and the fourth high temperature stages. Since the vapor pressure of oil components with comparatively higher carbon numbers (C_{20} or higher) rapidly declines as the temperature drops, only a small amount moves to the fresh water side at the medium temperature stage. (refer to Fig. 4.2.4(10))

While AJ-I employs the final stage deaeration system condensation of steam, with evaporation of the deaeration part takes place in the same part of the final condensation stage and therefore separation is impossible. Inevitably, the product water contains high concentrations of oil (Figs. 4.2.4(1) to (5)).

With regard to the relation between the vapor pressure and the temperature of each kind of hydrocarbon, the vapor pressure of hydrocarbons with C_6 or less is higher than that of water, as shown in Fig. 4.2.2, but the vapor pressure of hydrocarbons with C_8 or more is lower than that of water. Therefore, hydrocarbons with C_6 or less are not condensed but are vented from the evaporation chamber as vent gas, and hydrocarbons with C_8 or more are condensed along with water vapor.