

Denne rapport  
tilhører



# L&U DOK. SENTER

L. NR. 30285320021

KODE Well 31/2-3 nr 45

Returneres etter bruk

UND - ARKIVET	
Nr.:	
PRODUCTION TEST	
NORWAY - WELL 31/2-3	
SAMPLING AND ANALYSIS	
OF GAS AND CONDENSATE	



SHELL INTERNATIONALE PETROLEUM MAATSCHAPPIJ B.V. - THE HAGUE

EXPLORATION AND PRODUCTION

UND - ARKIVET

Nr.:

PRODUCTION TEST

NORWAY - WELL 31/2-3

SAMPLING AND ANALYSIS

OF GAS AND CONDENSATE

PRODUCTION TEST  
NORWAY - WELL 31/2-3  
SAMPLING AND ANALYSIS  
OF GAS AND CONDENSATE

SUMMARY

The Thornton well-head testing equipment has been used to determine the well-head fluid composition and equilibrium data by split phase sampling, of well 31/2-3. Both the micaceous and clean sand zones were evaluated during the production test period on the Borgny Dolphin.

→ SAMPLING AND ANALYSIS OF GAS AND CONDENSATE  
NORWAY- WELL 31/2-3

1. INTRODUCTION

In June/July 1980 Thornton carried out a series of gas tests using the Thornton well-head testing equipment on Well 31/2-3, during the production testing period. The object of the Thornton tests was to obtain detailed gas/liquid equilibrium data for use in designing production streams.

2. EXPERIMENTAL AND RESULTS

The Thornton well-head testing equipment consists of two main pieces of equipment comprising a large heavy-duty sampling manifold (ref. Figure 1) containing a mixing device to ensure that a fully representative sample of well-head fluid is obtained for testing. The latter sample is fed by means of a probe into the second piece of equipment, which is a miniature laboratory containing a series of separators controlled at selected conditions of temperature and pressure (ref. Figure 2).

The Thornton manifold is placed next to the well-head Christmas tree, upstream of the Flopetrol choke manifold and test separator.

After preliminary evaluation of the gas, two stage separations were selected for treating the gas at specific times during the production test. The conditions chosen were:

	<u>psig</u>	<u>°F</u>
1st stage	1000	32 → 42*
2nd stage	500	Minus 3 → 12*

Gases and condensates obtained from these tests were recombined to reproduce a well-head fluid composition. In addition condensate/gas ratios (CGRs) were determined for both separations at test conditions and also vented to atmosphere.

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\* Constant temperature between these limits.

The series of gas tests carried out using the Thornton equipment on Well 31/2-3 during production testing are reported as follows:

Micaceous gas zone

<u>Test no.</u> <u>ND:</u>	<u>Approximate flow</u> <u>MMSCF/D</u>	<u>Results of phase compositions</u> <u>Table no.</u>
1	5	1
2	5	2
3	10	3
4	18	4

Clean sand zone

5	10	5
6	20	6
7	30	7

The results of these tests are reported in Tables 1-7.

The experimentally measured liquid/gas ratios at test conditions and also vented to atmosphere are reported in Table 8. Schematic separation diagrams together with condensate/gas ratios (CGR) are shown in Figures 3-9. The schematic diagram is in effect, two diagrams in one. The upper figures in each box show the molar split of the reservoir fluid throughout the separation sequence, whilst the lower figures show the related quantities of liquids and gas involved in each separation resulting in an end volume of 1MMSCF. The two sets of figures are not equivalent.

A comparison of well-head fluid compositions from all tests is given in Table 9.

Table 1

Test ND1

Compositions (mol%) - Experimentally determined

Component	Feed composition	Separation 1 1000 psig/40°F		Separation 2 500 psig/5°F	
		Liquid	Gas	Liquid	Gas
C1	92.510	26.953	92.899	20.518	93.035
2	3.946	5.296	3.938	6.479	3.933
3	0.332	2.117	0.321	2.120	0.318
i4	0.369	3.192	0.352	6.200	0.341
n4	0.049	0.711	0.045	1.162	0.043
15	0.055	2.320	0.042	2.467	0.037
n5	0.015	0.534	0.012	1.000	0.010
6	0.170	12.356	0.098	19.839	0.061
7	0.199	21.650	0.072	28.787	0.018
8	0.056	7.591	0.012	6.175	-
9	0.036	5.337	0.005	2.488	
10	0.029	4.558	0.002	0.946	
11	0.012	1.949	-	0.116	
12	0.005	0.905			
13	0.004	0.600			
14	0.002	0.290			
15	-	0.135			
16		0.050			
17		0.029			
18		0.025			
19		0.009			
Benzene	-	0.022	-	0.044	-
Toluene	0.002	0.228	-	0.157	-
Xylene	0.018	2.640	0.002	1.111	-
N <sub>2</sub>	1.613	0.079	1.622	0.089	1.625
CO <sub>2</sub>	0.578	0.424	0.578	0.302	0.579
Mole ratio		0.0059	0.9941	0.0019	0.9981
CGR bbl/MMSCF		5.01 (4.15)*		1.50 (1.37)*	

\* Vented to 1 atmos.

Table 2

Test ND2

Compositions (mol%) - Experimentally determined

Component	Feed composition	Separation 1 1000 psig/40°F		Separation 2 500 psig/5°F	
		Liquid	Gas	Liquid	Gas
C1	93.179	26.113	93.499	20.656	93.656
2	3.558	5.388	3.549	5.839	3.544
3	0.421	1.961	0.414	2.727	0.409
14	0.356	3.667	0.340	5.964	0.328
n4	0.046	0.711	0.043	1.108	0.041
i5	0.078	2.470	0.066	3.867	0.058
n5	0.015	0.578	0.012	1.000	0.010
6	0.168	12.115	0.110	18.270	0.071
7	0.182	21.853	0.077	28.881	0.015
8	0.051	7.702	0.014	6.493	-
9	0.032	5.484	0.006	2.597	-
10	0.025	4.724	0.002	0.947	-
11	0.010	1.949	-	0.094	-
12	0.005	0.961	-	-	-
13	-	0.494	-	-	-
14	-	0.275	-	-	-
15	-	0.108	-	-	-
16	-	-	-	-	-
17	-	-	-	-	-
18	-	-	-	-	-
19	-	-	-	-	-
Benzene	-	0.015	-	0.021	-
Toluene	0.001	0.158	-	0.089	-
Xylene	0.016	2.916	0.002	1.157	-
N <sub>2</sub>	1.455	0.050	1.462	0.080	1.465
CO <sub>2</sub>	0.402	0.358	0.403	0.210	0.403
Mole ratio		0.0048	0.9952	0.0021	0.9979
CGR bbl/MMSCF		4.13 (3.40)*		1.72 (1.54)*	

\* Vented to 1 atmos.

Table 3

Test ND3

Compositions (mol%) - Experimentally determined

Component	Feed composition	Separation 1 800 psig/38°F		Separation 2 250 psig/-3°F	
		Liquid	Gas	Liquid	Gas
C1	92.852	23.145	93.370	11.761	93.492
2	3.627	4.915	3.617	4.249	3.616
3	0.436	1.899	0.425	2.358	0.422
i4	0.376	3.730	0.351	5.914	0.343
n4	0.050	0.731	0.045	1.162	0.043
15	0.092	2.563	0.074	4.786	0.067
n5	0.020	0.598	0.015	1.625	0.013
6	0.195	12.624	0.103	22.702	0.069
7	0.236	22.912	0.067	33.140	0.017
8	0.069	7.908	0.011	6.973	-
9	0.047	5.866	0.004	2.716	-
10	0.038	5.004	0.001	0.964	-
11	0.018	2.417	-	0.099	-
12	0.009	1.194	-	-	-
13	0.004	0.610	-	-	-
14	0.002	0.275	-	-	-
15	0.001	0.147	-	-	-
16	-	-	-	-	-
17	-	-	-	-	-
18	-	-	-	-	-
19	-	-	-	-	-
Benzene	-	0.016	-	0.025	-
Toluene	0.001	0.143	-	0.092	-
Xylene	0.023	2.902	0.002	1.223	-
N <sub>2</sub>	1.381	0.068	1.391	0.038	1.393
CO <sub>2</sub>	0.523	0.333	0.524	0.173	0.525
Mole ratio		0.0074	0.9926	0.0015	0.9985
CGR bbl/MMSCF		6.57 (5.63)*		1.31 (1.24)*	

\* Vented to 1 atmos.



Table 4

Test ND4

Compositions (mol%) - Experimentally determined

Component	Feed composition	Separation 1 1000 psig/32°F		Separation 2 500 psig/6°F	
		Liquid	Gas	Liquid	Gas
C1	92.470	25.166	93.094	20.558	93.212
2	3.562	5.703	3.542	5.829	3.538
3	0.428	2.079	0.413	2.727	0.409
14	0.375	3.868	0.342	6.054	0.333
n4	0.051	0.734	0.044	1.135	0.042
15	0.112	3.022	0.085	5.133	0.077
n5	0.020	0.541	0.015	1.300	0.013
6	0.219	11.408	0.114	13.610	0.093
7	0.248	19.618	0.067	26.829	0.025
8	0.079	7.088	0.014	8.221	0.001
9	0.057	5.487	0.006	4.004	-
10	0.052	5.356	0.003	1.889	-
11	0.026	2.710	0.001	0.345	-
12	0.015	1.636	-	0.035	-
13	0.012	1.310	-	-	-
14	0.006	0.677	-	-	-
15	0.003	0.347	-	-	-
16	0.001	0.053	-	-	-
17	-	0.066	-	-	-
18	-	-	-	-	-
19	-	-	-	-	-
Benzene	-	-	-	0.021	-
Toluene	-	0.112	-	0.143	-
Xylene	0.026	2.552	0.003	1.799	-
N <sub>2</sub>	1.715	0.064	1.731	0.095	1.733
CO <sub>2</sub>	0.523	0.403	0.525	0.273	0.525
Mole ratio		0.0093	0.9907	0.0015	0.9985
CGR bbl/MMSCF		8.16 (6.86)*		1.26 (1.13)*	

\* Vented to atmos.

Table 5

Test ND5

Compositions (mol%) - Experimentally determined

Component	Feed composition	Separation 1 1000 psig/30°F		Separation 2 500 psig/12°F	
		Liquid	Gas	Liquid	Gas
C1	92.827	27.388	93.327	20.607	93.431
2	3.576	6.049	3.557	5.855	3.554
3	0.428	2.227	0.414	2.740	0.441
i4	0.372	4.191	0.343	6.091	0.335
n4	0.052	0.793	0.045	1.162	0.043
i5	0.120	2.589	0.102	6.200	0.093
n5	0.022	0.587	0.018	1.600	0.016
6	0.251	11.385	0.166	38.099	0.112
7	0.188	19.155	0.043	9.239	0.030
8	0.057	6.812	0.006	4.102	-
9	0.042	5.163	0.003	1.753	-
10	0.038	4.896	0.001	0.374	-
11	0.018	2.409	-	0.037	-
12	0.011	1.489	-	-	-
13	0.007	0.916	-	-	-
14	0.006	0.732	-	-	-
15	0.001	0.134	-	-	-
16	-	0.049	-	-	-
17	-	-	-	-	-
18	-	-	-	-	-
19	-	-	-	-	-
Benzene	-	-	-	0.025	-
Toluene	0.001	0.105	-	0.094	-
Xylene	0.021	2.425	0.002	1.669	-
N <sub>2</sub>	1.436	0.077	1.446	0.079	1.448
CO <sub>2</sub>	0.526	0.429	0.527	0.274	0.527
Mole ratio		0.0076	0.9924	0.0014	0.9986
CGR bbl/MMSCF		6.38 (5.24)*		1.09 (1.00)*	

\* Vented to 1 atmos.

Table 6

Test ND6

Compositions (mol%) - Experimentally determined

Component	Feed composition	Separation 1 1000 psig/37°F		Separation 2 500 psig/7°F	
		Liquid	Gas	Liquid	Gas
C1	92.851	25.013	93.378	20.912	93.518
2	3.528	5.356	3.513	5.800	3.509
3	0.420	1.936	0.409	3.829	0.402
i4	0.363	3.620	0.338	5.945	0.327
n4	0.047	0.693	0.042	1.081	0.040
i5	0.112	2.304	0.095	5.600	0.084
n5	0.024	0.527	0.020	1.700	0.017
6	0.199	11.280	0.113	16.026	0.082
7	0.227	20.060	0.072	26.270	0.022
8	0.070	7.473	0.013	6.643	-
9	0.051	5.829	0.006	2.959	-
10	0.046	5.663	0.002	1.245	-
11	0.022	2.808	-	0.197	-
12	0.013	1.651	-	0.017	-
13	0.009	1.218	-	-	-
14	0.005	0.655	-	-	-
15	0.003	0.399	-	-	-
16	0.001	0.126	-	-	-
17	-	0.042	-	-	-
18	-	0.032	-	-	-
19	-	-	-	-	-
20	-	-	-	-	-
Benzene	-	0.007	-	0.020	-
Toluene	0.001	0.120	-	0.103	-
Xylene	0.024	2.728	0.003	1.341	-
N <sub>2</sub>	1.560	0.061	1.571	0.088	1.574
CO <sub>2</sub>	0.424	0.399	0.425	0.224	0.425
Mole ratio		0.0077	0.9923	0.0019	0.9981
CGR bbl/MMSCF		6.89 (5.84)*		1.54 (1.39)*	

\* Vented to 1 atmos.

Table 7

Test ND7

Compositions (mol%) - Experimentally determined

Component	Feed composition	Separation 1 1000 psig/42°F		Separation 2 500 psig/12°F	
		Liquid	Gas	Liquid	Gas
C1	92.630	25.016	93.216	20.587	93.339
2	3.641	5.612	3.624	5.965	3.621
3	0.438	2.052	0.424	2.800	0.420
i4	0.383	3.842	0.353	6.236	0.343
n4	0.051	0.733	0.045	1.162	0.043
15	0.097	2.408	0.077	4.600	0.069
n5	0.020	0.551	0.015	1.300	0.013
6	0.199	11.121	0.105	15.018	0.080
7	0.234	19.558	0.067	27.030	0.022
8	0.075	7.264	0.013	7.589	-
9	0.055	5.673	0.006	3.587	-
10	0.051	5.566	0.003	1.664	-
11	0.025	2.802	0.001	0.300	-
12	0.015	1.719	-	0.028	-
13	0.011	1.235	-	-	-
14	0.007	0.784	-	-	-
15	0.004	0.492	-	-	-
16	0.001	0.147	-	-	-
17	0.001	0.062	-	-	-
18	0.001	0.056	-	-	-
19	-	0.030	-	-	-
20	-	0.009	-	-	-
Benzene	-	-	-	0.021	-
Toluene	0.001	0.114	-	0.114	-
Xylene	0.026	2.673	0.003	1.636	-
N <sub>2</sub>	1.497	0.074	1.510	0.083	1.512
CO <sub>2</sub>	0.537	0.407	0.538	0.280	0.538
Mole ratio CGR bbl/MMSCF		0.0086 7.71 (6.48)*	0.9914	0.0016 1.34 (1.20)*	0.9984

\* Vented to 1 atmos.

Table 8

Liquid/gas ratios for well-head tests

Test no.	Well flow-rate (approx.), MMSCF/D	Date & Time	Separation conditions, psig/°F	Measured liquid/gas ratio			
				At test conditions		At 1 atmosphere*	
				kg/MM Nm <sup>3</sup>	bbl/MMSCF	kg/MM Nm <sup>3</sup>	bbl/MMSCF
1	5	16.6.80 12-00	1. 1000/40	5.01	20063	17404	4.15
			2. 500/5	1.50	6051	5531	1.37
2	5	18.6.80 13-50	1. 1000/40	4.13	16497	14218	3.40
			2. 500/5	1.72	6906	6309	1.54
3	10	20.6.80 11-40	1. 800/38	6.57	26528	23409	5.63
			2. 250/-3	1.31	5380	5036	1.24
4	18	23.6.80 02-08	1. 1000/32	8.16	34947	30425	6.86
			2. 500/6	1.26	5120	4672	1.13
5	10	7.7.80 22-40	1. 1000/30	6.38	25736	21861	5.24
			2. 500/12	1.09	4314	3913	1.00
6	20	8.7.80 00-20	1. 1000/37	6.89	27915	24527	5.84
			2. 500/7	1.54	6156	5665	1.39
7	20	8.7.80 03-40	1. 1000/42	7.71	31093	27163	6.48
			2. 500/12	1.34	5386	4904	1.20

\* Refer to Figures 3 - 9 for flash temperature

Table 9

Comparison of well-head fluid compositions (mol%)

Test ND	1	2	3	4	5	6	7
C1	92.510	93.179	92.852	92.470	92.827	92.851	92.630
2	3.946	3.558	3.627	3.562	3.576	3.528	3.641
3	0.332	0.421	0.436	0.428	0.428	0.420	0.438
i4	0.369	0.356	0.376	0.375	0.372	0.363	0.383
n4	0.049	0.046	0.050	0.051	0.052	0.047	0.051
15	0.055	0.078	0.092	0.112	0.120	0.112	0.097
n5	0.015	0.015	0.020	0.020	0.022	0.024	0.020
6	0.170	0.168	0.195	0.219	0.251	0.199	0.199
7	0.199	0.182	0.236	0.248	0.188	0.227	0.234
8	0.056	0.051	0.069	0.079	0.057	0.070	0.075
9	0.036	0.032	0.047	0.057	0.042	0.051	0.055
10	0.029	0.025	0.038	0.052	0.038	0.046	0.051
11	0.012	0.010	0.018	0.026	0.018	0.022	0.025
12	0.005	0.005	0.009	0.015	0.011	0.013	0.015
13	0.004	-	0.004	0.012	0.007	0.009	0.011
14	0.002		0.002	0.006	0.006	0.005	0.007
15	-		0.001	0.003	0.001	0.003	0.004
16			-	0.001	-	0.001	0.001
17				-		-	0.001
18							0.001
19							-
Benzene	-	-	-	-	-	-	-
Toluene	0.002	0.001	0.001	-	0.001	0.001	0.001
Xylene	0.018	0.016	0.023	0.026	0.021	0.024	0.026
N <sub>2</sub>	1.613	1.455	1.381	1.715	1.436	1.560	1.497
CO <sub>2</sub>	0.578	0.402	0.523	0.523	0.526	0.424	0.537

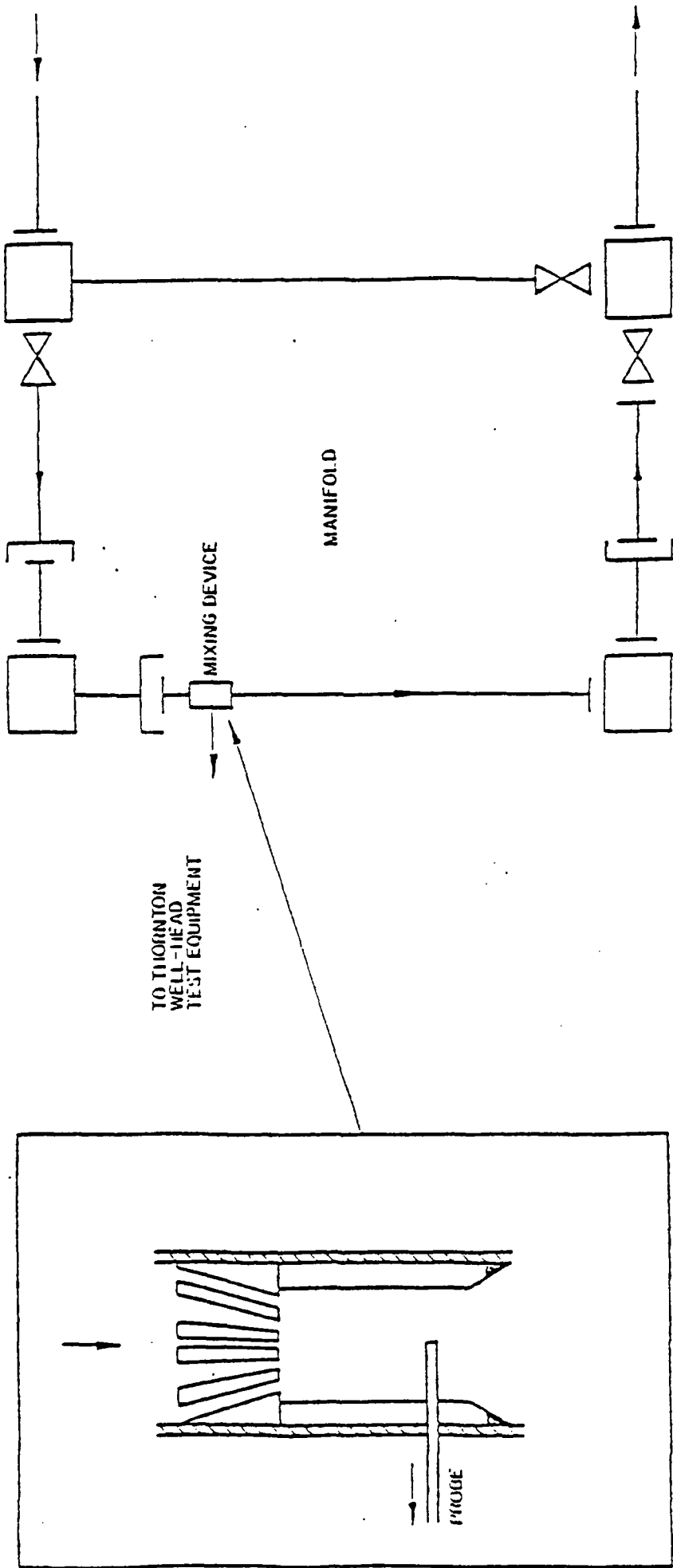


FIG. 1 - Thornton sample manifold and mixing device

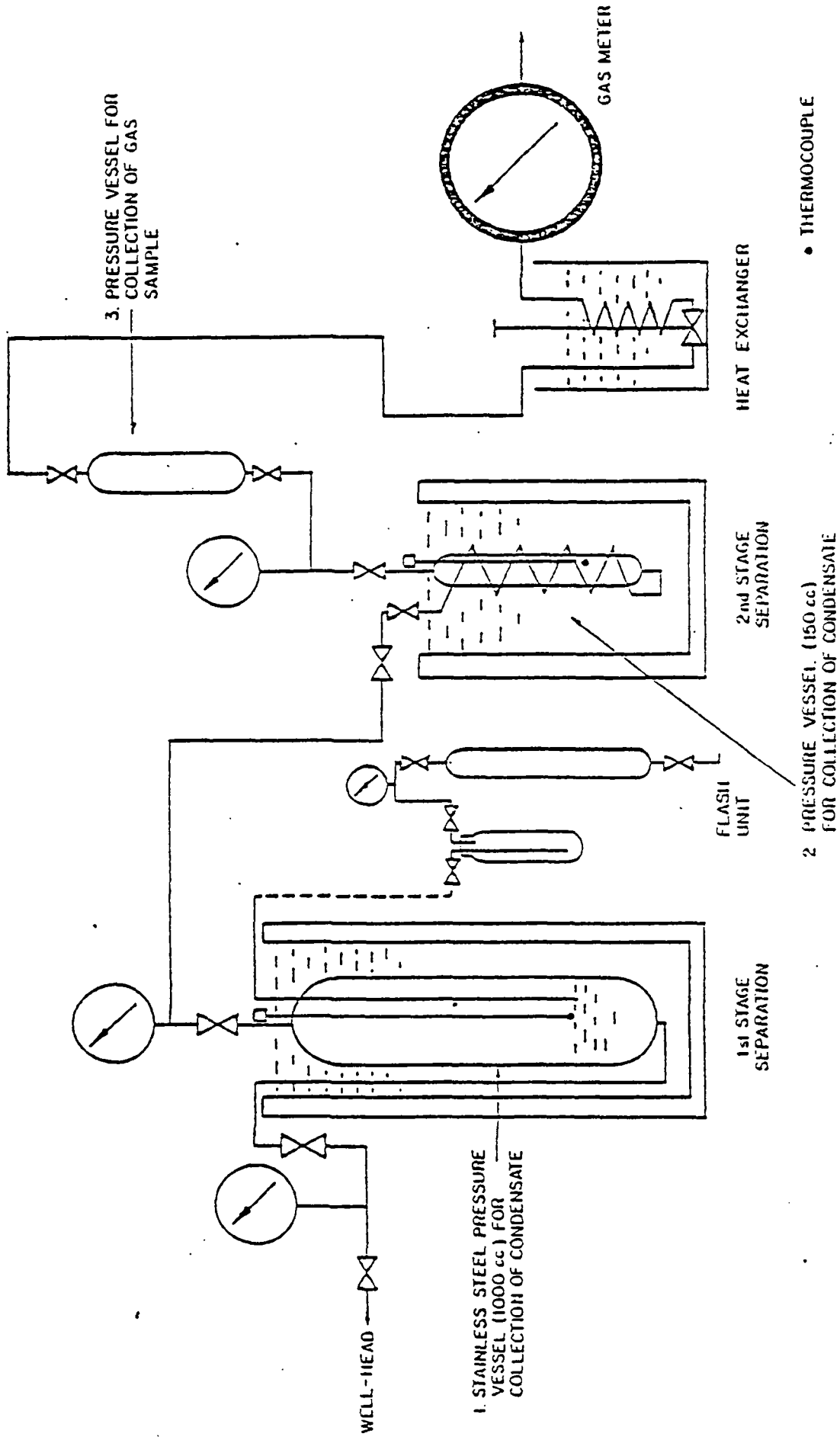


FIG. 2 — Well-head test equipment



FIG. 2

TEST HDI

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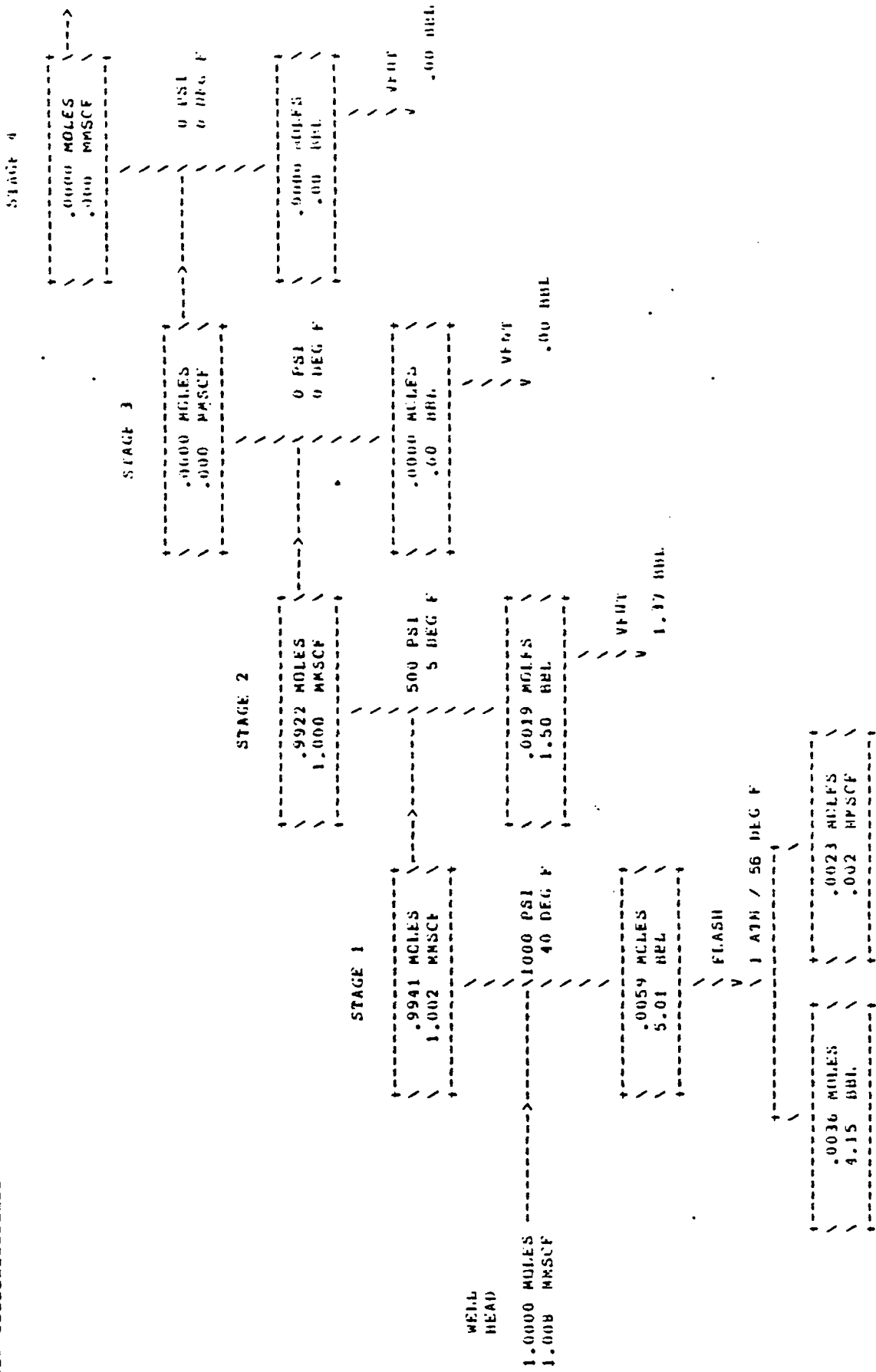
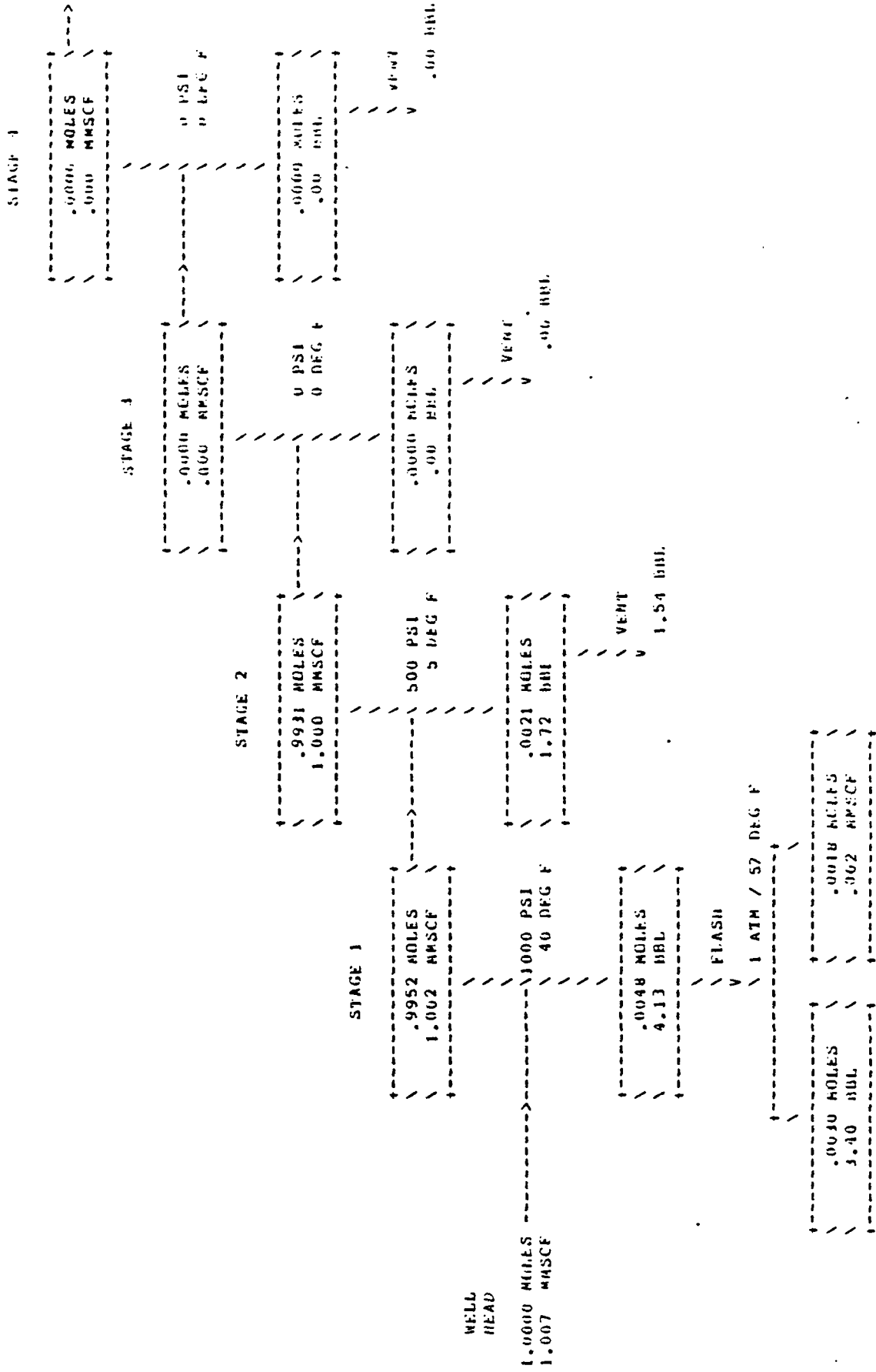


FIG. 4

TEST RD2

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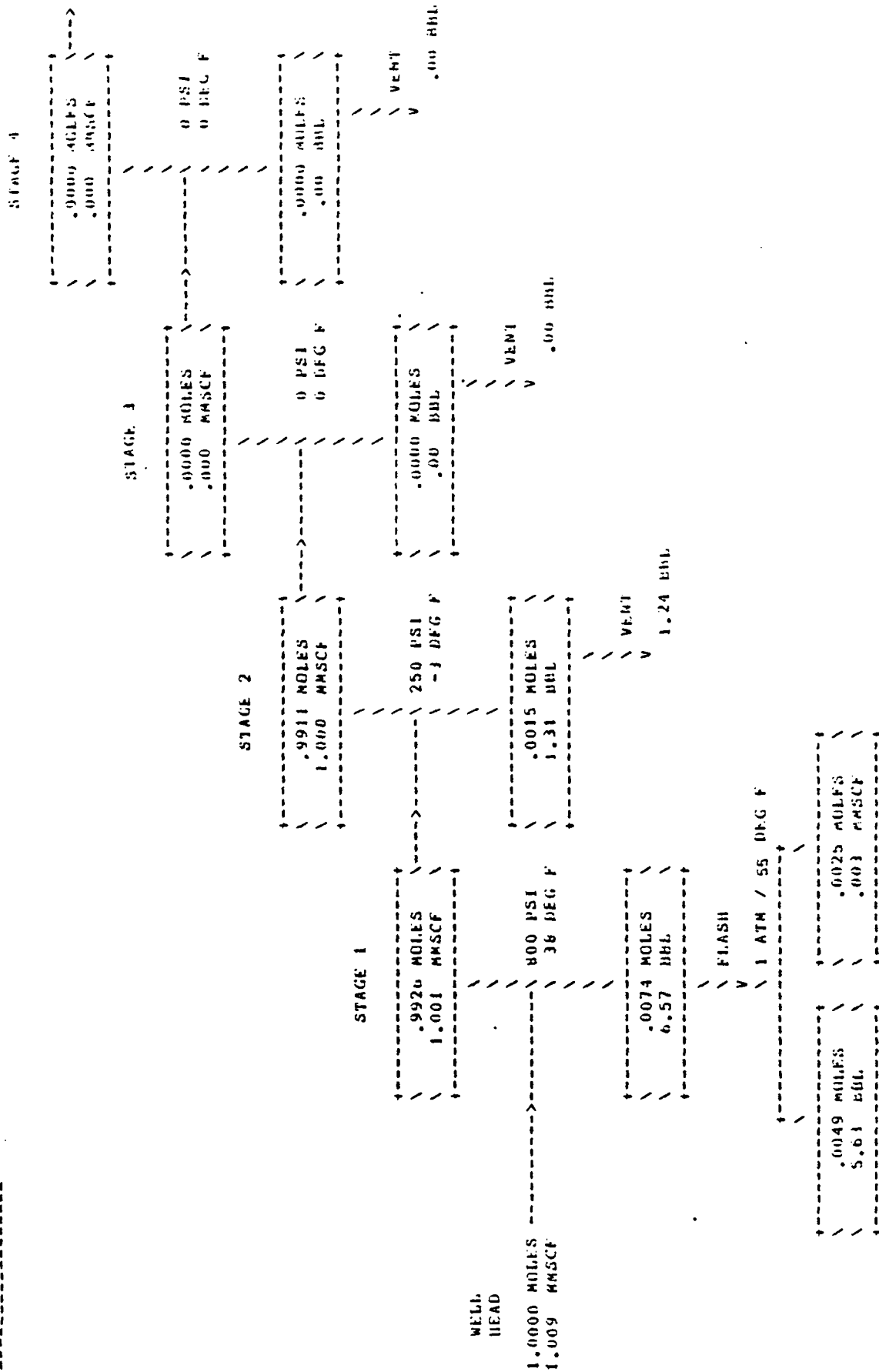


G.L.M. = 295483. SCF/cft.

FIG. 5

TEST ND3

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G.G.R. = 178458 SCF/BBL

FIG. 6

TEST NO4

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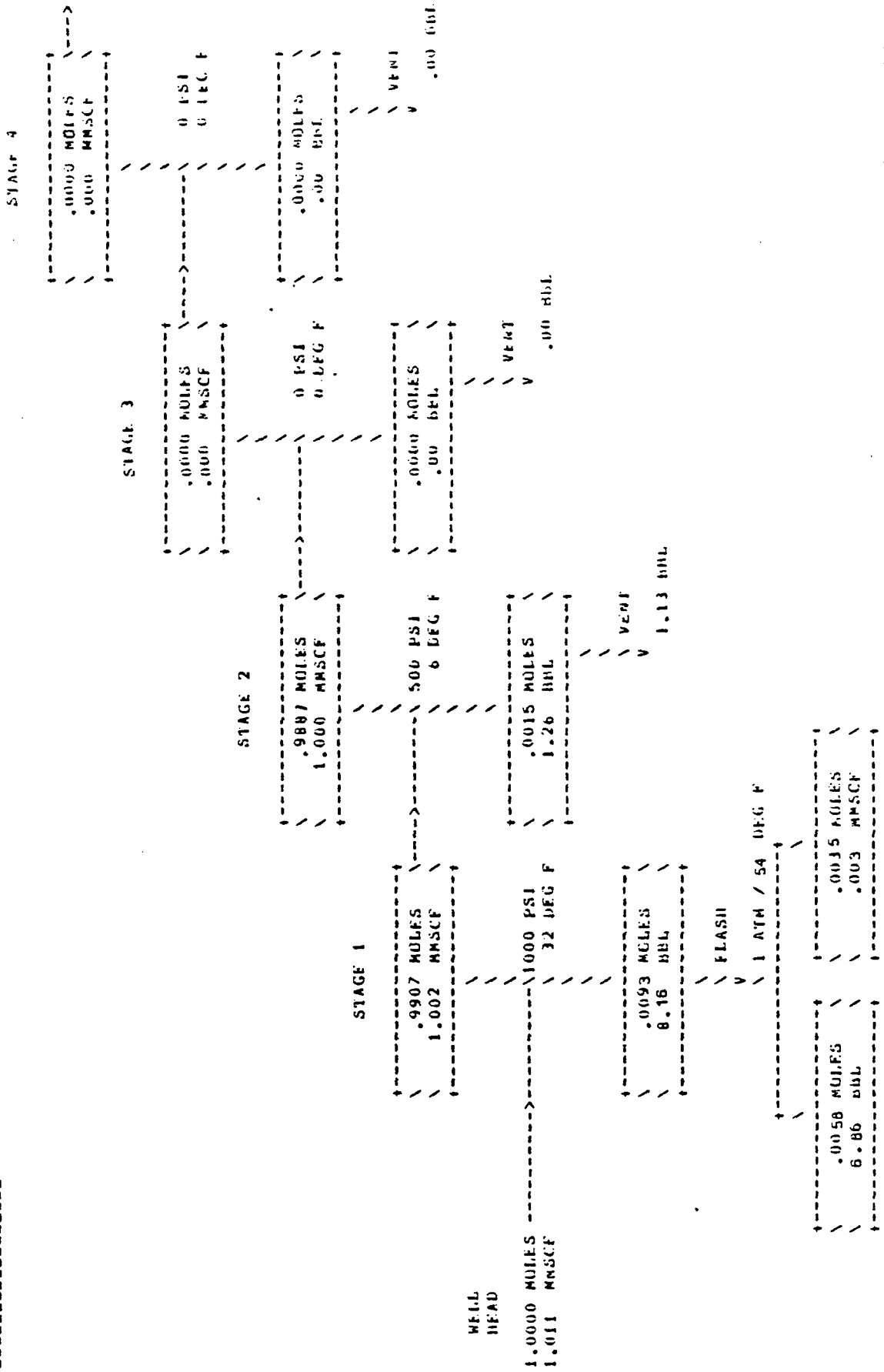


FIG. 7

TEST ADS

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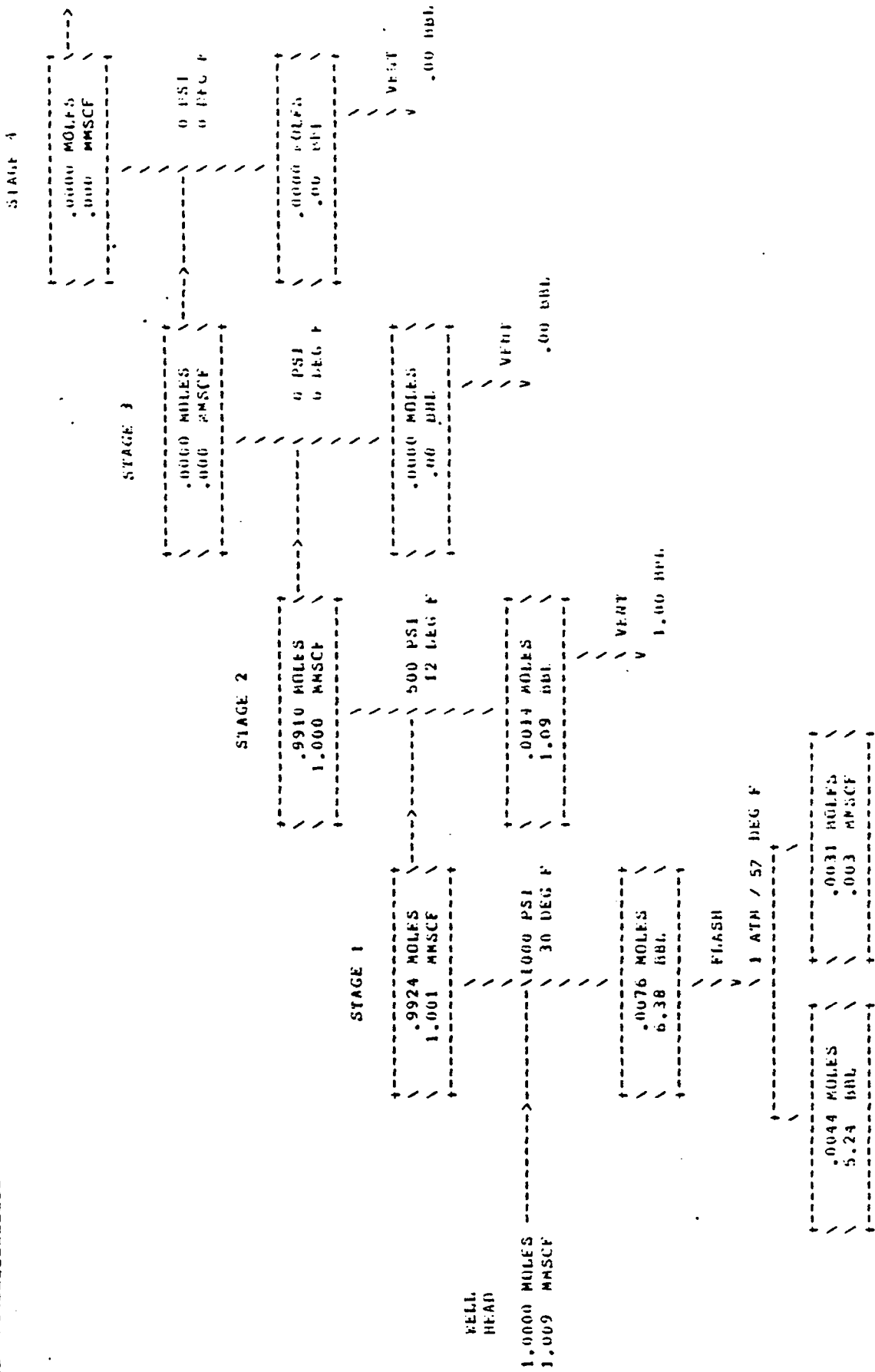


FIG. 8

TEST MDD

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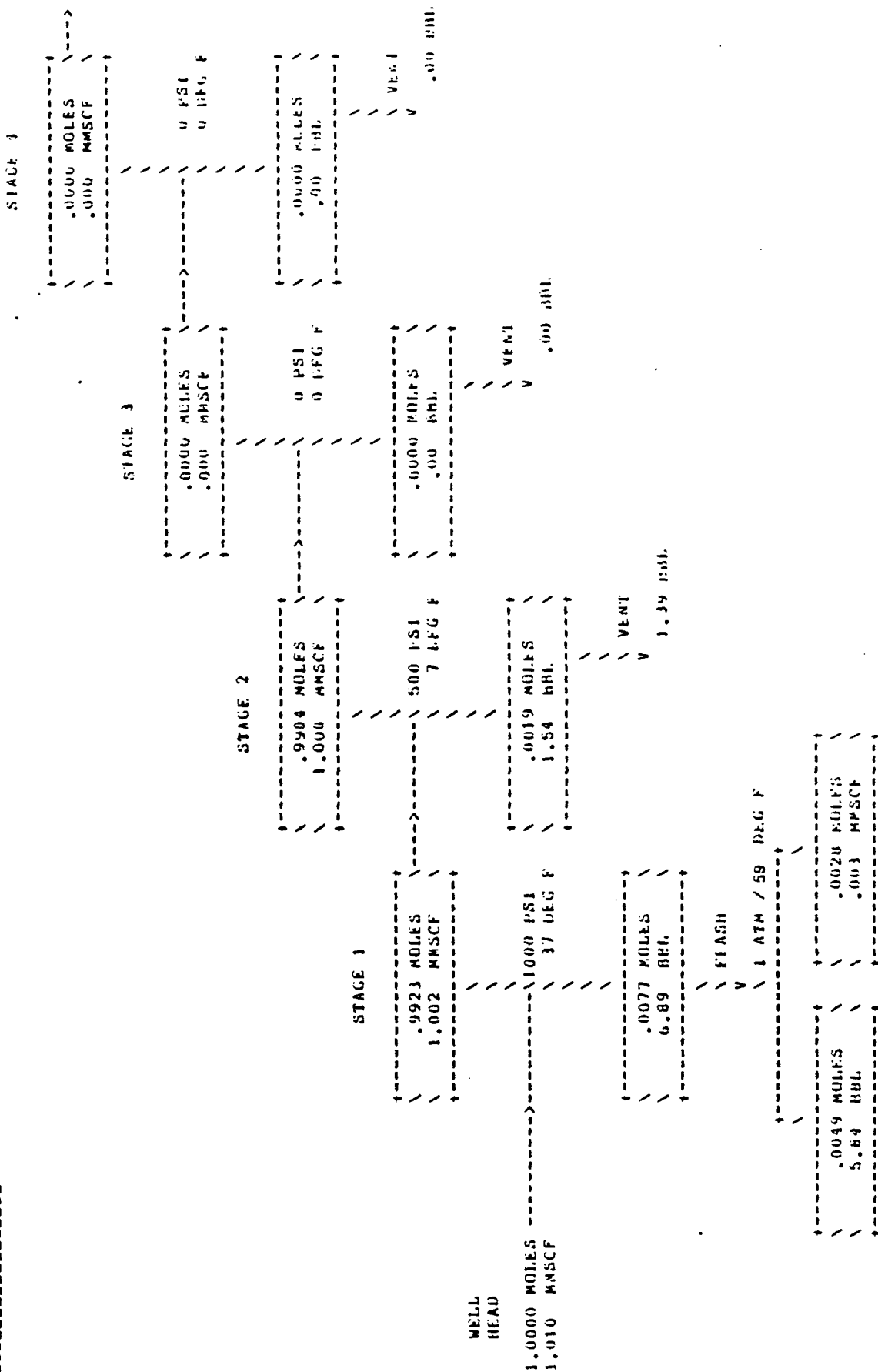
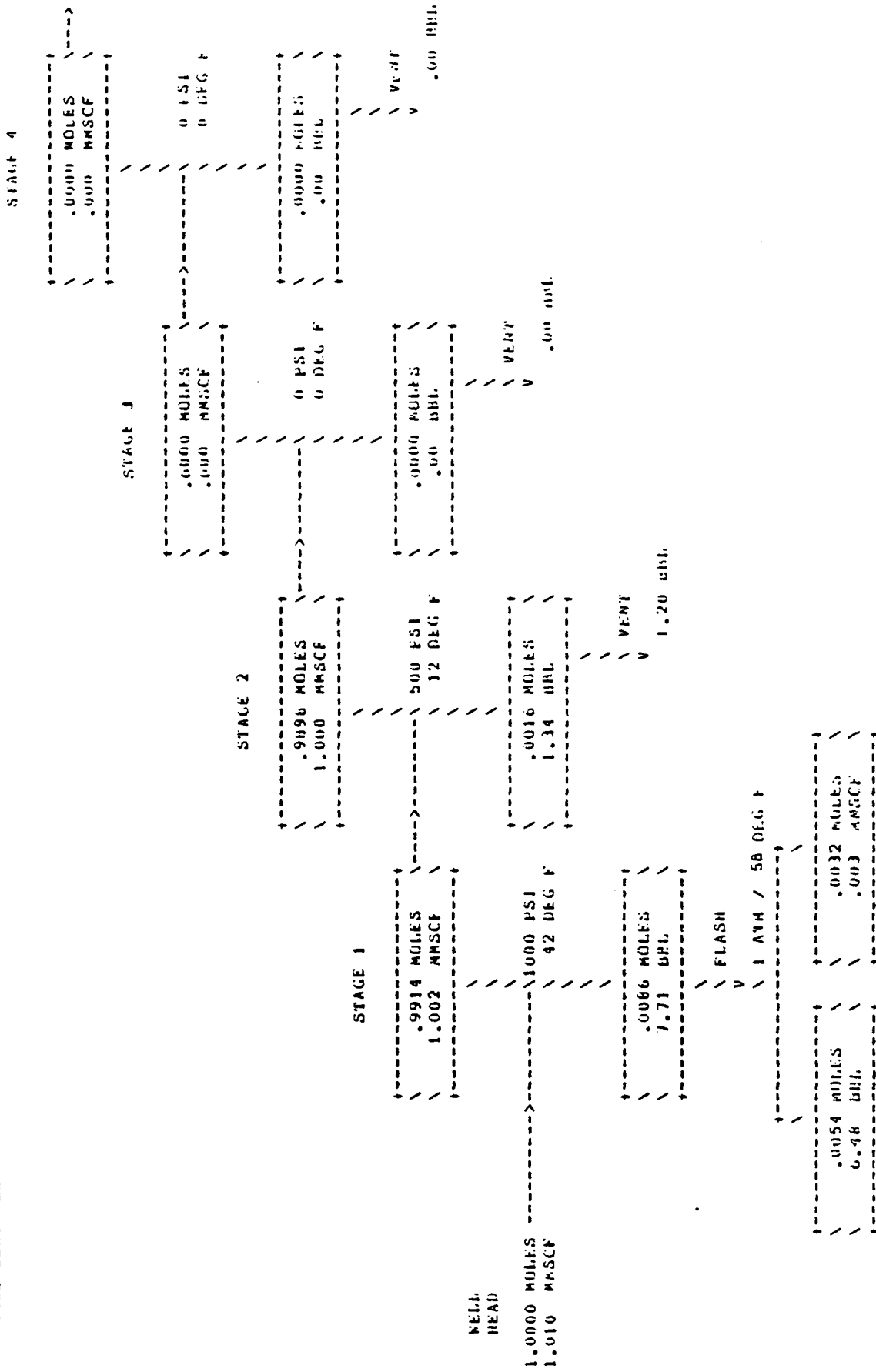


FIG. 9

TEST HD7

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U.C.C.R. = 155016. 507/507