Poker Cards Analysis – May 2024

The Directors
Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **May 01, 2024,** to **May 31, 2024** as recorded by the respective game servers and analyzed the Poker cards for statistical randomness. The results of the analysis are given below.

For details on the gaming sites serviced by the Entain Plc game servers and used in this audit refer to the List.

1. Poker hand types statistics

These calculations were done for Royal Flush, Straight Flush, Four of a Kind, Full House, Flush, Straight, 3 of a Kind, 2 pairs, 1 Pair, High Card.

The Poker hand types analysis involved creating subsets of data and conducting Chi-square tests on each subset.

The null hypothesis for the chi-square test is that the observed frequencies of each type of hand matches the theoretical values for a deck that has been shuffled using a perfect random number generator. The p-values observed in these multiple tests are expected to follow a uniform distribution for the range 0.0 to 1.0.

The analysis performs a KS Test (Kolmogorov-Smirnov test) for uniform distribution on the observed p-values, and the combined p-value result of this test is taken as the final result of the Poker hand types statistics tests.

1.1 Poker hand types statistics for 52 cards deck:

Test No.	DOF	ChiSqr	P-Value
1	9	13.82	0.12894
2	9	10.11	0.34181
3	9	17.74	0.03826
4	9	9.25	0.41461
5	9	8.09	0.52498
6	9	15.82	0.07076
7	9	15.25	0.08442
8	9	4.33	0.88871
9	9	5.62	0.77724
10	9	8.38	0.49633
11	9	8.75	0.46066
12	9	8.44	0.49017
13	9	4.50	0.87559
14	9	8.44	0.49045
15	9	10.93	0.28076
16	9	6.58	0.68103
17	9	7.79	0.55541
18	9	11.43	0.24726
19	9	2.50	0.98077
20	9	7.02	0.63476
21	9	5.25	0.81206
22	9	11.33	0.25348
23	9	12.13	0.20600
24	9	6.17	0.72250
25	9	8.84	0.45205
26	9	10.99	0.27611
27	9	3.77	0.92608

28	9	12.22	0.20142
29	9	6.88	0.64961
30	9	9.47	0.39475
31	9	11.90	0.21905
32	9	7.39	0.59630
33	9	14.64	0.10120
34	9	5.86	0.75368
35	9	5.62	0.77698
36	9	10.31	0.32595
37	9	13.96	0.12390
38	9	3.48	0.94223
39	9	14.54	0.10437
40	9	7.14	0.62303
41	9	5.39	0.79901
42	9	7.22	0.61467
43	9	8.44	0.49032
44	9	16.36	0.05974
45	9	8.44	0.49089
46	9	10.87	0.28469
47	9	11.33	0.25390
48	9	5.33	0.80458
49	9	8.77	0.45918
50	9	3.96	0.91423
51	9	9.19	0.41985
52	9	5.07	0.82806
53	9	3.50	0.94114
54	9	4.43	0.88089
55	9	14.12	0.11799
56	9	6.45	0.69407
57	9	4.39	0.88406
58	9	4.04	0.90879
59	9	4.91	0.84201
60	9	6.30	0.70925
61	9	7.20	0.61617
62	9	10.12	0.34102
63	9	1.30	0.99836
64	9	11.83	0.22305
65	9	3.56	0.93800
66	9	8.21	0.51343
67	9	12.03	0.21143
68	9	17.36	0.04335
69	9	8.72	0.46333
70	9	16.50	0.05718
71	9	4.85	0.84681
72	9	14.94	0.09259
73	9	13.23	0.15227
74	9	3.53	0.93936
75	9	16.32	0.06055
76	9	9.74	0.37198
77	9	9.13	0.42494
78	9	4.33	0.88821
79	9	6.21	0.71884
80	9	10.47	0.31393
81	9	7.09	0.62767
82	9	7.71	0.56331
83	9	5.52	0.78684

84	9	7.10	0.62621
85	9	10.76	0.29261
86	9	2.48	0.98139
87	9	6.57	0.68182
88	9	3.54	0.93878
89	9	8.79	0.45731
90	9	3.62	0.93473
91	9	14.75	0.09801
92	9	2.26	0.98674
93	9	5.81	0.75921
94	9	7.40	0.59590
95	9	4.10	0.90498
96	9	7.15	0.62126
97	9	4.23	0.89586
98	9	3.96	0.91374
99	9	16.26	0.06156
100	9	12.10	0.20751
Combined P-value for all tests (Using KS method)			0.43976

Notes:

1) The P-values are observed probabilities from the Chi-Square tests. The last row shows the result of the KS Test performed on the p-values for all Chi-Square tests, where there are sufficient data.

1.2 Poker hand types statistics for 36 cards deck:

Test No.	DOF	ChiSqr	P-Value
1	8	12.15	0.14456
2	8	6.01	0.64633
Combined P-value for all tests (Using KS method)			N/A (Insufficient data)

Notes:

1) Since the number of samples available was insufficient to ensure at least 5 samples in the lowest probability hand type, (Royal Flush), the chi-square test has been performed by merging the Royal Flush and Straight Flush categories.

2) As the total number of tests (2) is insufficient to perform a meaningful KS Test, individual p-values from these tests are carried over to the next stage for combining using the Holm's method.

3) Since the number of games played each month using 36 card decks is small, the number of samples available this month as well as a few previous months were insufficient to perform a meaningful statistical analysis. Hence the analysis performed this month was done using the cumulative data for the last 10 months - i.e July 2023 to May 2024.

2. Poker rank statistics

The Poker rank analysis aims to establish that the rank of the cards in each position was equally distributed in one of the 13 possible ranks (2, 3, 4, 5, 6, 7, 8, 9, 10, J, Q, K, A) for a 52 card deck and 9 ranks (6, 7, 8, 9, 10, J, Q, K, A) for a 36 card deck.

The Poker rank analysis involved creating subsets of data and conducting Chi-square tests on each subset. The analysis performs a KS Test (Kolmogorov-Smirnov test) for uniform distribution on the observed p-values, and the combined p-value result of this test is taken as the final result of the Ranks statistics tests.

2.1 Poker rank statistics for 52 cards deck:

Test No.	DOF	ChiSqr	P-Value
1	84	99.50	0.11906
2	84	94.45	0.20441
3	84	96.58	0.16437
4	84	65.04	0.93793
5	84	78.70	0.64295
6	84	53.65	0.99599

7	84	77.63	0.67452
8	84	82.24	0.53407
9	84	73.96	0.77516
10	84	86.54	0.40310
11	84	94.62	0.20095
12	84	64.06	0.94824
13	84	85.19	0.44308
14	84	79.28	0.62546
15	84	87.75	0.36815
16	84	72.45	0.81141
17	84	56.73	0.99021
18	84	88.46	0.34861
19	84	101.45	0.09448
20	84	77.14	0.68879
21	84	108.85	0.03548
22	84	70.28	0.85765
23	84	91.99	0.25826
24	84	85.33	0.43913
25	84	79.08	0.63138
26	84	85.56	0.43215
27	84	72.84	0.80239
28	84	59.81	0.97883
29	84	94.05	0.21255
30	84	104.28	0.06627
31	84	61.27	0.97059
32	84	69.82	0.86647
33	84	89.78	0.31303
34	84	86.28	0.41062
35	84	94.78	0.19777
36	84	101.31	0.09610
37	84	80.70	0.58186
38	84	74.45	0.76271
39	84	61.55	0.96881
40	84	96.54	0.16510
41	84	68.86	0.88388
42	84	75.76	0.72765
43	84	77.80	0.66969
44	84	109.28	0.03338
45	84	89.03	0.33299
46	84	71.73	0.82762
47	84	91.04	0.28098
48	84	89.09	0.33133
49	84	91.08	0.28016
50	84	84.87	0.45305
51	84	85.18	0.44344
52	84	72.97	0.79931
53	84	68.07	0.89688
54	84	72.87	0.80171
55	84	85.51	0.43367
56	84	95.63	0.18148
57	84	95.17	0.19011
58	84	93.30	0.22850
59	84	70.65	0.85033
60	84	85.36	0.43817
61	84	72.30	0.81495
62	84	103.35	0.07466

63	84	72.05	0.82063
64	84	82.43	0.52792
65	84	66.29	0.92275
66	84	94.06	0.21249
67	84	71.10	0.84111
68	84	71.33	0.83634
69	84	73.11	0.79613
70	84	77.06	0.69104
71	84	68.78	0.88519
72	84	80.41	0.59078
73	84	86.36	0.40841
74	84	78.43	0.65099
75	84	108.90	0.03525
76	84	91.30	0.27460
77	84	79.02	0.63314
78	84	98.67	0.13079
79	84	74.66	0.75719
80	84	96.30	0.16930
81	84	62.50	0.96188
82	84	103.17	0.07635
83	84	71.32	0.83648
84	84	94.60	0.20135
85	84	84.41	0.46680
86	84	102.71	0.08088
87	84	94.60	0.20133
88	84	66.28	0.92286
89	84	65.17	0.93644
90	84	100.88	0.10126
91	84	75.75	0.72796
92	84	67.93	0.89919
93	84	63.37	0.95467
94	84	88.08	0.35904
95	84	67.25	0.90946
96	84	101.82	0.09036
97	84	74.61	0.75844
98	84	86.27	0.41106
99	84	98.60	0.13184
100	84	102.19	0.08631
Combined P-value for all tests (Using KS method)			0.18899

Notes:

1) The P-values are observed probabilities from the Chi-Square tests. The last row shows the result of the KS Test performed on the p-values for all Chi-Square tests, where there are sufficient data.

2.2 Poker rank statistics for 36 cards deck:

Test No.	Positions	DOF	ChiSqr	P-Value
1	7	56	72.74	0.06570
2	7	56	50.37	0.68714
3	7	56	48.76	0.74276
4	7	56	67.86	0.13301
5	7	56	44.19	0.87312
6	7	56	51.95	0.62888
7	7	56	66.49	0.15920
8	7	56	63.76	0.22238
Combined P-value for all tests (Using KS method)				N/A (Insufficient data)

Notes:

1) As the total number of tests (8) is insufficient to perform a meaningful KS Test, individual p-values from these tests are carried over to the next stage for combining using the Holm's method.
2) Since the number of games played each month using 36 card decks is small, the number of samples available this month as well as a few previous months were insufficient to perform a meaningful statistical analysis. Hence the analysis performed this month was done using the cumulative data for the last 10 months - i.e July 2023 to May 2024.

3. Poker suits statistics

The Poker suits analysis aims to verify that that the cards dealt exhibit an equal probability of all 4 suits (Clubs, Diamonds, Hearts and Spades) in all positions.

The Poker suits analysis involved creating subsets of data and conducting Chi-square tests on each subset. The analysis performs a KS Test (Kolmogorov-Smirnov test) for uniform distribution on the observed p-values, and the combined p-value result of this test is taken as the final result of the Suits statistics tests.

3.1 Poker suits statistics for 52 cards deck:

Test No.	Positions	DOF	ChiSqr	P-Value
1	7	21	17.70	0.66814
2	7	21	27.05	0.16906
3	7	21	14.12	0.86428
4	7	21	21.84	0.40850
5	7	21	12.25	0.93272
6	7	21	28.79	0.11907
7	7	21	19.57	0.54869
8	7	21	22.52	0.37004
9	7	21	14.91	0.82727
10	7	21	14.32	0.85529
11	7	21	27.16	0.16564
12	7	21	17.57	0.67585
13	7	21	14.20	0.86091
14	7	21	23.57	0.31433
15	7	21	10.92	0.96438
16	7	21	31.13	0.07148
17	7	21	9.94	0.97970
18	7	21	21.97	0.40117
19	7	21	18.81	0.59715
20	7	21	23.54	0.31601
21	7	21	26.72	0.18046
22	7	21	21.87	0.40705
23	7	21	15.61	0.79101

24	7	21	23.83	0.30116
25	7	21	9.84	0.98087
26	7	21	26.86	0.17556
27	7	21	11.34	0.95583
28	7	21	33.05	0.04571
29	7	21	21.42	0.43382
30	7	21	31.16	0.07110
31	7	21	16.83	0.72147
32	7	21	16.91	0.71632
33	7	21	22.07	0.39532
34	7	21	29.09	0.11192
35	7	21	19.18	0.57363
36	7	21	26.85	0.17602
37	7	21	14.63	0.84088
38	7	21	36.05	0.02161
39	7	21	11.59	0.94999
40	7	21	18.72	0.60335
41	7	21	35.84	0.02281
42	7	21	20.37	0.49823
43	7	21	21.42	0.43352
44	7	21	12.80	0.91563
45	7	21	29.30	0.10702
46	7	21	23.21	0.33308
47	7	21	21.49	0.42937
48	7	21	12.21	0.93368
49	7	21	12.04	0.93850
50	7	21	15.40	0.80240
51	7	21	20.64	0.48117
52	7	21	17.78	0.66318
53	7	21	29.70	0.09813
54	7	21	21.03	0.45723
55	7	21	11.26	0.95752
56	7	21	8.67	0.99156
57	7	21	31.98	0.05888
58	7	21	19.99	0.52210
59	7	21	14.47	0.84853
60	7	21	20.75	0.47402
61	7	21	27.18	0.16489
62	7	21	11.52	0.95176
63	7	21	18.26	0.63266
64	7	21	17.10	0.70494
65	7	21	14.51	0.84649
66	7	21	15.00	0.82279
67	7	21	15.72	0.78538
68	7	21	15.91	0.77470
69	7	21	16.04	0.76749
70	7	21	18.47	0.61878
71	7	21	20.67	0.47894
72	7	21	12.97	0.90976
73	7	21	17.73	0.66616
74	7	21	20.88	0.46628
75	7	21	19.89	0.52819
76	7	21	26.83	0.17669
77	7	21	18.94	0.58871
78	7	21	31.55	0.06501
79	7	21	17.79	0.66219

80	7	21	24.37	0.27556
81	7	21	23.59	0.31340
82	7	21	20.35	0.49894
83	7	21	31.44	0.06662
84	7	21	17.86	0.65758
85	7	21	18.86	0.59397
86	7	21	22.76	0.35667
87	7	21	16.37	0.74870
88	7	21	20.86	0.46747
89	7	21	28.24	0.13345
90	7	21	16.50	0.74122
91	7	21	32.02	0.05829
92	7	21	17.00	0.71139
93	7	21	9.74	0.98205
94	7	21	20.22	0.50728
95	7	21	20.12	0.51372
96	7	21	21.97	0.40136
97	7	21	18.34	0.62730
98	7	21	18.02	0.64758
99	7	21	30.18	0.08838
100	7	21	21.49	0.42950
Combined P-value for all tests (Using KS method)				0.30864

Notes:

1) The P-values are observed probabilities from the Chi-Square tests. The last row shows the result of the KS Test performed on the p-values for all Chi-Square tests, where there are sufficient data.

3.2 Poker suits statistics for 36 cards deck:

Test No.	Positions	DOF	ChiSqr	P-Value
1	7	21	14.42	0.85071
2	7	21	17.25	0.69597
3	7	21	32.39	0.05341
4	7	21	19.10	0.57847
5	7	21	19.66	0.54262
6	7	21	23.55	0.31527
7	7	21	22.36	0.37903
8	7	21	34.84	0.02937
Combined P-value for all tests (Using KS method)				N/A (Insufficient data)

Notes:

1) As the total number of tests (8) is insufficient to perform a meaningful KS Test, individual p-values from these tests are carried over to the next stage for combining using the Holm's method.

2) Since the number of games played each month using 36 card decks is small, the number of samples available this month as well as a few previous months were insufficient to perform a meaningful statistical analysis. Hence the analysis performed this month was done using the cumulative data for the last 10 months - i.e July 2023 to May 2024.

4. Summary of the analysis

4.1 Summary of the analysis of 52 cards deck:

The analysis of 52 cards completes by combining the result of the KS Test performed in the 3 types of analysis (Hand Types, Ranks and Suits) for 52 card decks using the Holm's method and producing a single Combined P -value.

The combined p-value produced using the Holm's method is used as indication for statistical randomness.

Combination of p-values using Holm's Method		
Test	**P-Value**	**P-Adjusted**
Ranks Test	0.18899	0.56698
Suits Test	0.30864	0.61728
Hand Types Test	0.43976	0.61728
Combined P-Value using Holm's Method		0.56698

Notes:

1) The combined p-value of all statistical tests using Holm's Method conducted for 52 card decks is greater than the minimum value of 0.05 which indicates that the randomness of the observed data falls within 95% confidence limits.

The final outcome of the analysis of 52 cards deck indicates that the RNG is working correctly.

4.2 Summary of the analysis of 36 cards deck:

The analysis of 36 cards completes by combining the result of the KS Test performed in the 3 types of analysis (Hand Types, Ranks and Suits) for 36 card decks using the Holm's method and producing a single Combined P -value. Where there is insufficient data the individual Chi-Square tests results are used in the Holm's method for producing a combined p-value.

The combined p-value produced from the using the Holm's method is used as indication for statistical randomness.

Combination of p-values using Holm's Method		
Test	**P-Value**	**P-Adjusted**
Ranks Test 1	0.06570	1.00000
Ranks Test 2	0.68714	1.00000
Ranks Test 3	0.74276	1.00000
Ranks Test 4	0.13301	1.00000
Ranks Test 5	0.87312	1.00000
Ranks Test 6	0.62888	1.00000
Ranks Test 7	0.15920	1.00000
Ranks Test 8	0.22238	1.00000
Suits Test 1	0.85071	1.00000
Suits Test 2	0.69597	1.00000
Suits Test 3	0.05341	0.90795
Suits Test 4	0.57847	1.00000
Suits Test 5	0.54262	1.00000
Suits Test 6	0.31527	1.00000
Suits Test 7	0.37903	1.00000
Suits Test 8	0.02937	0.52864
Hand Types Test 1	0.14456	1.00000
Hand Types Test 2	0.64633	1.00000
Combined P-Value using Holm's Method		0.52864

Notes:

1) The combined p-value of all statistical tests using Holm's Method conducted for 36 card decks is greater than the minimum value of 0.05 which indicates that the randomness of the observed data falls within 95% confidence limits.
2) Since the number of games played each month using 36 card decks is small, the number of samples available this month as well as a few previous months were insufficient to perform a meaningful statistical analysis. Hence the analysis performed this month was done using the cumulative data for the last 10 months - i.e July 2023 to May 2024.

The final outcome of the analysis of 36 cards deck indicates that the RNG is working correctly.

5. Conclusion

Analysis of actual data from game logs for 'Hand Types, 'Ranks' and 'Suits' for **52-card decks** and **36-card decks** indicated statistical randomness.

iTech Labs has done limited sanity checks to verify the integrity of the game logs. iTech Labs also maintains a copy of the game logs for verification purposes. There were a large enough number of game records to give the calculations sufficient statistical power.

We conclude that the Random Number Generator (RNG) is working correctly.

Please click here to see the Original report.

Signed:	**Signed:**
	
Alvin Rizaldi **Chief Executive Officer** **iTech Labs** Date: 12 June 2024	**Divya Bhargava** **Project Manager** **iTech Labs** Date: 12 June 2024

Disclaimer.
While it is not possible to test all possible scenarios in a laboratory environment, iTech Labs has conducted a level of testing appropriate for a component test of this type.