Poker Cards Analysis – July 2024

The Directors
Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **July 01, 2024,** to **July 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	8.97	0.44039
2	9	5.40	0.79837
3	9	9.96	0.35351
4	9	7.98	0.53567
5	9	12.61	0.18103
6	9	5.79	0.76057
7	9	6.57	0.68213
8	9	7.64	0.57092
9	9	2.78	0.97248
10	9	8.73	0.46261
11	9	5.77	0.76234
12	9	4.10	0.90452
13	9	21.76	0.00969
14	9	9.80	0.36655
15	9	8.58	0.47648
16	9	10.10	0.34246
17	9	5.49	0.78948
18	9	7.91	0.54300
19	9	7.67	0.56809
20	9	13.63	0.13625
21	9	4.22	0.89647
22	9	5.68	0.77112
23	9	3.38	0.94742
24	9	8.21	0.51274
25	9	2.06	0.99053
26	9	7.12	0.62498
27	9	4.18	0.89901

28	9	9.59	0.38467
29	9	11.65	0.23392
30	9	8.20	0.51386
31	9	5.30	0.80702
32	9	5.69	0.77080
33	9	14.57	0.10342
34	9	13.12	0.15721
35	9	2.66	0.97622
36	9	9.12	0.42612
37	9	5.75	0.76483
38	9	7.55	0.57998
39	9	8.63	0.47165
40	9	9.66	0.37829
41	9	7.86	0.54814
42	9	5.67	0.77213
43	9	9.60	0.38345
44	9	19.69	0.01990
45	9	7.01	0.63598
46	9	15.05	0.08961
47	9	13.15	0.15581
48	9	8.77	0.45905
49	9	8.77	0.45902
50	9	9.59	0.38457
51	9	6.22	0.71732
52	9	3.44	0.94432
53	9	4.52	0.87381
54	9	6.01	0.73881
55	9	1.92	0.99272
56	9	8.55	0.47943
57	9	9.26	0.41378
58	9	1.87	0.99340
59	9	6.14	0.72613
60	9	8.84	0.45249
61	9	3.66	0.93258
62	9	10.16	0.33731
63	9	9.66	0.37836
64	9	6.64	0.67454
65	9	12.93	0.16577
66	9	6.97	0.64043
67	9	14.24	0.11397
68	9	2.39	0.98367
69	9	5.55	0.78396
70	9	11.39	0.24975
71	9	8.96	0.44089
72	9	4.23	0.89586
73	9	5.82	0.75735
74	9	13.11	0.15758
75	9	4.98	0.83594
76	9	3.32	0.95046
77	9	6.27	0.71217
78	9	2.11	0.98964
79	9	8.31	0.50292
80	9	5.02	0.83267
81	9	6.36	0.70356
82	9	7.38	0.59766
83	9	13.53	0.13993

84	9	8.45	0.48973
85	9	7.69	0.56568
86	9	3.07	0.96157
87	9	7.63	0.57206
88	9	2.97	0.96533
89	9	4.11	0.90419
90	9	9.09	0.42884
91	9	14.08	0.11938
92	9	13.47	0.14259
93	9	8.83	0.45302
94	9	7.31	0.60515
95	9	4.95	0.83866
96	9	5.84	0.75562
97	9	6.52	0.68666
98	9	4.91	0.84231
99	9	4.36	0.88617
100	9	10.46	0.31478
Combined P-value for all tests (Using KS method)			0.00597

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	9.56	0.29748
2	8	5.31	0.72365
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 12 months - i.e July 2023 to July 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	113.08	0.01891
2	84	82.12	0.53781
3	84	79.19	0.62796
4	84	107.31	0.04411
5	84	77.43	0.68037
6	84	86.59	0.40177

7	84	92.79	0.23972
8	84	75.58	0.73264
9	84	79.73	0.61159
10	84	91.81	0.26251
11	84	81.91	0.54436
12	84	68.75	0.88565
13	84	88.72	0.34134
14	84	105.37	0.05740
15	84	78.08	0.66132
16	84	94.69	0.19968
17	84	88.19	0.35595
18	84	85.18	0.44344
19	84	90.67	0.29026
20	84	76.49	0.70729
21	84	66.49	0.92010
22	84	75.85	0.72525
23	84	75.50	0.73481
24	84	91.24	0.27601
25	84	76.01	0.72072
26	84	65.09	0.93732
27	84	69.36	0.87498
28	84	67.43	0.90676
29	84	85.29	0.44026
30	84	102.95	0.07853
31	84	86.91	0.39220
32	84	66.88	0.91474
33	84	81.35	0.56172
34	84	67.96	0.89874
35	84	93.33	0.22794
36	84	88.36	0.35126
37	84	93.81	0.21759
38	84	90.86	0.28558
39	84	80.69	0.58205
40	84	89.00	0.33368
41	84	92.56	0.24499
42	84	68.74	0.88582
43	84	78.57	0.64661
44	84	65.88	0.92795
45	84	88.77	0.33995
46	84	92.79	0.23992
47	84	75.96	0.72222
48	84	100.67	0.10374
49	84	90.86	0.28542
50	84	105.89	0.05354
51	84	106.94	0.04642
52	84	75.64	0.73090
53	84	87.82	0.36623
54	84	82.77	0.51736
55	84	87.57	0.37350
56	84	104.85	0.06146
57	84	77.31	0.68379
58	84	81.85	0.54612
59	84	86.99	0.38999
60	84	93.53	0.22369
61	84	70.67	0.84998
62	84	83.95	0.48091

63	84	80.74	0.58049
64	84	105.65	0.05528
65	84	64.35	0.94532
66	84	74.39	0.76423
67	84	76.70	0.70156
68	84	108.92	0.03515
69	84	86.70	0.39853
70	84	92.42	0.24823
71	84	68.17	0.89534
72	84	96.43	0.16700
73	84	88.50	0.34748
74	84	77.92	0.66620
75	84	99.14	0.12401
76	84	84.99	0.44941
77	84	90.08	0.30514
78	84	104.45	0.06477
79	84	58.42	0.98485
80	84	92.34	0.25001
81	84	81.67	0.55168
82	84	92.88	0.23776
83	84	80.11	0.59993
84	84	63.47	0.95380
85	84	98.10	0.13932
86	84	68.06	0.89712
87	84	85.23	0.44203
88	84	65.16	0.93663
89	84	94.59	0.20157
90	84	75.54	0.73361
91	84	84.46	0.46526
92	84	116.00	0.01189
93	84	68.28	0.89357
94	84	106.87	0.04687
95	84	66.44	0.92080
96	84	100.40	0.10718
97	84	84.82	0.45428
98	84	99.17	0.12360
99	84	71.43	0.83427
100	84	90.25	0.30096
Combined P-value for all tests (Using KS method)			0.72580

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	41.89	0.91940
4	7	56	58.77	0.37429
5	7	56	53.25	0.57977
6	7	56	50.29	0.68972
7	7	56	44.08	0.87559
8	7	56	54.44	0.53421
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 12 months - i.e July 2023 to July 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	19.62	0.54526
2	7	21	22.89	0.34961
3	7	21	30.39	0.08433
4	7	21	14.60	0.84243
5	7	21	19.40	0.55963
6	7	21	27.02	0.17024
7	7	21	23.33	0.32684
8	7	21	21.56	0.42502
9	7	21	15.29	0.80807
10	7	21	13.46	0.89150
11	7	21	24.31	0.27805
12	7	21	17.88	0.65684
13	7	21	30.14	0.08919
14	7	21	22.81	0.35445
15	7	21	26.93	0.17302
16	7	21	7.13	0.99788
17	7	21	30.54	0.08166
18	7	21	14.63	0.84099
19	7	21	34.34	0.03334
20	7	21	20.02	0.51983
21	7	21	24.23	0.28223
22	7	21	22.50	0.37146
23	7	21	21.83	0.40962

24	7	21	22.99	0.34465
25	7	21	17.45	0.68356
26	7	21	23.12	0.33740
27	7	21	26.61	0.18406
28	7	21	23.62	0.31200
29	7	21	28.30	0.13183
30	7	21	32.81	0.04835
31	7	21	31.23	0.06994
32	7	21	21.87	0.40680
33	7	21	23.84	0.30082
34	7	21	18.41	0.62264
35	7	21	13.92	0.87294
36	7	21	22.41	0.37604
37	7	21	19.76	0.53661
38	7	21	19.86	0.52998
39	7	21	34.82	0.02955
40	7	21	19.52	0.55191
41	7	21	22.27	0.38391
42	7	21	17.78	0.66301
43	7	21	13.10	0.90519
44	7	21	19.11	0.57831
45	7	21	21.47	0.43070
46	7	21	25.38	0.23124
47	7	21	19.80	0.53392
48	7	21	16.78	0.72448
49	7	21	16.55	0.73821
50	7	21	19.27	0.56783
51	7	21	27.60	0.15188
52	7	21	15.03	0.82136
53	7	21	18.28	0.63107
54	7	21	17.57	0.67607
55	7	21	21.80	0.41100
56	7	21	32.02	0.05830
57	7	21	22.74	0.35820
58	7	21	17.96	0.65181
59	7	21	16.10	0.76418
60	7	21	24.50	0.26932
61	7	21	18.29	0.63067
62	7	21	34.82	0.02956
63	7	21	31.53	0.06521
64	7	21	20.07	0.51678
65	7	21	13.53	0.88905
66	7	21	12.81	0.91508
67	7	21	23.81	0.30211
68	7	21	21.07	0.45478
69	7	21	36.72	0.01812
70	7	21	15.02	0.82171
71	7	21	26.17	0.19999
72	7	21	29.26	0.10793
73	7	21	23.19	0.33386
74	7	21	25.11	0.24261
75	7	21	25.96	0.20796
76	7	21	17.91	0.65445
77	7	21	15.34	0.80571
78	7	21	11.33	0.95592
79	7	21	13.92	0.87289

80	7	21	16.39	0.74757
81	7	21	14.22	0.85984
82	7	21	15.11	0.81747
83	7	21	15.68	0.78741
84	7	21	27.83	0.14495
85	7	21	20.29	0.50322
86	7	21	16.12	0.76303
87	7	21	28.33	0.13090
88	7	21	19.97	0.52342
89	7	21	25.22	0.23762
90	7	21	14.16	0.86244
91	7	21	9.95	0.97956
92	7	21	18.97	0.58697
93	7	21	26.68	0.18167
94	7	21	27.35	0.15943
95	7	21	29.89	0.09420
96	7	21	25.68	0.21896
97	7	21	25.90	0.21027
98	7	21	18.65	0.60749
99	7	21	9.39	0.98580
100	7	21	14.12	0.86441
Combined P-value for all tests (Using KS method)				0.86323

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	27.34	0.15975
4	7	21	19.66	0.54262
5	7	21	15.52	0.79599
6	7	21	10.61	0.96989
7	7	21	15.60	0.79169
8	7	21	23.93	0.29642
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 12 months - i.e July 2023 to July 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	0.72580	1.00000
Suits Test	0.86323	1.00000
Hand Types Test	0.00597	0.01792
Combined P-Value using Holm's Method		0.01792

Notes:

Truly random numbers are expected to produce patterns occasionally. '95% confidence tests' should report a failure 5% of the time if the input is truly random. We investigate each 'fail' to ensure they do not repeat more often than the expected 5% of the time.
Our overall result for this period was a 'fail', due to a failing Hand Types test.

We also performed a combined Chi-Square test for Hands Type for the entire data manually, and its result shows a p-value of 0.836 which shows that there is no reason to suspect any systemic failure of the RNG, and hence we would attribute the low p-value observed in the multi-set Hands Type test to just a random statistical event. Hence our final assessment of the analysis of 52 cards deck would be that the RNG is working correctly.

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	0.91940	1.00000
Ranks Test 4	0.37429	1.00000
Ranks Test 5	0.57977	1.00000
Ranks Test 6	0.68972	1.00000
Ranks Test 7	0.87559	1.00000
Ranks Test 8	0.53421	1.00000
Suits Test 1	0.85071	1.00000
Suits Test 2	0.69597	1.00000
Suits Test 3	0.15975	1.00000
Suits Test 4	0.54262	1.00000
Suits Test 5	0.79599	1.00000
Suits Test 6	0.96989	1.00000
Suits Test 7	0.79169	1.00000
Suits Test 8	0.29642	1.00000
Hand Types Test 1	0.29748	1.00000
Hand Types Test 2	0.72365	1.00000
Combined P-Value using Holm's Method		1.00000

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 12 months - i.e July 2023 to July 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: 22 August 2024	**Divya Bhargava** **Project Manager** **iTech Labs** Date: 22 August 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.