Poker Cards Analysis – August 2024

The Directors
Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **August 01, 2024,** to **August 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	10.48	0.31292
2	9	2.85	0.96991
3	9	4.50	0.87548
4	9	8.57	0.47750
5	9	8.71	0.46442
6	9	10.23	0.33211
7	9	6.29	0.71010
8	9	11.00	0.27582
9	9	3.95	0.91465
10	9	16.24	0.06211
11	9	3.93	0.91577
12	9	13.77	0.13085
13	9	4.60	0.86799
14	9	28.41	0.00081
15	9	12.45	0.18930
16	9	6.66	0.67213
17	9	8.76	0.45931
18	9	4.89	0.84379
19	9	14.41	0.10832
20	9	10.07	0.34478
21	9	17.42	0.04252
22	9	8.45	0.48905
23	9	9.66	0.37884
24	9	11.25	0.25873
25	9	12.14	0.20551
26	9	6.07	0.73264
27	9	17.13	0.04677

28	9	7.69	0.56525
29	9	8.04	0.52966
30	9	8.73	0.46252
31	9	13.80	0.12956
32	9	18.29	0.03192
33	9	1.79	0.99435
34	9	5.86	0.75420
35	9	6.21	0.71832
36	9	8.25	0.50940
37	9	7.72	0.56228
38	9	6.45	0.69379
39	9	6.18	0.72212
40	9	6.40	0.69890
41	9	5.19	0.81707
42	9	7.18	0.61890
43	9	7.53	0.58254
44	9	10.58	0.30536
45	9	7.28	0.60813
46	9	1.10	0.99918
47	9	13.26	0.15131
48	9	8.31	0.50369
49	9	14.98	0.09143
50	9	9.92	0.35711
51	9	7.40	0.59591
52	9	8.45	0.48940
53	9	13.06	0.15984
54	9	7.06	0.63079
55	9	25.44	0.00252
56	9	2.67	0.97581
57	9	14.17	0.11645
58	9	7.29	0.60663
59	9	16.91	0.05010
60	9	5.76	0.76367
61	9	10.57	0.30653
62	9	13.45	0.14347
63	9	10.10	0.34233
64	9	11.93	0.21713
65	9	5.88	0.75173
66	9	9.14	0.42457
67	9	11.06	0.27147
68	9	6.50	0.68919
69	9	7.71	0.56324
70	9	9.26	0.41391
71	9	5.57	0.78250
72	9	15.36	0.08157
73	9	4.34	0.88796
74	9	15.97	0.06746
75	9	9.78	0.36850
76	9	2.55	0.97944
77	9	10.42	0.31724
78	9	3.75	0.92720
79	9	9.37	0.40405
80	9	3.61	0.93505
81	9	4.89	0.84338
82	9	3.22	0.95505
83	9	14.87	0.09445

84	9	10.09	0.34359
85	9	9.74	0.37164
86	9	3.44	0.94432
87	9	3.40	0.94608
88	9	17.36	0.04336
89	9	6.52	0.68678
90	9	8.04	0.52974
91	9	20.25	0.01645
92	9	3.25	0.95362
93	9	10.67	0.29934
94	9	12.19	0.20289
95	9	9.60	0.38379
96	9	7.58	0.57673
97	9	8.79	0.45734
98	9	6.84	0.65344
99	9	24.08	0.00418
100	9	14.08	0.11947
Combined P-value for all tests (Using KS method)			0.95850

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	11.58	0.17090
2	8	11.20	0.19052
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 13 months - i.e July 2023 to August 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	97.05	0.15630
2	84	94.81	0.19728
3	84	89.91	0.30959
4	84	107.05	0.04568
5	84	78.54	0.64770
6	84	67.55	0.90506

7	84	84.17	0.47425
8	84	84.66	0.45943
9	84	97.00	0.15709
10	84	77.62	0.67492
11	84	59.51	0.98029
12	84	75.55	0.73347
13	84	102.75	0.08049
14	84	64.47	0.94411
15	84	73.99	0.77439
16	84	99.51	0.11886
17	84	89.50	0.32030
18	84	91.40	0.27234
19	84	85.55	0.43227
20	84	63.24	0.95583
21	84	84.58	0.46171
22	84	66.54	0.91937
23	84	97.45	0.14971
24	84	86.84	0.39432
25	84	90.96	0.28300
26	84	97.50	0.14892
27	84	111.68	0.02342
28	84	81.68	0.55132
29	84	70.68	0.84968
30	84	98.46	0.13392
31	84	60.64	0.97442
32	84	97.86	0.14307
33	84	96.19	0.17115
34	84	77.00	0.69292
35	84	104.83	0.06167
36	84	90.89	0.28474
37	84	92.57	0.24473
38	84	108.59	0.03686
39	84	97.74	0.14507
40	84	72.62	0.80748
41	84	95.43	0.18520
42	84	59.92	0.97828
43	84	118.48	0.00788
44	84	87.53	0.37464
45	84	89.58	0.31835
46	84	131.67	0.00069
47	84	85.13	0.44491
48	84	93.05	0.23393
49	84	63.49	0.95359
50	84	85.04	0.44765
51	84	102.42	0.08384
52	84	112.52	0.02061
53	84	102.34	0.08475
54	84	70.47	0.85394
55	84	77.44	0.68022
56	84	95.08	0.19187
57	84	74.61	0.75841
58	84	71.42	0.83433
59	84	67.96	0.89870
60	84	58.64	0.98401
61	84	98.56	0.13243
62	84	85.15	0.44444

63	84	84.42	0.46647
64	84	88.53	0.34660
65	84	93.78	0.21823
66	84	74.15	0.77044
67	84	80.04	0.60200
68	84	98.29	0.13645
69	84	111.83	0.02290
70	84	71.09	0.84129
71	84	88.33	0.35205
72	84	108.84	0.03553
73	84	92.68	0.24240
74	84	96.50	0.16565
75	84	96.39	0.16759
76	84	96.99	0.15739
77	84	92.85	0.23837
78	84	75.23	0.74213
79	84	93.00	0.23511
80	84	61.82	0.96698
81	84	115.47	0.01295
82	84	101.99	0.08846
83	84	83.69	0.48912
84	84	73.69	0.78194
85	84	96.70	0.16230
86	84	83.07	0.50804
87	84	54.47	0.99485
88	84	103.19	0.07617
89	84	74.80	0.75351
90	84	82.37	0.53002
91	84	82.29	0.53231
92	84	104.63	0.06327
93	84	88.42	0.34963
94	84	79.18	0.62848
95	84	76.55	0.70557
96	84	125.53	0.00226
97	84	79.75	0.61114
98	84	76.65	0.70296
99	84	75.25	0.74142
100	84	82.46	0.52715
Combined P-value for all tests (Using KS method)			0.01418

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	50.91	0.66757
4	7	56	46.37	0.81702
5	7	56	59.29	0.35640
6	7	56	71.50	0.07936
7	7	56	48.71	0.74456
8	7	56	53.31	0.57729
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 13 months - i.e July 2023 to August 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	23.19	0.33376
2	7	21	8.18	0.99433
3	7	21	33.58	0.04015
4	7	21	25.27	0.23582
5	7	21	23.00	0.34390
6	7	21	9.86	0.98064
7	7	21	17.78	0.66319
8	7	21	14.44	0.85014
9	7	21	30.71	0.07867
10	7	21	18.51	0.61655
11	7	21	13.60	0.88619
12	7	21	25.15	0.24086
13	7	21	20.08	0.51640
14	7	21	18.51	0.61623
15	7	21	28.09	0.13771
16	7	21	26.33	0.19408
17	7	21	12.33	0.93030
18	7	21	15.43	0.80084
19	7	21	10.09	0.97770
20	7	21	29.49	0.10273
21	7	21	15.12	0.81664
22	7	21	15.53	0.79571
23	7	21	9.96	0.97946

24	7	21	20.08	0.51623
25	7	21	12.14	0.93578
26	7	21	24.86	0.25334
27	7	21	14.80	0.83265
28	7	21	18.04	0.64625
29	7	21	18.67	0.60640
30	7	21	27.44	0.15677
31	7	21	18.16	0.63883
32	7	21	25.88	0.21099
33	7	21	22.25	0.38540
34	7	21	16.90	0.71710
35	7	21	34.76	0.02997
36	7	21	21.31	0.44023
37	7	21	18.06	0.64540
38	7	21	18.64	0.60823
39	7	21	21.13	0.45121
40	7	21	28.36	0.13023
41	7	21	27.41	0.15778
42	7	21	20.78	0.47254
43	7	21	14.57	0.84409
44	7	21	25.47	0.22749
45	7	21	17.14	0.70242
46	7	21	31.69	0.06293
47	7	21	19.63	0.54480
48	7	21	24.98	0.24823
49	7	21	18.15	0.63946
50	7	21	15.58	0.79289
51	7	21	13.97	0.87068
52	7	21	19.47	0.55482
53	7	21	35.37	0.02569
54	7	21	17.82	0.66051
55	7	21	19.44	0.55711
56	7	21	27.00	0.17075
57	7	21	13.05	0.90673
58	7	21	19.81	0.53304
59	7	21	25.53	0.22500
60	7	21	11.88	0.94289
61	7	21	34.65	0.03081
62	7	21	10.21	0.97599
63	7	21	24.96	0.24902
64	7	21	31.63	0.06377
65	7	21	19.53	0.55087
66	7	21	14.60	0.84236
67	7	21	33.55	0.04048
68	7	21	12.92	0.91151
69	7	21	11.08	0.96124
70	7	21	21.84	0.40902
71	7	21	29.28	0.10747
72	7	21	23.77	0.30445
73	7	21	16.54	0.73841
74	7	21	12.61	0.92175
75	7	21	13.03	0.90747
76	7	21	18.33	0.62812
77	7	21	28.40	0.12921
78	7	21	20.60	0.48353
79	7	21	16.93	0.71509

80	7	21	10.95	0.96372
81	7	21	20.48	0.49124
82	7	21	18.86	0.59395
83	7	21	12.15	0.93534
84	7	21	16.69	0.72987
85	7	21	16.58	0.73612
86	7	21	21.15	0.45004
87	7	21	17.78	0.66261
88	7	21	20.46	0.49258
89	7	21	21.46	0.43133
90	7	21	25.43	0.22897
91	7	21	26.04	0.20474
92	7	21	19.13	0.57709
93	7	21	28.01	0.13998
94	7	21	26.87	0.17521
95	7	21	20.32	0.50111
96	7	21	34.11	0.03530
97	7	21	15.18	0.81398
98	7	21	26.51	0.18751
99	7	21	30.61	0.08043
100	7	21	16.19	0.75870
Combined P-value for all tests (Using KS method)				0.80180

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	20.71	0.47665
4	7	21	11.35	0.95549
5	7	21	25.78	0.21512
6	7	21	17.27	0.69449
7	7	21	12.58	0.92250
8	7	21	29.79	0.09629
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 13 months - i.e July 2023 to August 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	0.01418	0.04255
Suits Test	0.80180	1.00000
Hand Types Test	0.95850	1.00000
Combined P-Value using Holm's Method		0.04255

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 Rank test.

We also performed a combined Chi-Square test for Rank for the entire data manually, and its result shows a p-value of 0.92925 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 Rank 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	0.66757	1.00000
Ranks Test 4	0.81702	1.00000
Ranks Test 5	0.35640	1.00000
Ranks Test 6	0.07936	1.00000
Ranks Test 7	0.74456	1.00000
Ranks Test 8	0.57729	1.00000
Suits Test 1	0.85071	1.00000
Suits Test 2	0.69597	1.00000
Suits Test 3	0.47665	1.00000
Suits Test 4	0.95549	1.00000
Suits Test 5	0.21512	1.00000
Suits Test 6	0.69449	1.00000
Suits Test 7	0.92250	1.00000
Suits Test 8	0.09629	1.00000
Hand Types Test 1	0.17090	1.00000
Hand Types Test 2	0.19052	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 13 months - i.e July 2023 to August 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: 18 September 2024	**Divya Bhargava** **Project Manager** **iTech Labs** Date: 18 September 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.