



Poker Cards Analysis - September 2022

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **Sep 01, 2022** to **Sep 30, 2022** 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	10.17	0.33716
2	9	6.91	0.64679
3	9	10.81	0.28926
4	9	7.12	0.62507
5	9	4.90	0.84269
6	9	8.92	0.44434
7	9	8.59	0.47595
8	9	6.69	0.66943
9	9	11.34	0.25300
10	9	4.34	0.88789
11	9	12.13	0.20584
12	9	14.36	0.10995
13	9	7.97	0.53766
14	9	12.76	0.17356
15	9	3.49	0.94164
16	9	5.27	0.80993
17	9	8.08	0.52616
18	9	13.81	0.12920
19	9	10.48	0.31291
20	9	6.23	0.71667
21	9	14.84	0.09541
22	9	14.69	0.09993
23	9	20.23	0.01656
24	9	16.63	0.05491

25	9	3.69	0.93045
26	9	11.19	0.26260
27	9	2.98	0.96517
28	9	2.03	0.99096
29	9	16.22	0.06235
30	9	7.38	0.59792
31	9	6.85	0.65308
32	9	9.00	0.43707
33	9	6.52	0.68651
34	9	5.30	0.80729
35	9	4.53	0.87356
36	9	6.98	0.63967
37	9	11.40	0.24929
38	9	5.81	0.75894
39	9	6.38	0.70087
40	9	10.13	0.34032
41	9	7.52	0.58340
42	9	9.47	0.39523
43	9	12.22	0.20116
44	9	9.68	0.37659
45	9	10.73	0.29480
46	9	5.35	0.80272
47	9	19.46	0.02155
48	9	7.80	0.55425
49	9	6.16	0.72354
50	9	4.01	0.91086
51	9	5.13	0.82300
52	9	9.99	0.35100
53	9	10.85	0.28594
54	9	13.36	0.14686
55	9	9.29	0.41057
56	9	10.82	0.28803
57	9	11.01	0.27520
58	9	4.28	0.89177
59	9	4.33	0.88820
60	9	8.62	0.47340
61	9	16.30	0.06096
62	9	10.80	0.28987
63	9	7.30	0.60543
64	9	3.93	0.91622
65	9	9.18	0.42105
66	9	8.47	0.48733
67	9	11.00	0.27548
68	9	3.92	0.91679
69	9	10.30	0.32641
70	9	9.57	0.38621
71	9	10.31	0.32568
72	9	5.06	0.82946
73	9	9.07	0.43085
74	9	6.92	0.64546
75	9	10.50	0.31118
76	9	7.31	0.60469
77	9	6.86	0.65185
78	9	7.36	0.59990
79	9	2.58	0.97857

80	9	5.34	0.80372
81	9	5.87	0.75238
82	9	7.07	0.63001
83	9	6.15	0.72469
84	9	3.11	0.95982
85	9	11.28	0.25696
86	9	7.29	0.60677
87	9	2.95	0.96640
88	9	15.48	0.07863
89	9	4.58	0.86945
90	9	3.31	0.95070
91	9	11.64	0.23452
92	9	8.06	0.52783
93	9	3.17	0.95703
94	9	5.47	0.79130
95	9	6.33	0.70668
96	9	9.81	0.36588
97	9	4.55	0.87162
98	9	6.60	0.67877
99	9	14.81	0.09615
100	9	24.18	0.00402
Combined P-value for all tests (Using KS method)			0.53884

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	8.82	0.35802
2	8	2.45	0.96419
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.

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.	Positions	DOF	ChiSqr	P-Value
1	7	84	86.43	0.40620
2	7	84	70.37	0.85597

3	7	84	57.48	0.98807
4	7	84	80.85	0.57713
5	7	84	83.80	0.48562
6	7	84	67.41	0.90704
7	7	84	83.09	0.50764
8	7	84	77.34	0.68297
9	7	84	81.67	0.55173
10	7	84	84.50	0.46412
11	7	84	97.60	0.14733
12	7	84	70.20	0.85933
13	7	84	93.29	0.22870
14	7	84	85.61	0.43067
15	7	84	74.94	0.74973
16	7	84	83.00	0.51039
17	7	84	90.65	0.29084
18	7	84	62.69	0.96041
19	7	84	95.67	0.18072
20	7	84	81.59	0.55414
21	7	84	77.26	0.68552
22	7	84	88.14	0.35727
23	7	84	80.21	0.59702
24	7	84	68.66	0.88722
25	7	84	75.95	0.72255
26	7	84	87.06	0.38793
27	7	84	77.09	0.69024
28	7	84	76.76	0.69968
29	7	84	92.88	0.23791
30	7	84	101.73	0.09133
31	7	84	69.52	0.87215
32	7	84	83.00	0.51038
33	7	84	84.14	0.47519
34	7	84	95.41	0.18562
35	7	84	91.29	0.27490
36	7	84	60.42	0.97565
37	7	84	94.22	0.20901
38	7	84	90.04	0.30616
39	7	84	89.16	0.32937
40	7	84	94.69	0.19961
41	7	84	95.92	0.17616
42	7	84	68.25	0.89410
43	7	84	95.41	0.18559
44	7	84	69.80	0.86694
45	7	84	80.44	0.58974
46	7	84	84.54	0.46308
47	7	84	75.75	0.72799
48	7	84	74.02	0.77360
49	7	84	108.86	0.03545
50	7	84	85.54	0.43266
51	7	84	79.53	0.61784
52	7	84	74.02	0.77350
53	7	84	75.65	0.73074
54	7	84	66.16	0.92438
55	7	84	60.80	0.97353
56	7	84	59.75	0.97916
57	7	84	94.69	0.19954

58	7	84	82.42	0.52846
59	7	84	60.19	0.97691
60	7	84	82.68	0.52040
61	7	84	65.32	0.93474
62	7	84	71.93	0.82334
63	7	84	65.17	0.93646
64	7	84	115.49	0.01292
65	7	84	83.90	0.48244
66	7	84	73.03	0.79787
67	7	84	80.17	0.59814
68	7	84	89.70	0.31525
69	7	84	122.83	0.00370
70	7	84	87.13	0.38588
71	7	84	83.25	0.50253
72	7	84	117.23	0.00971
73	7	84	89.43	0.32224
74	7	84	63.53	0.95325
75	7	84	82.21	0.53494
76	7	84	91.99	0.25814
77	7	84	93.38	0.22679
78	7	84	104.78	0.06206
79	7	84	81.06	0.57071
80	7	84	87.83	0.36599
81	7	84	86.65	0.39975
82	7	84	97.91	0.14226
83	7	84	96.95	0.15800
84	7	84	80.06	0.60140
85	7	84	63.66	0.95204
86	7	84	67.17	0.91059
87	7	84	77.46	0.67955
88	7	84	86.78	0.39595
89	7	84	78.34	0.65362
90	7	84	86.22	0.41253
91	7	84	109.05	0.03450
92	7	84	84.82	0.45438
93	7	84	92.89	0.23767
94	7	84	76.67	0.70224
95	7	84	94.13	0.21090
96	7	84	96.90	0.15877
97	7	84	82.05	0.53990
98	7	84	60.97	0.97251
99	7	84	72.72	0.80533
100	7	84	82.24	0.53399
Combined P-value for all tests (Using KS method)				0.65733

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	47.74	0.77605
2	7	56	44.48	0.86638
3	7	56	48.42	0.75408
4	7	56	56.95	0.43936
5	7	56	63.67	0.22475
6	7	56	62.71	0.25043
7	7	56	57.03	0.43671
8	7	56	68.73	0.11825
9	7	56	60.82	0.30644
10	7	56	58.25	0.39256
11	7	56	40.50	0.94082
Combined P-value for all tests (Using KS method)				0.98231

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. 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	25.00	0.24728
2	7	21	21.08	0.45408
3	7	21	17.43	0.68448
4	7	21	33.01	0.04613
5	7	21	24.33	0.27722
6	7	21	21.60	0.42301
7	7	21	14.86	0.83003
8	7	21	17.24	0.69645
9	7	21	11.52	0.95174
10	7	21	32.09	0.05732
11	7	21	17.22	0.69793
12	7	21	20.42	0.49509
13	7	21	21.61	0.42202
14	7	21	18.76	0.60051
15	7	21	18.33	0.62773
16	7	21	32.04	0.05805
17	7	21	18.61	0.60984
18	7	21	11.37	0.95508
19	7	21	29.26	0.10784
20	7	21	14.91	0.82725
21	7	21	32.00	0.05862
22	7	21	15.27	0.80910

23	7	21	20.15	0.51204
24	7	21	25.51	0.22561
25	7	21	16.06	0.76640
26	7	21	17.46	0.68301
27	7	21	13.24	0.90007
28	7	21	19.12	0.57716
29	7	21	16.96	0.71346
30	7	21	16.17	0.75994
31	7	21	21.06	0.45520
32	7	21	14.91	0.82750
33	7	21	17.61	0.67377
34	7	21	33.01	0.04610
35	7	21	17.49	0.68125
36	7	21	15.27	0.80923
37	7	21	16.63	0.73303
38	7	21	27.38	0.15869
39	7	21	45.94	0.00130
40	7	21	9.60	0.98366
41	7	21	15.32	0.80644
42	7	21	24.59	0.26524
43	7	21	17.25	0.69591
44	7	21	14.50	0.84730
45	7	21	15.66	0.78845
46	7	21	15.19	0.81313
47	7	21	16.60	0.73518
48	7	21	26.21	0.19863
49	7	21	13.52	0.88929
50	7	21	20.78	0.47244
51	7	21	14.58	0.84333
52	7	21	20.52	0.48853
53	7	21	22.55	0.36855
54	7	21	28.15	0.13596
55	7	21	21.04	0.45658
56	7	21	32.91	0.04728
57	7	21	25.81	0.21364
58	7	21	9.60	0.98366
59	7	21	17.28	0.69393
60	7	21	25.93	0.20910
61	7	21	28.61	0.12363
62	7	21	17.37	0.68867
63	7	21	19.50	0.55294
64	7	21	19.50	0.55296
65	7	21	13.31	0.89733
66	7	21	19.88	0.52888
67	7	21	15.06	0.81968
68	7	21	13.06	0.90647
69	7	21	30.25	0.08701
70	7	21	20.57	0.48538
71	7	21	17.92	0.65420
72	7	21	30.87	0.07589
73	7	21	24.81	0.25567
74	7	21	17.53	0.67852
75	7	21	24.64	0.26311
76	7	21	11.17	0.95928
77	7	21	15.63	0.79013

78	7	21	22.93	0.34750
79	7	21	22.38	0.37773
80	7	21	20.02	0.52027
81	7	21	15.93	0.77357
82	7	21	16.68	0.73042
83	7	21	27.31	0.16083
84	7	21	37.21	0.01593
85	7	21	31.51	0.06558
86	7	21	20.35	0.49905
87	7	21	19.65	0.54342
88	7	21	16.49	0.74126
89	7	21	18.12	0.64158
90	7	21	11.92	0.94169
91	7	21	28.81	0.11868
92	7	21	30.10	0.09006
93	7	21	19.98	0.52229
94	7	21	16.20	0.75855
95	7	21	20.61	0.48290
96	7	21	39.75	0.00797
97	7	21	19.01	0.58451
98	7	21	20.41	0.49549
99	7	21	10.53	0.97123
100	7	21	20.60	0.48336
Combined P-value for all tests (Using KS method)				0.08483

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	16.99	0.71159
2	7	21	16.42	0.74538
3	7	21	11.10	0.96072
4	7	21	12.32	0.93057
5	7	21	17.15	0.70185
6	7	21	16.62	0.73363
7	7	21	21.01	0.45846
8	7	21	20.31	0.50158
9	7	21	16.14	0.76151
10	7	21	14.08	0.86614
11	7	21	28.70	0.12149
Combined P-value for all tests (Using KS method)				0.02373

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.

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	0.65733	1.00000
Suits Test	0.08483	0.25448
HandTypes Test	0.53884	1.00000
Combined P-Value using Holm's Method		0.25448

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 are 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	0.98231	1.00000
Suits Test	0.02373	0.09493
HandTypes Test	0.35802	1.00000
HandTypes Test	0.96419	1.00000
Combined P-Value using Holm's Method		0.09493

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.

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:



Kiren Sreekumar
Principal Consultant
iTech Labs Australia
Date: 13 Sep 2022

Signed:



Geoff Nicoll
Principal Consultant
iTech Labs Australia
Date: 13 Sep 2022

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.

