



Poker Cards Analysis - November 2023

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **November 01, 2023 to November 30, 2023** 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	7.32	0.60413
2	9	7.61	0.57377
3	9	2.76	0.97316
4	9	6.22	0.71804
5	9	10.43	0.31715
6	9	13.34	0.14790
7	9	11.29	0.25626
8	9	15.39	0.08067
9	9	7.81	0.55308
10	9	10.04	0.34715
11	9	16.09	0.06508
12	9	4.80	0.85166
13	9	6.84	0.65428
14	9	7.07	0.63025
15	9	3.29	0.95158
16	9	24.18	0.00403
17	9	14.29	0.11241
18	9	7.97	0.53730
19	9	8.80	0.45554
20	9	7.50	0.58489
21	9	8.76	0.45925
22	9	5.38	0.80002
23	9	5.22	0.81482
24	9	7.77	0.55775
25	9	9.62	0.38183
26	9	11.05	0.27214
27	9	11.81	0.22440

28	9	11.12	0.26791
29	9	6.78	0.65951
30	9	10.52	0.30983
31	9	7.95	0.53952
32	9	7.04	0.63248
33	9	14.89	0.09389
34	9	7.51	0.58452
35	9	4.44	0.87988
36	9	8.47	0.48733
37	9	13.42	0.14447
38	9	6.55	0.68406
39	9	6.12	0.72831
40	9	8.81	0.45509
41	9	16.57	0.05583
42	9	15.82	0.07082
43	9	10.86	0.28549
44	9	7.47	0.58801
45	9	8.91	0.44587
46	9	10.06	0.34575
47	9	7.01	0.63640
48	9	6.20	0.71997
49	9	5.03	0.83201
50	9	9.73	0.37289
51	9	9.17	0.42144
52	9	9.88	0.36037
53	9	5.94	0.74627
54	9	8.79	0.45724
55	9	16.65	0.05440
56	9	7.30	0.60626
57	9	4.43	0.88112
58	9	10.72	0.29527
59	9	10.89	0.28307
60	9	7.54	0.58093
61	9	4.37	0.88521
62	9	11.83	0.22296
63	9	10.84	0.28711
64	9	14.66	0.10056
65	9	9.27	0.41284
66	9	7.82	0.55197
67	9	4.61	0.86683
68	9	10.03	0.34822
69	9	5.99	0.74077
70	9	18.39	0.03091
71	9	7.57	0.57765
72	9	8.57	0.47796
73	9	7.49	0.58635
74	9	8.79	0.45683
75	9	6.22	0.71791
76	9	8.85	0.45077
77	9	6.77	0.66139
78	9	14.21	0.11499
79	9	7.67	0.56732
80	9	5.29	0.80819
81	9	9.52	0.39058
82	9	5.53	0.78561
83	9	10.01	0.34975

84	9	12.35	0.19405
85	9	6.91	0.64682
86	9	5.47	0.79164
87	9	7.87	0.54695
88	9	8.68	0.46696
89	9	3.10	0.96006
90	9	5.47	0.79118
91	9	4.55	0.87152
92	9	6.43	0.69599
93	9	4.25	0.89449
94	9	7.24	0.61205
95	9	14.99	0.09113
96	9	3.08	0.96094
97	9	5.50	0.78901
98	9	11.24	0.25932
99	9	6.86	0.65197
100	9	11.33	0.25350
Combined P-value for all tests (Using KS method)			0.47148

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	9.31	0.31688
2	8	6.59	0.58152
3	8	8.44	0.39180
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 (3) 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 6 months - i.e June 2023 to November 2023.

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	70.70	0.84937
2	84	98.30	0.13639
3	84	81.08	0.57008
4	84	75.88	0.72429
5	84	93.20	0.23068

6	84	71.47	0.83341
7	84	97.96	0.14156
8	84	94.07	0.21220
9	84	88.19	0.35599
10	84	85.93	0.42109
11	84	78.35	0.65324
12	84	81.02	0.57189
13	84	63.25	0.95577
14	84	90.46	0.29560
15	84	84.59	0.46141
16	84	82.69	0.51992
17	84	88.86	0.33742
18	84	91.42	0.27177
19	84	88.95	0.33507
20	84	94.75	0.19831
21	84	67.86	0.90031
22	84	79.08	0.63146
23	84	93.01	0.23503
24	84	67.95	0.89879
25	84	103.48	0.07343
26	84	78.73	0.64181
27	84	86.84	0.39442
28	84	98.16	0.13847
29	84	83.49	0.49523
30	84	71.76	0.82691
31	84	99.61	0.11745
32	84	90.97	0.28267
33	84	58.02	0.98632
34	84	92.22	0.25280
35	84	100.16	0.11022
36	84	73.18	0.79426
37	84	62.52	0.96177
38	84	90.55	0.29334
39	84	79.15	0.62936
40	84	99.58	0.11790
41	84	77.19	0.68739
42	84	103.96	0.06901
43	84	81.63	0.55287
44	84	99.22	0.12291
45	84	76.65	0.70285
46	84	90.98	0.28247
47	84	71.39	0.83501
48	84	80.50	0.58800
49	84	81.70	0.55072
50	84	79.53	0.61779
51	84	79.26	0.62588
52	84	79.65	0.61417
53	84	74.59	0.75904
54	84	88.43	0.34942
55	84	98.31	0.13616
56	84	66.96	0.91360
57	84	89.14	0.32993
58	84	71.83	0.82556
59	84	78.63	0.64497
60	84	79.55	0.61716
61	84	85.51	0.43354

62	84	88.25	0.35434
63	84	84.16	0.47446
64	84	77.75	0.67101
65	84	98.87	0.12781
66	84	88.43	0.34927
67	84	98.55	0.13256
68	84	83.82	0.48515
69	84	69.09	0.87977
70	84	75.12	0.74503
71	84	71.13	0.84060
72	84	70.07	0.86178
73	84	89.84	0.31149
74	84	66.15	0.92451
75	84	77.22	0.68641
76	84	83.08	0.50787
77	84	102.08	0.08753
78	84	74.78	0.75397
79	84	88.41	0.34972
80	84	88.30	0.35297
81	84	101.77	0.09089
82	84	105.41	0.05706
83	84	82.41	0.52859
84	84	66.04	0.92594
85	84	66.63	0.91819
86	84	72.80	0.80335
87	84	96.63	0.16355
88	84	69.16	0.87852
89	84	85.03	0.44798
90	84	77.52	0.67796
91	84	85.58	0.43148
92	84	84.18	0.47385
93	84	89.54	0.31930
94	84	83.44	0.49676
95	84	86.67	0.39935
96	84	83.76	0.48701
97	84	105.78	0.05433
98	84	74.09	0.77189
99	84	81.82	0.54687
100	84	90.74	0.28837
Combined P-value for all tests (Using KS method)			0.92243

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	52.81	0.59623
2	7	56	65.86	0.17245
3	7	56	42.82	0.90223
4	7	56	58.25	0.39256
5	7	56	48.42	0.75408
6	7	56	67.47	0.14023
7	7	56	58.27	0.39192
8	7	56	45.16	0.84954
9	7	56	65.47	0.18118
10	7	56	68.65	0.11943
11	7	56	56.54	0.45467
12	7	56	46.68	0.80822
13	7	56	42.06	0.91642
Combined P-value for all tests (Using KS method)				0.94895

Notes:

- 1) 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 6 months - i.e June 2023 to November 2023.

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	25.87	0.21140
2	7	21	19.09	0.57966
3	7	21	18.58	0.61235
4	7	21	35.38	0.02563
5	7	21	21.68	0.41823
6	7	21	19.88	0.52890
7	7	21	21.75	0.41408
8	7	21	23.46	0.32000
9	7	21	12.05	0.93819
10	7	21	25.02	0.24648
11	7	21	23.63	0.31125
12	7	21	40.34	0.00676
13	7	21	16.63	0.73328
14	7	21	7.52	0.99688
15	7	21	19.62	0.54554
16	7	21	14.97	0.82462
17	7	21	18.68	0.60536
18	7	21	20.04	0.51890
19	7	21	21.48	0.42981
20	7	21	15.07	0.81936

21	7	21	25.63	0.22079
22	7	21	19.20	0.57235
23	7	21	12.31	0.93083
24	7	21	8.25	0.99397
25	7	21	21.71	0.41651
26	7	21	13.81	0.87748
27	7	21	16.56	0.73756
28	7	21	23.70	0.30775
29	7	21	26.50	0.18791
30	7	21	28.85	0.11770
31	7	21	18.27	0.63162
32	7	21	23.92	0.29678
33	7	21	20.42	0.49462
34	7	21	16.99	0.71196
35	7	21	27.19	0.16455
36	7	21	38.23	0.01212
37	7	21	14.56	0.84424
38	7	21	19.44	0.55717
39	7	21	27.16	0.16552
40	7	21	23.30	0.32800
41	7	21	44.68	0.00191
42	7	21	23.69	0.30853
43	7	21	26.83	0.17670
44	7	21	24.26	0.28076
45	7	21	17.27	0.69465
46	7	21	23.75	0.30543
47	7	21	12.68	0.91947
48	7	21	19.31	0.56512
49	7	21	11.09	0.96100
50	7	21	17.78	0.66278
51	7	21	16.51	0.74010
52	7	21	13.59	0.88669
53	7	21	14.50	0.84712
54	7	21	18.85	0.59475
55	7	21	20.41	0.49522
56	7	21	18.57	0.61264
57	7	21	22.95	0.34688
58	7	21	25.20	0.23844
59	7	21	19.42	0.55853
60	7	21	15.30	0.80744
61	7	21	19.40	0.55925
62	7	21	20.95	0.46202
63	7	21	37.49	0.01480
64	7	21	17.25	0.69591
65	7	21	11.39	0.95461
66	7	21	14.98	0.82410
67	7	21	15.42	0.80126
68	7	21	21.99	0.40013
69	7	21	27.77	0.14682
70	7	21	15.58	0.79292
71	7	21	13.39	0.89424
72	7	21	29.53	0.10190
73	7	21	24.76	0.25778
74	7	21	13.28	0.89840
75	7	21	27.80	0.14583
76	7	21	23.51	0.31743

77	7	21	17.14	0.70263
78	7	21	26.40	0.19155
79	7	21	29.64	0.09937
80	7	21	13.40	0.89409
81	7	21	26.76	0.17891
82	7	21	16.91	0.71684
83	7	21	28.27	0.13259
84	7	21	21.17	0.44860
85	7	21	21.52	0.42752
86	7	21	25.21	0.23799
87	7	21	27.85	0.14447
88	7	21	22.75	0.35732
89	7	21	24.79	0.25635
90	7	21	11.45	0.95336
91	7	21	21.72	0.41597
92	7	21	26.21	0.19857
93	7	21	15.20	0.81260
94	7	21	33.39	0.04204
95	7	21	19.59	0.54747
96	7	21	25.79	0.21472
97	7	21	16.71	0.72881
98	7	21	18.98	0.58620
99	7	21	29.23	0.10854
100	7	21	18.86	0.59402
Combined P-value for all tests (Using KS method)				0.97541

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	14.21	0.86050
2	7	21	27.94	0.14175
3	7	21	29.68	0.09861
4	7	21	25.68	0.21891
5	7	21	8.46	0.99289
6	7	21	22.20	0.38806
7	7	21	19.15	0.57539
8	7	21	25.52	0.22535
9	7	21	19.17	0.57436
10	7	21	12.67	0.91968
11	7	21	16.80	0.72316
12	7	21	29.54	0.10154
13	7	21	20.14	0.51269
Combined P-value for all tests (Using KS method)				0.99916

Notes:

- 1) 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 6 months - i.e June 2023 to November 2023.

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	0.92243	1.00000
Suits Test	0.97541	1.00000
Hand Types Test	0.47148	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 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	0.94895	1.00000
Suits Test	0.99916	1.00000
Hand Types Test 1	0.31688	1.00000
Hand Types Test 2	0.58152	1.00000
Hand Types Test 3	0.39180	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 6 months - i.e June 2023 to November 2023.

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:



Alvin Rizaldi
Chief Executive Officer
iTech Labs
Date: 27 December 2023

Signed:



Divya Bhargava
Project Manager
iTech Labs
Date: 27 December 2023

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.

