



Poker Cards Analysis - March 2023

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **Mar 01, 2023** to **Mar 31, 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	4.38	0.88440
2	9	14.14	0.11754
3	9	6.94	0.64317
4	9	4.10	0.90500
5	9	10.74	0.29418
6	9	11.18	0.26367
7	9	5.43	0.79567
8	9	7.66	0.56849
9	9	9.57	0.38635
10	9	9.70	0.37492
11	9	17.24	0.04513
12	9	9.61	0.38296
13	9	1.46	0.99743
14	9	4.33	0.88851
15	9	7.05	0.63187
16	9	12.27	0.19834
17	9	8.68	0.46687
18	9	4.58	0.86888
19	9	6.25	0.71450
20	9	6.44	0.69553
21	9	10.67	0.29885
22	9	4.09	0.90527
23	9	15.22	0.08515
24	9	7.57	0.57748
25	9	5.51	0.78732

26	9	4.56	0.87097
27	9	2.46	0.98195
28	9	5.65	0.77390
29	9	15.09	0.08841
30	9	11.94	0.21678
31	9	5.80	0.75937
32	9	5.85	0.75527
33	9	15.99	0.06719
34	9	6.20	0.71942
35	9	3.61	0.93497
36	9	13.37	0.14671
37	9	7.94	0.54052
38	9	13.01	0.16219
39	9	8.75	0.46022
40	9	4.43	0.88103
41	9	7.89	0.54521
42	9	7.49	0.58643
43	9	14.14	0.11742
44	9	15.15	0.08690
45	9	10.27	0.32876
46	9	7.27	0.60955
47	9	4.96	0.83761
48	9	8.48	0.48653
49	9	6.68	0.67000
50	9	7.55	0.58002
51	9	6.17	0.72282
52	9	4.57	0.87046
53	9	7.18	0.61853
54	9	15.70	0.07344
55	9	7.84	0.55022
56	9	5.38	0.80020
57	9	8.14	0.52023
58	9	3.02	0.96362
59	9	5.46	0.79280
60	9	12.65	0.17914
61	9	3.91	0.91731
62	9	15.69	0.07374
63	9	15.31	0.08272
64	9	17.70	0.03881
65	9	6.66	0.67198
66	9	8.77	0.45902
67	9	17.44	0.04222
68	9	12.14	0.20556
69	9	7.92	0.54216
70	9	5.31	0.80605
71	9	7.04	0.63336
72	9	7.74	0.56069
73	9	10.10	0.34224
74	9	4.71	0.85861
75	9	18.16	0.03337
76	9	8.73	0.46218
77	9	16.54	0.05641
78	9	4.72	0.85778
79	9	7.76	0.55873
80	9	17.85	0.03695
81	9	11.36	0.25170

82	9	6.68	0.67008
83	9	12.58	0.18241
84	9	7.66	0.56885
85	9	8.72	0.46389
86	9	13.17	0.15504
87	9	15.56	0.07672
88	9	9.10	0.42784
89	9	3.91	0.91703
90	9	8.52	0.48223
91	9	8.26	0.50821
92	9	15.96	0.06762
93	9	4.61	0.86652
94	9	11.95	0.21625
95	9	7.51	0.58369
96	9	7.01	0.63586
97	9	7.32	0.60409
98	9	6.81	0.65725
99	9	5.80	0.75947
100	9	4.36	0.88595
Combined P-value for all tests (Using KS method)			0.26665

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	7.25	0.51006
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 (1) 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	95.78	0.17863
2	7	84	99.55	0.11826
3	7	84	71.15	0.84012

4	7	84	93.17	0.23150
5	7	84	75.60	0.73217
6	7	84	75.37	0.73843
7	7	84	84.40	0.46711
8	7	84	88.08	0.35902
9	7	84	103.99	0.06873
10	7	84	73.84	0.77814
11	7	84	80.36	0.59220
12	7	84	77.97	0.66452
13	7	84	68.50	0.88991
14	7	84	65.27	0.93530
15	7	84	101.54	0.09351
16	7	84	71.65	0.82949
17	7	84	85.30	0.43987
18	7	84	76.57	0.70503
19	7	84	82.84	0.51539
20	7	84	88.89	0.33672
21	7	84	102.48	0.08327
22	7	84	86.86	0.39372
23	7	84	112.76	0.01985
24	7	84	91.36	0.27314
25	7	84	92.11	0.25529
26	7	84	87.32	0.38065
27	7	84	68.58	0.88857
28	7	84	96.34	0.16847
29	7	84	86.21	0.41289
30	7	84	73.34	0.79051
31	7	84	84.47	0.46516
32	7	84	79.30	0.62465
33	7	84	88.65	0.34321
34	7	84	101.36	0.09549
35	7	84	89.05	0.33237
36	7	84	86.92	0.39201
37	7	84	73.36	0.78991
38	7	84	60.28	0.97643
39	7	84	109.81	0.03088
40	7	84	74.61	0.75848
41	7	84	54.63	0.99460
42	7	84	67.61	0.90416
43	7	84	69.95	0.86402
44	7	84	68.74	0.88592
45	7	84	82.18	0.53582
46	7	84	87.72	0.36923
47	7	84	62.53	0.96171
48	7	84	81.51	0.55654
49	7	84	84.21	0.47315
50	7	84	96.14	0.17204
51	7	84	96.98	0.15751
52	7	84	69.82	0.86646
53	7	84	68.14	0.89574
54	7	84	70.35	0.85632
55	7	84	63.40	0.95441
56	7	84	87.57	0.37349
57	7	84	66.27	0.92295
58	7	84	73.38	0.78946
59	7	84	83.03	0.50940

60	7	84	98.22	0.13759
61	7	84	70.83	0.84674
62	7	84	70.86	0.84620
63	7	84	90.46	0.29563
64	7	84	100.55	0.10527
65	7	84	82.35	0.53062
66	7	84	87.26	0.38220
67	7	84	106.20	0.05131
68	7	84	71.90	0.82402
69	7	84	79.27	0.62556
70	7	84	91.52	0.26931
71	7	84	84.49	0.46449
72	7	84	88.30	0.35276
73	7	84	79.94	0.60516
74	7	84	59.44	0.98063
75	7	84	70.34	0.85657
76	7	84	68.43	0.89117
77	7	84	78.73	0.64204
78	7	84	69.52	0.87219
79	7	84	103.60	0.07233
80	7	84	68.15	0.89568
81	7	84	89.52	0.31989
82	7	84	108.31	0.03835
83	7	84	91.84	0.26160
84	7	84	104.64	0.06323
85	7	84	89.35	0.32426
86	7	84	103.64	0.07195
87	7	84	89.86	0.31086
88	7	84	83.30	0.50109
89	7	84	72.16	0.81803
90	7	84	80.57	0.58587
91	7	84	70.92	0.84493
92	7	84	62.16	0.96453
93	7	84	112.69	0.02006
94	7	84	90.95	0.28337
95	7	84	93.45	0.22536
96	7	84	64.06	0.94824
97	7	84	83.51	0.49456
98	7	84	74.78	0.75392
99	7	84	85.21	0.44260
100	7	84	87.88	0.36472
Combined P-value for all tests (Using KS method)				0.26189

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	48.73	0.74399
Combined P-value for all tests (Using KS method)				N/A (Insufficient data)

Notes:

- 1) As the total number of tests (1) 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. 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	29.10	0.11165
2	7	21	39.11	0.00953
3	7	21	25.56	0.22358
4	7	21	17.90	0.65561
5	7	21	24.25	0.28130
6	7	21	29.24	0.10847
7	7	21	12.23	0.93327
8	7	21	17.26	0.69531
9	7	21	34.38	0.03300
10	7	21	17.31	0.69233
11	7	21	22.35	0.37943
12	7	21	32.89	0.04749
13	7	21	14.66	0.83969
14	7	21	14.52	0.84604
15	7	21	16.76	0.72581
16	7	21	22.48	0.37247
17	7	21	15.08	0.81900
18	7	21	27.28	0.16190
19	7	21	12.31	0.93101
20	7	21	29.11	0.11132
21	7	21	17.03	0.70919
22	7	21	24.27	0.28012
23	7	21	15.73	0.78458
24	7	21	28.91	0.11623
25	7	21	22.64	0.36366
26	7	21	19.32	0.56441
27	7	21	14.67	0.83909
28	7	21	35.91	0.02240
29	7	21	18.08	0.64381
30	7	21	29.70	0.09819
31	7	21	12.99	0.90909
32	7	21	36.43	0.01954
33	7	21	18.85	0.59447

34	7	21	16.37	0.74827
35	7	21	30.84	0.07640
36	7	21	26.86	0.17545
37	7	21	23.91	0.29731
38	7	21	29.69	0.09845
39	7	21	17.31	0.69209
40	7	21	20.09	0.51551
41	7	21	17.72	0.66656
42	7	21	13.07	0.90622
43	7	21	18.73	0.60240
44	7	21	28.22	0.13399
45	7	21	31.32	0.06850
46	7	21	12.77	0.91660
47	7	21	12.45	0.92681
48	7	21	27.23	0.16335
49	7	21	22.63	0.36391
50	7	21	6.97	0.99820
51	7	21	18.38	0.62463
52	7	21	19.84	0.53143
53	7	21	24.39	0.27451
54	7	21	27.28	0.16179
55	7	21	18.52	0.61595
56	7	21	17.76	0.66435
57	7	21	25.73	0.21698
58	7	21	27.11	0.16728
59	7	21	20.39	0.49665
60	7	21	32.33	0.05417
61	7	21	15.31	0.80699
62	7	21	22.08	0.39493
63	7	21	17.56	0.67656
64	7	21	26.62	0.18375
65	7	21	17.70	0.66765
66	7	21	34.72	0.03032
67	7	21	11.87	0.94311
68	7	21	19.77	0.53592
69	7	21	19.58	0.54789
70	7	21	23.98	0.29380
71	7	21	20.37	0.49810
72	7	21	11.99	0.93992
73	7	21	17.10	0.70515
74	7	21	14.76	0.83487
75	7	21	19.53	0.55131
76	7	21	19.26	0.56878
77	7	21	39.77	0.00792
78	7	21	17.21	0.69848
79	7	21	38.83	0.01028
80	7	21	16.26	0.75484
81	7	21	23.01	0.34350
82	7	21	23.69	0.30820
83	7	21	14.67	0.83932
84	7	21	21.98	0.40078
85	7	21	28.60	0.12392
86	7	21	14.12	0.86429
87	7	21	20.04	0.51896
88	7	21	23.07	0.34020
89	7	21	16.68	0.73030

90	7	21	17.65	0.67084
91	7	21	19.46	0.55535
92	7	21	20.77	0.47284
93	7	21	33.22	0.04379
94	7	21	18.33	0.62814
95	7	21	15.07	0.81948
96	7	21	23.74	0.30607
97	7	21	10.87	0.96529
98	7	21	20.79	0.47169
99	7	21	8.71	0.99130
100	7	21	20.20	0.50834
Combined P-value for all tests (Using KS method)				0.75850

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	23.52	0.31707
Combined P-value for all tests (Using KS method)				N/A (Insufficient data)

Notes:

- 1) As the total number of tests (1) 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.

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	0.26189	0.78567
Suits Test	0.75850	0.78567
Hand Types Test	0.26665	0.78567
Combined P-Value using Holm's Method		0.78567

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	0.74399	1.00000
Suits Test	0.31707	0.95122
Hand Types Test	0.51006	1.00000
Combined P-Value using Holm's Method		0.95122

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

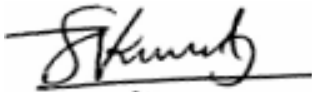
Analysis of actual data from game logs for 'Hand Types', 'Ranks' and 'Suits' for **52-card decks** and **36-card decks** indicated statistical randomness.

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: 16 May 2023

Signed:



Geoff Nicoll
Principal Consultant
iTech Labs Australia
Date: 16 May 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.