



Poker Cards Analysis - January 2023

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **Jan 01, 2023** to **Jan 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	12.36	0.19351
2	9	12.62	0.18034
3	9	6.73	0.66480
4	9	8.80	0.45589
5	9	7.63	0.57196
6	9	31.89	0.00021
7	9	7.18	0.61798
8	9	7.59	0.57545
9	9	8.95	0.44228
10	9	8.07	0.52753
11	9	23.05	0.00609
12	9	3.48	0.94210
13	9	11.72	0.22958
14	9	5.49	0.78979
15	9	16.59	0.05553
16	9	19.39	0.02209
17	9	10.43	0.31702
18	9	10.48	0.31321
19	9	19.57	0.02073
20	9	11.50	0.24292
21	9	5.32	0.80602
22	9	6.88	0.64941
23	9	10.48	0.31275
24	9	8.34	0.50040

25	9	10.01	0.34964
26	9	3.65	0.93294
27	9	10.29	0.32726
28	9	6.93	0.64446
29	9	12.59	0.18224
30	9	6.13	0.72669
31	9	2.65	0.97667
32	9	4.70	0.85933
33	9	6.78	0.66019
34	9	6.01	0.73908
35	9	8.01	0.53295
36	9	9.94	0.35548
37	9	1.20	0.99881
38	9	8.20	0.51389
39	9	11.88	0.22044
40	9	12.79	0.17253
41	9	8.01	0.53336
42	9	3.12	0.95949
43	9	3.73	0.92833
44	9	6.12	0.72789
45	9	15.61	0.07559
46	9	10.55	0.30766
47	9	13.33	0.14810
48	9	6.89	0.64882
49	9	9.76	0.37066
50	9	4.64	0.86482
51	9	11.58	0.23833
52	9	3.96	0.91416
53	9	7.00	0.63706
54	9	4.29	0.89137
55	9	5.76	0.76406
56	9	16.17	0.06332
57	9	12.67	0.17826
58	9	4.06	0.90713
59	9	9.05	0.43275
60	9	16.50	0.05711
61	9	6.39	0.69987
62	9	14.31	0.11159
63	9	8.52	0.48236
64	9	17.44	0.04221
65	9	16.58	0.05568
66	9	9.03	0.43446
67	9	6.14	0.72590
68	9	16.63	0.05481
69	9	16.90	0.05037
70	9	13.01	0.16221
71	9	8.72	0.46371
72	9	4.89	0.84396
73	9	10.16	0.33799
74	9	11.43	0.24708
75	9	8.65	0.47008
76	9	5.69	0.77085
77	9	7.27	0.60954
78	9	5.96	0.74365
79	9	6.08	0.73153

80	9	9.39	0.40226
81	9	9.95	0.35429
82	9	11.38	0.25027
83	9	9.70	0.37496
84	9	17.43	0.04242
85	9	11.41	0.24851
86	9	6.97	0.64048
87	9	11.94	0.21650
88	9	7.90	0.54440
89	9	12.23	0.20078
90	9	4.66	0.86274
91	9	8.02	0.53248
92	9	8.57	0.47830
93	9	2.41	0.98316
94	9	13.64	0.13557
95	9	11.64	0.23462
96	9	13.48	0.14224
97	9	4.06	0.90724
98	9	6.28	0.71127
99	9	8.78	0.45807
100	9	2.58	0.97868
Combined P-value for all tests (Using KS method)			0.70045

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	9.94	0.26907
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	72.75	0.80466
2	7	84	94.42	0.20493
3	7	84	85.45	0.43539

4	7	84	88.59	0.34498
5	7	84	102.26	0.08558
6	7	84	78.12	0.66006
7	7	84	81.68	0.55147
8	7	84	84.26	0.47146
9	7	84	93.27	0.22928
10	7	84	89.58	0.31827
11	7	84	103.53	0.07293
12	7	84	51.34	0.99811
13	7	84	78.66	0.64411
14	7	84	75.73	0.72866
15	7	84	71.35	0.83596
16	7	84	89.08	0.33149
17	7	84	88.80	0.33904
18	7	84	74.09	0.77176
19	7	84	90.63	0.29117
20	7	84	78.89	0.63703
21	7	84	102.24	0.08578
22	7	84	72.48	0.81086
23	7	84	96.31	0.16903
24	7	84	49.43	0.99905
25	7	84	80.41	0.59071
26	7	84	71.85	0.82507
27	7	84	94.80	0.19744
28	7	84	60.72	0.97395
29	7	84	79.80	0.60938
30	7	84	96.84	0.15992
31	7	84	82.96	0.51148
32	7	84	90.38	0.29751
33	7	84	99.44	0.11976
34	7	84	50.34	0.99867
35	7	84	84.90	0.45196
36	7	84	77.86	0.66800
37	7	84	80.24	0.59586
38	7	84	90.59	0.29222
39	7	84	82.36	0.53029
40	7	84	98.84	0.12825
41	7	84	60.48	0.97532
42	7	84	89.15	0.32974
43	7	84	115.43	0.01303
44	7	84	92.80	0.23964
45	7	84	90.67	0.29026
46	7	84	61.10	0.97170
47	7	84	82.26	0.53323
48	7	84	86.27	0.41092
49	7	84	82.58	0.52335
50	7	84	91.81	0.26234
51	7	84	86.52	0.40358
52	7	84	59.29	0.98128
53	7	84	79.83	0.60856
54	7	84	84.91	0.45184
55	7	84	97.95	0.14171
56	7	84	74.96	0.74934
57	7	84	77.54	0.67728
58	7	84	80.79	0.57899

59	7	84	87.59	0.37281
60	7	84	72.36	0.81347
61	7	84	77.88	0.66725
62	7	84	100.86	0.10143
63	7	84	67.62	0.90397
64	7	84	80.93	0.57478
65	7	84	96.46	0.16638
66	7	84	62.69	0.96043
67	7	84	59.93	0.97823
68	7	84	62.14	0.96463
69	7	84	104.21	0.06682
70	7	84	98.46	0.13385
71	7	84	88.01	0.36110
72	7	84	101.09	0.09871
73	7	84	108.45	0.03756
74	7	84	84.50	0.46427
75	7	84	76.59	0.70466
76	7	84	94.54	0.20262
77	7	84	76.60	0.70425
78	7	84	67.03	0.91261
79	7	84	94.97	0.19399
80	7	84	83.36	0.49923
81	7	84	99.96	0.11287
82	7	84	62.63	0.96090
83	7	84	88.53	0.34659
84	7	84	89.55	0.31907
85	7	84	82.87	0.51423
86	7	84	58.99	0.98259
87	7	84	73.22	0.79333
88	7	84	66.38	0.92155
89	7	84	84.62	0.46066
90	7	84	74.33	0.76584
91	7	84	85.26	0.44106
92	7	84	75.58	0.73255
93	7	84	100.27	0.10880
94	7	84	83.25	0.50260
95	7	84	98.30	0.13632
96	7	84	88.09	0.35882
97	7	84	65.48	0.93280
98	7	84	93.25	0.22973
99	7	84	99.58	0.11797
100	7	84	94.71	0.19923
Combined P-value for all tests (Using KS method)				0.52026

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	67.83	0.13366
2	7	56	49.00	0.73489
3	7	56	56.38	0.46071
4	7	56	55.23	0.50413
5	7	56	60.34	0.32189
6	7	56	48.01	0.76749
7	7	56	65.32	0.18450
Combined P-value for all tests (Using KS method)				N/A (Insufficient data)

Notes:

- 1) As the total number of tests (7) 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 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	27.55	0.15326
2	7	21	34.49	0.03207
3	7	21	19.47	0.55473
4	7	21	19.29	0.56648
5	7	21	26.34	0.19381
6	7	21	18.37	0.62577
7	7	21	14.48	0.84802
8	7	21	16.24	0.75599
9	7	21	7.63	0.99651
10	7	21	21.12	0.45146
11	7	21	28.16	0.13561
12	7	21	19.17	0.57405
13	7	21	25.52	0.22519
14	7	21	24.16	0.28538
15	7	21	16.49	0.74163
16	7	21	30.24	0.08728
17	7	21	17.02	0.71010
18	7	21	33.24	0.04358
19	7	21	31.92	0.05967
20	7	21	18.06	0.64517
21	7	21	22.09	0.39456
22	7	21	26.01	0.20604
23	7	21	19.48	0.55464
24	7	21	20.33	0.50031
25	7	21	13.96	0.87147
26	7	21	18.20	0.63601

27	7	21	20.00	0.52120
28	7	21	45.56	0.00146
29	7	21	30.92	0.07493
30	7	21	19.62	0.54546
31	7	21	25.24	0.23683
32	7	21	19.00	0.58525
33	7	21	17.03	0.70900
34	7	21	17.49	0.68119
35	7	21	15.62	0.79077
36	7	21	10.34	0.97411
37	7	21	10.60	0.97010
38	7	21	25.56	0.22386
39	7	21	22.39	0.37718
40	7	21	47.77	0.00074
41	7	21	28.21	0.13429
42	7	21	16.09	0.76430
43	7	21	18.53	0.61501
44	7	21	22.94	0.34692
45	7	21	22.54	0.36874
46	7	21	11.49	0.95247
47	7	21	14.68	0.83890
48	7	21	11.81	0.94450
49	7	21	22.58	0.36654
50	7	21	21.33	0.43892
51	7	21	15.51	0.79644
52	7	21	20.56	0.48583
53	7	21	20.64	0.48090
54	7	21	25.89	0.21052
55	7	21	18.06	0.64533
56	7	21	9.81	0.98126
57	7	21	17.82	0.66018
58	7	21	23.28	0.32939
59	7	21	17.25	0.69564
60	7	21	18.49	0.61811
61	7	21	14.41	0.85128
62	7	21	10.28	0.97499
63	7	21	16.05	0.76691
64	7	21	22.88	0.35032
65	7	21	21.05	0.45609
66	7	21	21.77	0.41269
67	7	21	15.10	0.81814
68	7	21	28.10	0.13737
69	7	21	29.75	0.09710
70	7	21	21.53	0.42712
71	7	21	31.36	0.06791
72	7	21	25.13	0.24139
73	7	21	10.11	0.97740
74	7	21	16.23	0.75669
75	7	21	19.11	0.57814
76	7	21	13.61	0.88580
77	7	21	27.73	0.14800
78	7	21	14.90	0.82799
79	7	21	12.68	0.91951
80	7	21	15.54	0.79485
81	7	21	18.66	0.60683

82	7	21	34.59	0.03126
83	7	21	19.72	0.53921
84	7	21	22.63	0.36394
85	7	21	15.98	0.77082
86	7	21	27.90	0.14301
87	7	21	20.22	0.50729
88	7	21	18.22	0.63519
89	7	21	15.38	0.80361
90	7	21	23.75	0.30509
91	7	21	33.67	0.03929
92	7	21	20.97	0.46100
93	7	21	27.49	0.15513
94	7	21	23.24	0.33157
95	7	21	33.38	0.04215
96	7	21	26.09	0.20294
97	7	21	35.23	0.02664
98	7	21	15.82	0.77945
99	7	21	16.34	0.75034
100	7	21	23.87	0.29916
Combined P-value for all tests (Using KS method)				0.99964

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	14.95	0.82535
2	7	21	31.52	0.06543
3	7	21	23.59	0.31324
4	7	21	18.35	0.62663
5	7	21	12.40	0.92818
6	7	21	15.26	0.80948
7	7	21	8.52	0.99250
Combined P-value for all tests (Using KS method)				N/A (Insufficient data)

Notes:

- 1) As the total number of tests (7) 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	0.52026	1.00000
Suits Test	0.99964	1.00000
Hand Types Test	0.70045	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 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 1	0.13366	1.00000
Ranks Test 2	0.73489	1.00000
Ranks Test 3	0.46071	1.00000
Ranks Test 4	0.50413	1.00000
Ranks Test 5	0.32189	1.00000
Ranks Test 6	0.76749	1.00000
Ranks Test 7	0.18450	1.00000
Suits Test 1	0.82535	1.00000
Suits Test 2	0.06543	0.98143
Suits Test 3	0.31324	1.00000
Suits Test 4	0.62663	1.00000
Suits Test 5	0.92818	1.00000
Suits Test 6	0.80948	1.00000
Suits Test 7	0.99250	1.00000
Hand Types Test	0.26907	1.00000
Combined P-Value using Holm's Method		0.98143

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

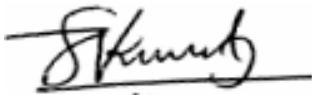
Analysis of actual data from game logs for 'Hand Types', 'Ranks' and 'Suits' for **52-card decks** and **36-card decks** indicated statistical randomness.

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: 15 February 2023

Signed:



Geoff Nicoll
Principal Consultant
iTech Labs Australia
Date: 15 February 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.

