

Poker Cards Analysis - November 2022

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **Nov 01, 2022** to **Nov 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	18.56	0.02918
2	9	13.74	0.13190
3	9	5.31	0.80615
4	9	16.76	0.05261
5	9	6.24	0.71589
6	9	7.35	0.60087
7	9	9.48	0.39448
8	9	10.87	0.28479
9	9	7.21	0.61550
10	9	2.61	0.97767
11	9	2.32	0.98535
12	9	5.03	0.83176
13	9	18.55	0.02933
14	9	5.61	0.77820
15	9	8.65	0.46984
16	9	15.90	0.06907
17	9	8.91	0.44580
18	9	3.85	0.92105
19	9	11.35	0.25236
20	9	6.16	0.72420
21	9	7.19	0.61738
22	9	11.47	0.24462
23	9	10.30	0.32703
24	9	10.38	0.32093

25	9	4.25	0.89424
26	9	6.07	0.73285
27	9	7.89	0.54527
28	9	3.89	0.91828
29	9	7.38	0.59722
30	9	3.54	0.93924
31	9	10.01	0.34960
32	9	10.82	0.28803
33	9	4.90	0.84261
34	9	6.83	0.65457
35	9	5.64	0.77560
36	9	6.28	0.71144
37	9	8.15	0.51952
38	9	11.73	0.22917
39	9	8.09	0.52488
40	9	15.02	0.09050
41	9	19.46	0.02158
42	9	7.96	0.53784
43	9	7.75	0.56000
44	9	13.08	0.15887
45	9	7.35	0.60101
46	9	5.34	0.80387
47	9	6.76	0.66235
48	9	6.09	0.73128
49	9	8.16	0.51850
50	9	6.62	0.67705
51	9	5.38	0.80039
52	9	10.89	0.28330
53	9	5.04	0.83039
54	9	9.00	0.43700
55	9	7.06	0.63067
56	9	8.57	0.47769
57	9	25.23	0.00273
58	9	7.13	0.62371
59	9	18.87	0.02634
60	9	11.17	0.26413
61	9	7.85	0.54976
62	9	16.20	0.06292
63	9	10.28	0.32798
64	9	8.09	0.52487
65	9	7.45	0.59027
66	9	11.43	0.24744
67	9	10.52	0.31005
68	9	2.59	0.97836
69	9	8.33	0.50146
70	9	8.12	0.52256
71	9	18.98	0.02539
72	9	9.69	0.37638
73	9	9.82	0.36496
74	9	4.60	0.86764
75	9	11.58	0.23780
76	9	8.18	0.51618
77	9	19.27	0.02300
78	9	10.53	0.30958
79	9	3.78	0.92518

80	9	14.41	0.10856
81	9	5.67	0.77212
82	9	13.03	0.16138
83	9	11.45	0.24641
84	9	4.21	0.89736
85	9	5.62	0.77732
86	9	13.52	0.14026
87	9	7.46	0.58920
88	9	9.49	0.39350
89	9	7.04	0.63290
90	9	15.31	0.08276
91	9	8.17	0.51710
92	9	8.14	0.52014
93	9	3.19	0.95645
94	9	14.07	0.11996
95	9	7.98	0.53604
96	9	4.11	0.90411
97	9	12.32	0.19564
98	9	7.65	0.57019
99	9	9.70	0.37531
100	9	11.92	0.21794
Combined P-value for all tests (Using KS method)			0.89144

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	15.55	0.04927
2	8	7.87	0.44621
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	82.99	0.51070
2	7	84	89.17	0.32924

3	7	84	96.44	0.16678
4	7	84	87.23	0.38313
5	7	84	73.24	0.79298
6	7	84	83.65	0.49030
7	7	84	48.66	0.99929
8	7	84	71.80	0.82609
9	7	84	82.00	0.54140
10	7	84	73.79	0.77937
11	7	84	71.83	0.82552
12	7	84	75.94	0.72278
13	7	84	89.74	0.31409
14	7	84	76.50	0.70708
15	7	84	87.60	0.37261
16	7	84	77.76	0.67071
17	7	84	73.70	0.78152
18	7	84	84.92	0.45150
19	7	84	89.74	0.31411
20	7	84	80.14	0.59901
21	7	84	94.68	0.19982
22	7	84	73.09	0.79651
23	7	84	62.76	0.95985
24	7	84	87.67	0.37068
25	7	84	95.57	0.18264
26	7	84	111.71	0.02330
27	7	84	70.95	0.84430
28	7	84	73.91	0.77643
29	7	84	96.21	0.17095
30	7	84	84.93	0.45121
31	7	84	77.33	0.68347
32	7	84	84.87	0.45298
33	7	84	70.70	0.84929
34	7	84	90.46	0.29544
35	7	84	90.69	0.28985
36	7	84	78.38	0.65247
37	7	84	83.52	0.49412
38	7	84	98.36	0.13545
39	7	84	78.51	0.64867
40	7	84	86.94	0.39143
41	7	84	95.97	0.17517
42	7	84	100.60	0.10464
43	7	84	68.24	0.89425
44	7	84	65.01	0.93828
45	7	84	87.88	0.36468
46	7	84	92.83	0.23895
47	7	84	71.62	0.83009
48	7	84	77.59	0.67585
49	7	84	76.94	0.69464
50	7	84	88.20	0.35557
51	7	84	75.57	0.73292
52	7	84	85.98	0.41955
53	7	84	84.89	0.45218
54	7	84	101.72	0.09140
55	7	84	82.27	0.53292
56	7	84	73.21	0.79367
57	7	84	85.12	0.44532

58	7	84	69.29	0.87621
59	7	84	85.37	0.43772
60	7	84	67.55	0.90495
61	7	84	74.46	0.76248
62	7	84	75.00	0.74835
63	7	84	62.65	0.96075
64	7	84	68.18	0.89523
65	7	84	103.96	0.06903
66	7	84	82.03	0.54050
67	7	84	69.73	0.86818
68	7	84	96.59	0.16409
69	7	84	98.13	0.13894
70	7	84	86.05	0.41745
71	7	84	89.01	0.33357
72	7	84	76.08	0.71875
73	7	84	72.15	0.81828
74	7	84	89.49	0.32067
75	7	84	97.59	0.14741
76	7	84	98.87	0.12788
77	7	84	75.48	0.73526
78	7	84	61.57	0.96867
79	7	84	65.19	0.93620
80	7	84	78.14	0.65944
81	7	84	74.65	0.75741
82	7	84	87.62	0.37192
83	7	84	81.62	0.55327
84	7	84	96.70	0.16229
85	7	84	85.69	0.42812
86	7	84	72.07	0.82007
87	7	84	62.78	0.95968
88	7	84	81.17	0.56733
89	7	84	87.06	0.38810
90	7	84	93.63	0.22140
91	7	84	92.06	0.25646
92	7	84	84.15	0.47501
93	7	84	60.52	0.97509
94	7	84	76.20	0.71556
95	7	84	97.33	0.15169
96	7	84	76.20	0.71563
97	7	84	96.08	0.17314
98	7	84	63.33	0.95499
99	7	84	67.42	0.90698
100	7	84	82.95	0.51205
Combined P-value for all tests (Using KS method)				0.27036

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	44.34	0.86978
2	7	56	62.70	0.25093
3	7	56	59.46	0.35093
4	7	56	67.16	0.14601
5	7	56	54.56	0.52952
6	7	56	39.57	0.95283
7	7	56	50.08	0.69742
8	7	56	50.76	0.67282
9	7	56	74.59	0.04899
10	7	56	44.26	0.87154
Combined P-value for all tests (Using KS method)				0.89758

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	13.73	0.88073
2	7	21	11.01	0.96264
3	7	21	34.67	0.03071
4	7	21	30.01	0.09173
5	7	21	21.76	0.41360
6	7	21	26.77	0.17849
7	7	21	13.28	0.89851
8	7	21	12.62	0.92135
9	7	21	15.41	0.80182
10	7	21	13.60	0.88597
11	7	21	30.53	0.08190
12	7	21	18.27	0.63206
13	7	21	26.57	0.18556
14	7	21	19.69	0.54084
15	7	21	18.41	0.62277
16	7	21	16.84	0.72097
17	7	21	21.71	0.41625
18	7	21	20.75	0.47454
19	7	21	15.57	0.79342
20	7	21	27.49	0.15527
21	7	21	17.49	0.68081
22	7	21	12.70	0.91870
23	7	21	15.24	0.81081

24	7	21	30.98	0.07392
25	7	21	20.49	0.49053
26	7	21	15.71	0.78575
27	7	21	17.60	0.67400
28	7	21	15.02	0.82202
29	7	21	23.48	0.31868
30	7	21	13.65	0.88434
31	7	21	21.52	0.42736
32	7	21	25.47	0.22731
33	7	21	17.76	0.66392
34	7	21	22.04	0.39736
35	7	21	16.90	0.71696
36	7	21	24.08	0.28909
37	7	21	24.47	0.27082
38	7	21	24.73	0.25889
39	7	21	23.03	0.34233
40	7	21	15.36	0.80443
41	7	21	23.39	0.32340
42	7	21	16.79	0.72382
43	7	21	24.07	0.28958
44	7	21	18.45	0.62011
45	7	21	19.50	0.55295
46	7	21	14.79	0.83352
47	7	21	41.96	0.00425
48	7	21	12.78	0.91607
49	7	21	30.63	0.08007
50	7	21	12.68	0.91948
51	7	21	20.73	0.47553
52	7	21	33.85	0.03760
53	7	21	34.08	0.03557
54	7	21	24.71	0.26015
55	7	21	28.33	0.13104
56	7	21	31.42	0.06702
57	7	21	28.43	0.12845
58	7	21	23.82	0.30188
59	7	21	16.07	0.76561
60	7	21	18.77	0.59974
61	7	21	20.96	0.46114
62	7	21	20.14	0.51212
63	7	21	27.64	0.15063
64	7	21	9.37	0.98602
65	7	21	11.50	0.95224
66	7	21	25.00	0.24736
67	7	21	26.22	0.19822
68	7	21	38.40	0.01156
69	7	21	22.59	0.36601
70	7	21	20.56	0.48598
71	7	21	17.36	0.68906
72	7	21	15.60	0.79167
73	7	21	13.57	0.88740
74	7	21	28.17	0.13532
75	7	21	15.87	0.77696
76	7	21	30.36	0.08503
77	7	21	25.87	0.21127
78	7	21	16.22	0.75719

79	7	21	18.36	0.62583
80	7	21	19.95	0.52415
81	7	21	41.82	0.00443
82	7	21	17.71	0.66737
83	7	21	19.15	0.57553
84	7	21	23.50	0.31795
85	7	21	26.40	0.19175
86	7	21	23.78	0.30381
87	7	21	23.66	0.30982
88	7	21	18.38	0.62462
89	7	21	17.11	0.70413
90	7	21	21.46	0.43130
91	7	21	30.84	0.07640
92	7	21	13.38	0.89459
93	7	21	23.41	0.32233
94	7	21	25.01	0.24682
95	7	21	18.94	0.58927
96	7	21	13.21	0.90102
97	7	21	32.42	0.05309
98	7	21	19.52	0.55158
99	7	21	27.56	0.15321
100	7	21	19.82	0.53245
Combined P-value for all tests (Using KS method)				0.75283

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	15.94	0.77324
2	7	21	24.83	0.25451
3	7	21	38.63	0.01086
4	7	21	19.79	0.53447
5	7	21	19.42	0.55847
6	7	21	22.79	0.35517
7	7	21	12.25	0.93268
8	7	21	16.93	0.71546
9	7	21	15.26	0.80989
10	7	21	14.35	0.85421
Combined P-value for all tests (Using KS method)				0.58074

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	0.27036	0.81108
Suits Test	0.75283	1.00000
Hand Types Test	0.89144	1.00000
Combined P-Value using Holm's Method		0.81108

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	0.89758	1.00000
Suits Test	0.58074	1.00000
HandTypes Test	0.04927	0.19707
HandTypes Test	0.44621	1.00000
Combined P-Value using Holm's Method		0.19707

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: 14 December 2022

Signed:



Geoff Nicoll
Principal Consultant
iTech Labs Australia
Date: 14 December 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.

