

Poker Cards Analysis - December 2022

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **Dec 01, 2022** to **Dec 31, 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	5.76	0.76380
2	9	9.62	0.38220
3	9	8.18	0.51586
4	9	4.81	0.85055
5	9	4.27	0.89246
6	9	4.27	0.89253
7	9	11.72	0.22943
8	9	9.71	0.37469
9	9	9.37	0.40391
10	9	8.02	0.53237
11	9	3.27	0.95259
12	9	12.76	0.17384
13	9	3.82	0.92270
14	9	15.74	0.07258
15	9	13.70	0.13348
16	9	10.12	0.34120
17	9	5.09	0.82606
18	9	4.87	0.84518
19	9	8.55	0.47984
20	9	12.20	0.20212
21	9	11.69	0.23157
22	9	6.66	0.67267
23	9	6.86	0.65122
24	9	8.77	0.45917

25	9	3.39	0.94691
26	9	7.55	0.57968
27	9	5.45	0.79316
28	9	8.86	0.45004
29	9	7.47	0.58866
30	9	16.98	0.04903
31	9	10.47	0.31387
32	9	7.34	0.60200
33	9	6.28	0.71112
34	9	9.63	0.38155
35	9	6.69	0.66928
36	9	10.19	0.33568
37	9	13.40	0.14520
38	9	9.32	0.40814
39	9	10.21	0.33349
40	9	9.52	0.39077
41	9	7.74	0.56058
42	9	12.43	0.18999
43	9	5.19	0.81723
44	9	9.12	0.42652
45	9	14.27	0.11291
46	9	11.61	0.23591
47	9	10.05	0.34659
48	9	3.85	0.92082
49	9	7.91	0.54300
50	9	3.21	0.95532
51	9	8.81	0.45512
52	9	11.02	0.27421
53	9	7.28	0.60764
54	9	8.24	0.50997
55	9	11.46	0.24549
56	9	9.98	0.35183
57	9	5.02	0.83232
58	9	9.13	0.42494
59	9	10.16	0.33763
60	9	4.05	0.90793
61	9	12.54	0.18479
62	9	11.90	0.21921
63	9	6.67	0.67185
64	9	5.96	0.74433
65	9	9.18	0.42105
66	9	9.82	0.36549
67	9	10.83	0.28775
68	9	9.24	0.41562
69	9	9.16	0.42308
70	9	8.81	0.45476
71	9	10.80	0.28938
72	9	10.44	0.31624
73	9	9.43	0.39893
74	9	2.87	0.96933
75	9	8.89	0.44729
76	9	11.39	0.25005
77	9	14.67	0.10041
78	9	8.12	0.52183
79	9	6.89	0.64813

80	9	6.76	0.66223
81	9	6.87	0.65062
82	9	9.12	0.42654
83	9	6.71	0.66719
84	9	24.59	0.00346
85	9	11.77	0.22637
86	9	3.53	0.93962
87	9	5.03	0.83179
88	9	11.61	0.23619
89	9	8.86	0.45024
90	9	4.70	0.85939
91	9	10.87	0.28438
92	9	3.61	0.93543
93	9	12.08	0.20882
94	9	7.30	0.60577
95	9	6.02	0.73811
96	9	6.70	0.66882
97	9	6.65	0.67355
98	9	5.94	0.74639
99	9	5.20	0.81662
100	9	4.51	0.87442
Combined P-value for all tests (Using KS method)			0.20972

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	13.82	0.08661
2	8	9.45	0.30572
3	8	9.76	0.28205
4	8	9.25	0.32188
5	8	8.84	0.35628
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 (5) 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	75.12	0.74503
2	7	84	93.24	0.22997
3	7	84	107.01	0.04594
4	7	84	82.51	0.52548
5	7	84	104.06	0.06814
6	7	84	66.79	0.91598
7	7	84	95.26	0.18851
8	7	84	80.18	0.59785
9	7	84	60.54	0.97500
10	7	84	97.22	0.15353
11	7	84	109.78	0.03105
12	7	84	83.52	0.49422
13	7	84	93.25	0.22968
14	7	84	75.10	0.74555
15	7	84	63.03	0.95760
16	7	84	63.32	0.95515
17	7	84	74.44	0.76280
18	7	84	95.24	0.18880
19	7	84	94.10	0.21150
20	7	84	70.26	0.85810
21	7	84	101.74	0.09122
22	7	84	77.22	0.68660
23	7	84	92.27	0.25172
24	7	84	72.05	0.82059
25	7	84	86.25	0.41147
26	7	84	82.35	0.53064
27	7	84	96.65	0.16318
28	7	84	73.03	0.79799
29	7	84	79.94	0.60516
30	7	84	99.03	0.12556
31	7	84	75.28	0.74078
32	7	84	83.12	0.50668
33	7	84	85.03	0.44802
34	7	84	67.28	0.90896
35	7	84	76.48	0.70771
36	7	84	66.42	0.92104
37	7	84	72.83	0.80272
38	7	84	104.69	0.06280
39	7	84	65.05	0.93781
40	7	84	86.31	0.40996
41	7	84	81.23	0.56528
42	7	84	96.26	0.17002
43	7	84	110.98	0.02600
44	7	84	98.83	0.12841
45	7	84	87.54	0.37429
46	7	84	97.61	0.14716
47	7	84	102.62	0.08179
48	7	84	100.36	0.10765
49	7	84	83.95	0.48105
50	7	84	89.05	0.33244
51	7	84	92.51	0.24617
52	7	84	101.23	0.09700
53	7	84	50.03	0.99881
54	7	84	84.41	0.46692

55	7	84	81.47	0.55775
56	7	84	90.38	0.29763
57	7	84	84.55	0.46259
58	7	84	84.89	0.45229
59	7	84	66.05	0.92580
60	7	84	75.64	0.73109
61	7	84	80.91	0.57510
62	7	84	85.16	0.44410
63	7	84	125.53	0.00226
64	7	84	72.27	0.81562
65	7	84	104.47	0.06463
66	7	84	80.34	0.59295
67	7	84	82.99	0.51062
68	7	84	79.12	0.63020
69	7	84	94.80	0.19742
70	7	84	97.19	0.15395
71	7	84	66.18	0.92416
72	7	84	96.93	0.15828
73	7	84	89.82	0.31211
74	7	84	73.60	0.78402
75	7	84	83.28	0.50168
76	7	84	88.96	0.33486
77	7	84	94.57	0.20192
78	7	84	74.39	0.76425
79	7	84	68.95	0.88229
80	7	84	91.46	0.27078
81	7	84	88.45	0.34874
82	7	84	73.02	0.79826
83	7	84	108.62	0.03665
84	7	84	77.35	0.68267
85	7	84	74.32	0.76609
86	7	84	73.57	0.78473
87	7	84	85.37	0.43778
88	7	84	76.51	0.70683
89	7	84	70.89	0.84553
90	7	84	94.33	0.20687
91	7	84	70.04	0.86230
92	7	84	60.64	0.97443
93	7	84	117.91	0.00868
94	7	84	74.45	0.76266
95	7	84	100.27	0.10881
96	7	84	80.86	0.57695
97	7	84	95.85	0.17740
98	7	84	97.55	0.14814
99	7	84	64.15	0.94735
100	7	84	93.13	0.23223
Combined P-value for all tests (Using KS method)				0.40051

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	49.83	0.70632
2	7	56	64.69	0.19913
3	7	56	49.70	0.71074
4	7	56	59.01	0.36622
5	7	56	50.17	0.69422
6	7	56	64.53	0.20303
7	7	56	46.01	0.82709
8	7	56	48.48	0.75231
9	7	56	53.16	0.58321
10	7	56	57.76	0.40988
11	7	56	55.86	0.48028
12	7	56	60.03	0.33182
13	7	56	57.76	0.40988
14	7	56	46.17	0.82260
15	7	56	66.75	0.15411
16	7	56	58.79	0.37366
17	7	56	59.10	0.36314
18	7	56	68.20	0.12701
19	7	56	50.04	0.69870
20	7	56	58.82	0.37262
Combined P-value for all tests (Using KS method)				0.85272

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	21.67	0.41859
2	7	21	10.22	0.97592
3	7	21	24.31	0.27806
4	7	21	17.22	0.69771
5	7	21	21.95	0.40266
6	7	21	26.08	0.20327
7	7	21	26.61	0.18419
8	7	21	9.54	0.98426
9	7	21	17.51	0.67964
10	7	21	19.22	0.57128
11	7	21	14.89	0.82827
12	7	21	21.38	0.43574
13	7	21	27.00	0.17097

14	7	21	25.49	0.22663
15	7	21	15.47	0.79843
16	7	21	37.83	0.01348
17	7	21	24.60	0.26474
18	7	21	23.61	0.31255
19	7	21	23.94	0.29618
20	7	21	22.25	0.38534
21	7	21	14.65	0.84028
22	7	21	14.70	0.83772
23	7	21	19.84	0.53159
24	7	21	14.83	0.83160
25	7	21	24.55	0.26697
26	7	21	17.36	0.68927
27	7	21	30.78	0.07745
28	7	21	12.19	0.93434
29	7	21	29.25	0.10822
30	7	21	20.77	0.47303
31	7	21	17.50	0.68032
32	7	21	18.10	0.64288
33	7	21	32.45	0.05269
34	7	21	26.10	0.20268
35	7	21	15.88	0.77615
36	7	21	19.55	0.54982
37	7	21	21.20	0.44704
38	7	21	7.31	0.99745
39	7	21	18.52	0.61600
40	7	21	40.66	0.00617
41	7	21	25.99	0.20694
42	7	21	17.35	0.68981
43	7	21	28.51	0.12618
44	7	21	16.17	0.75981
45	7	21	16.36	0.74922
46	7	21	23.91	0.29740
47	7	21	14.09	0.86584
48	7	21	35.54	0.02463
49	7	21	25.94	0.20882
50	7	21	19.39	0.56035
51	7	21	17.27	0.69435
52	7	21	36.95	0.01704
53	7	21	19.29	0.56670
54	7	21	27.07	0.16867
55	7	21	24.73	0.25910
56	7	21	37.97	0.01299
57	7	21	7.24	0.99761
58	7	21	18.88	0.59295
59	7	21	11.41	0.95426
60	7	21	13.51	0.88963
61	7	21	19.67	0.54218
62	7	21	31.27	0.06927
63	7	21	19.85	0.53105
64	7	21	22.16	0.39030
65	7	21	21.35	0.43800
66	7	21	16.91	0.71675
67	7	21	27.15	0.16588
68	7	21	16.99	0.71188

69	7	21	17.91	0.65498
70	7	21	23.23	0.33205
71	7	21	11.34	0.95584
72	7	21	22.63	0.36396
73	7	21	21.86	0.40782
74	7	21	19.61	0.54584
75	7	21	8.30	0.99375
76	7	21	28.52	0.12600
77	7	21	22.03	0.39787
78	7	21	26.10	0.20259
79	7	21	20.86	0.46722
80	7	21	17.32	0.69164
81	7	21	14.64	0.84062
82	7	21	18.70	0.60448
83	7	21	22.62	0.36459
84	7	21	17.76	0.66402
85	7	21	23.17	0.33507
86	7	21	22.21	0.38756
87	7	21	14.42	0.85075
88	7	21	18.33	0.62826
89	7	21	27.94	0.14197
90	7	21	29.38	0.10512
91	7	21	17.76	0.66417
92	7	21	22.65	0.36272
93	7	21	27.88	0.14352
94	7	21	24.41	0.27355
95	7	21	25.32	0.23343
96	7	21	16.68	0.73052
97	7	21	16.97	0.71317
98	7	21	15.57	0.79312
99	7	21	37.94	0.01310
100	7	21	19.99	0.52210
Combined P-value for all tests (Using KS method)				0.93301

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	22.64	0.36347
2	7	21	24.08	0.28920
3	7	21	32.87	0.04766
4	7	21	19.05	0.58206
5	7	21	33.43	0.04164
6	7	21	22.22	0.38716
7	7	21	18.15	0.63937
8	7	21	31.35	0.06800
9	7	21	27.26	0.16228
10	7	21	18.55	0.61385
11	7	21	20.72	0.47615
12	7	21	22.57	0.36744
13	7	21	14.16	0.86263
14	7	21	7.21	0.99770
15	7	21	22.76	0.35691

16	7	21	35.54	0.02459
17	7	21	24.11	0.28766
18	7	21	21.97	0.40136
19	7	21	21.70	0.41721
20	7	21	28.75	0.12013
Combined P-value for all tests (Using KS method)				0.19830

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	0.40051	0.80101
Suits Test	0.93301	0.93301
Hand Types Test	0.20972	0.62915
Combined P-Value using Holm's Method		0.62915

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	0.85272	1.00000
Suits Test	0.19830	1.00000
Hand Types Test 1	0.08661	0.60624
Hand Types Test 2	0.30572	1.00000
Hand Types Test 3	0.28205	1.00000
Hand Types Test 4	0.32188	1.00000
Hand Types Test 5	0.35628	1.00000
Combined P-Value using Holm's Method		0.60624

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

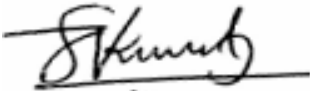
Analysis of actual data from game logs for 'Hand Types', 'Ranks' and 'Suits' for **52-card decks** and **36-card decks** indicated statistical randomness.

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: 20 February 2023

Signed:



Geoff Nicoll
Principal Consultant
iTech Labs Australia
Date: 20 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.