Poker Cards Analysis - March 2022

The Directors
Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **March 01, 2022** to **March 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	9.06	0.43213
2	9	5.79	0.76060
3	9	7.27	0.60939
4	9	14.97	0.09187
5	9	7.86	0.54861
6	9	11.38	0.25062
7	9	9.77	0.36963
8	9	4.57	0.86983
9	9	6.32	0.70704
10	9	14.73	0.09873
11	9	6.68	0.67046
12	9	9.81	0.36580
13	9	12.44	0.18972
14	9	13.45	0.14326
15	9	15.35	0.08188
16	9	3.23	0.95434
17	9	7.87	0.54712
18	9	5.51	0.78803
19	9	10.06	0.34596
20	9	7.67	0.56775
21	9	13.00	0.16272
22	9	7.39	0.59697
23	9	11.66	0.23303
24	9	10.04	0.34743

25	9	2.41	0.98322
26	9	7.83	0.55120
27	9	12.03	0.21163
28	9	6.21	0.71865
29	9	3.74	0.92796
30	9	4.23	0.89557
31	9	7.39	0.59629
32	9	7.32	0.60347
33	9	5.62	0.77683
34	9	4.25	0.89425
35	9	14.38	0.10937
36	9	9.65	0.37974
37	9	9.87	0.36139
38	9	6.49	0.69056
39	9	10.95	0.27895
40	9	12.23	0.20073
41	9	9.51	0.39186
42	9	10.53	0.30953
43	9	11.13	0.26667
44	9	9.98	0.35239
45	9	5.98	0.74142
46	9	8.96	0.44092
47	9	4.35	0.88671
48	9	4.72	0.85817
49	9	15.35	0.08178
50	9	12.28	0.19782
51	9	3.87	0.91994
52	9	6.91	0.64695
53	9	10.88	0.28394
54	9	17.41	0.04263
55	9	9.12	0.42585
56	9	9.10	0.42796
57	9	15.26	0.08416
58	9	6.94	0.64316
59	9	7.26	0.61043
60	9	13.28	0.15039
61	9	8.67	0.46791
62	9	18.89	0.02611
63	9	5.42	0.79651
64	9	10.76	0.29243
65	9	19.80	0.01920
66	9	7.07	0.62980
67	9	11.09	0.26945
68	9	15.76	0.07201
69	9	6.24	0.71576
70	9	10.21	0.33397
71	9	6.63	0.67538
72	9	9.84	0.36373
73	9	6.78	0.66037
74	9	6.14	0.72597
75	9	11.12	0.26775
76	9	13.12	0.15706
77	9	8.71	0.46417
78	9	8.32	0.50256
79	9	10.10	0.34239

80	9	9.17	0.42153
81	9	6.62	0.67656
82	9	5.53	0.78545
83	9	12.20	0.20212
84	9	7.91	0.54355
85	9	12.66	0.17854
86	9	6.01	0.73931
87	9	8.01	0.53291
88	9	8.75	0.46068
89	9	4.10	0.90471
90	9	17.40	0.04284
91	9	7.20	0.61657
92	9	4.39	0.88425
93	9	6.42	0.69700
94	9	8.06	0.52836
95	9	14.79	0.09679
96	9	30.67	0.00034
97	9	4.56	0.87056
98	9	7.53	0.58176
99	9	6.84	0.65347
100	9	7.65	0.56946
Combined P-value for all tests (Using KS method)			0.55057

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	6.39	0.60327
2	8	10.91	0.20660
3	8	6.31	0.61294
Combined P-value for all tests (Using KS method)			N/A (Insufficient data)

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. 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	78.88	0.63753
2	7	84	72.45	0.81158
3	7	84	78.73	0.64203

4	7	84	78.31	0.65461
5	7	84	92.95	0.23623
6	7	84	84.42	0.46669
7	7	84	88.05	0.35995
8	7	84	76.09	0.71869
9	7	84	104.65	0.06314
10	7	84	74.07	0.77240
11	7	84	96.22	0.17074
12	7	84	95.30	0.18765
13	7	84	91.79	0.26288
14	7	84	76.32	0.71222
15	7	84	98.92	0.12719
16	7	84	82.13	0.53736
17	7	84	84.15	0.47491
18	7	84	76.40	0.71003
19	7	84	78.01	0.66351
20	7	84	95.31	0.18743
21	7	84	90.61	0.29161
22	7	84	60.41	0.97574
23	7	84	91.59	0.26762
24	7	84	91.09	0.27984
25	7	84	72.31	0.81466
26	7	84	60.84	0.97327
27	7	84	70.66	0.85015
28	7	84	69.02	0.88108
29	7	84	81.65	0.55223
30	7	84	64.09	0.94789
31	7	84	74.94	0.74971
32	7	84	81.24	0.56505
33	7	84	77.90	0.66665
34	7	84	67.73	0.90229
35	7	84	93.16	0.23165
36	7	84	106.14	0.05179
37	7	84	101.10	0.09860
38	7	84	86.62	0.40066
39	7	84	84.32	0.46981
40	7	84	94.76	0.19817
41	7	84	76.63	0.70343
42	7	84	86.70	0.39837
43	7	84	69.66	0.86962
44	7	84	88.89	0.33661
45	7	84	94.53	0.20285
46	7	84	98.63	0.13135
47	7	84	84.95	0.45047
48	7	84	78.63	0.64502
49	7	84	63.51	0.95344
50	7	84	83.37	0.49877
51	7	84	82.35	0.53064
52	7	84	98.99	0.12614
53	7	84	89.21	0.32816
54	7	84	62.20	0.96419
55	7	84	65.06	0.93765
56	7	84	61.91	0.96631
57	7	84	79.41	0.62152
58	7	84	78.19	0.65807

59	7	84	73.53	0.78580
60	7	84	77.92	0.66602
61	7	84	92.24	0.25243
62	7	84	95.58	0.18239
63	7	84	80.57	0.58582
64	7	84	81.92	0.54393
65	7	84	70.01	0.86293
66	7	84	100.73	0.10305
67	7	84	91.58	0.26790
68	7	84	96.44	0.16678
69	7	84	79.70	0.61245
70	7	84	99.10	0.12458
71	7	84	87.59	0.37291
72	7	84	65.87	0.92809
73	7	84	85.41	0.43671
74	7	84	69.03	0.88090
75	7	84	84.61	0.46070
76	7	84	86.28	0.41081
77	7	84	80.22	0.59650
78	7	84	101.26	0.09667
79	7	84	108.64	0.03657
80	7	84	57.14	0.98910
81	7	84	76.80	0.69858
82	7	84	92.08	0.25617
83	7	84	70.69	0.84950
84	7	84	75.40	0.73741
85	7	84	77.89	0.66687
86	7	84	55.99	0.99202
87	7	84	68.00	0.89799
88	7	84	55.78	0.99247
89	7	84	85.65	0.42944
90	7	84	99.07	0.12501
91	7	84	87.61	0.37213
92	7	84	99.02	0.12565
93	7	84	73.53	0.78588
94	7	84	85.46	0.43517
95	7	84	94.29	0.20770
96	7	84	76.32	0.71221
97	7	84	87.59	0.37284
98	7	84	74.13	0.77078
99	7	84	130.38	0.00089
100	7	84	100.79	0.10230
Combined P-value for all tests (Using KS method)				0.88622

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	70.98	0.08576
2	7	56	52.33	0.61465
3	7	56	66.24	0.16441
4	7	56	50.31	0.68907
5	7	56	54.97	0.51372

6	7	56	60.05	0.33123
7	7	56	65.14	0.18855
8	7	56	42.46	0.90909
9	7	56	41.64	0.92365
10	7	56	74.13	0.05283
11	7	56	61.89	0.27415
12	7	56	49.92	0.70315
13	7	56	68.47	0.12242
14	7	56	67.47	0.14023
15	7	56	82.37	0.01244
Combined P-value for all tests (Using KS method)				0.46482

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	8.69	0.99142
2	7	21	30.11	0.08987
3	7	21	17.63	0.67216
4	7	21	21.96	0.40153
5	7	21	9.99	0.97899
6	7	21	20.15	0.51200
7	7	21	30.67	0.07932
8	7	21	40.17	0.00709
9	7	21	26.23	0.19796
10	7	21	22.28	0.38338
11	7	21	27.19	0.16450
12	7	21	15.61	0.79109
13	7	21	23.55	0.31548
14	7	21	16.12	0.76288
15	7	21	17.87	0.65735
16	7	21	11.89	0.94259
17	7	21	22.93	0.34794
18	7	21	17.13	0.70310
19	7	21	18.28	0.63152
20	7	21	36.34	0.02002
21	7	21	16.14	0.76199
22	7	21	16.34	0.74998
23	7	21	16.10	0.76374
24	7	21	13.71	0.88188
25	7	21	37.50	0.01474
26	7	21	20.69	0.47775
27	7	21	19.65	0.54377
28	7	21	9.71	0.98244
29	7	21	46.07	0.00125

30	7	21	16.24	0.75603
31	7	21	24.38	0.27491
32	7	21	28.70	0.12149
33	7	21	24.60	0.26502
34	7	21	19.10	0.57891
35	7	21	26.39	0.19179
36	7	21	23.06	0.34096
37	7	21	10.38	0.97359
38	7	21	30.21	0.08783
39	7	21	26.94	0.17301
40	7	21	11.69	0.94758
41	7	21	17.73	0.66608
42	7	21	22.73	0.35874
43	7	21	17.15	0.70209
44	7	21	28.74	0.12028
45	7	21	25.92	0.20955
46	7	21	21.13	0.45074
47	7	21	13.10	0.90513
48	7	21	26.27	0.19652
49	7	21	29.07	0.11244
50	7	21	29.81	0.09595
51	7	21	39.94	0.00757
52	7	21	21.09	0.45373
53	7	21	16.89	0.71766
54	7	21	12.51	0.92473
55	7	21	23.00	0.34423
56	7	21	21.63	0.42082
57	7	21	27.63	0.15105
58	7	21	22.57	0.36758
59	7	21	16.74	0.72686
60	7	21	15.65	0.78883
61	7	21	21.31	0.44007
62	7	21	22.62	0.36447
63	7	21	19.09	0.57957
64	7	21	22.94	0.34730
65	7	21	24.73	0.25886
66	7	21	6.79	0.99852
67	7	21	17.25	0.69563
68	7	21	15.93	0.77360
69	7	21	29.67	0.09886
70	7	21	11.97	0.94056
71	7	21	25.30	0.23431
72	7	21	22.96	0.34605
73	7	21	22.67	0.36199
74	7	21	28.89	0.11679
75	7	21	15.55	0.79432
76	7	21	29.04	0.11314
77	7	21	13.72	0.88121
78	7	21	22.94	0.34725
79	7	21	18.02	0.64762
80	7	21	22.65	0.36292
81	7	21	18.25	0.63283
82	7	21	28.53	0.12564
83	7	21	33.57	0.04026
84	7	21	30.72	0.07850

85	7	21	19.10	0.57888
86	7	21	32.45	0.05269
87	7	21	17.54	0.67813
88	7	21	34.64	0.03090
89	7	21	16.85	0.72015
90	7	21	18.21	0.63552
91	7	21	20.94	0.46237
92	7	21	24.03	0.29149
93	7	21	16.32	0.75169
94	7	21	22.52	0.37019
95	7	21	23.88	0.29883
96	7	21	19.26	0.56865
97	7	21	24.65	0.26284
98	7	21	25.34	0.23267
99	7	21	10.04	0.97842
100	7	21	6.62	0.99878
Combined P-value for all tests (Using KS method)				0.25816

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	22.26	0.38444
2	7	21	19.97	0.52329
3	7	21	23.80	0.30285
4	7	21	9.18	0.98769
5	7	21	17.41	0.68610
6	7	21	11.43	0.95370
7	7	21	24.96	0.24890
8	7	21	23.28	0.32923
9	7	21	22.32	0.38128
10	7	21	21.03	0.45699
11	7	21	14.31	0.85583
12	7	21	21.74	0.41486
13	7	21	27.87	0.14382
14	7	21	13.96	0.87131
15	7	21	28.63	0.12328
Combined P-value for all tests (Using KS method)				0.96658

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	0.88622	1.00000
Suits Test	0.25816	0.77448
Hand Types Test	0.55057	1.00000
Combined P-Value using Holm's Method		0.77448

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	0.46482	1.00000
Suits Test	0.96658	1.00000
Hands Type Test	0.60327	1.00000
Hands Type Test	0.20660	1.00000
Hands Type Test	0.61294	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.

The final outcome of the analysis of 36 cards deck indicates that the RNG is working correctly.

5. Conclusion

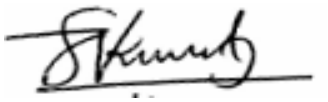
Analysis of actual data from game logs for 'Hand Types, 'Ranks' and 'Suits' for **52-card decks** and **36-card decks** indicated statistical randomness.

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: 26 April 2022

Signed:

Geoff Nicoll
Principal Consultant
iTech Labs Australia
Date: 26 April 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.