



Poker Cards Analysis - August 2023

The Directors

Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **August 01, 2023 to August 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	6.06	0.73396
2	9	4.28	0.89202
3	9	7.14	0.62252
4	9	12.77	0.17336
5	9	6.22	0.71819
6	9	7.98	0.53627
7	9	9.89	0.35951
8	9	4.23	0.89568
9	9	13.37	0.14674
10	9	7.98	0.53568
11	9	11.97	0.21507
12	9	10.54	0.30881
13	9	13.00	0.16261
14	9	5.24	0.81314
15	9	4.74	0.85598
16	9	5.19	0.81701
17	9	12.02	0.21223
18	9	6.33	0.70697
19	9	7.92	0.54190
20	9	6.45	0.69389
21	9	5.43	0.79491
22	9	8.60	0.47498
23	9	7.04	0.63313
24	9	13.87	0.12698
25	9	9.88	0.36011
26	9	4.97	0.83708
27	9	6.74	0.66374

28	9	8.24	0.51029
29	9	11.81	0.22442
30	9	3.98	0.91274
31	9	10.54	0.30855
32	9	9.37	0.40423
33	9	10.75	0.29354
34	9	7.08	0.62904
35	9	9.28	0.41215
36	9	6.02	0.73750
37	9	11.56	0.23947
38	9	8.14	0.52049
39	9	16.78	0.05231
40	9	5.55	0.78423
41	9	12.38	0.19257
42	9	9.14	0.42410
43	9	4.03	0.90944
44	9	11.23	0.26047
45	9	2.34	0.98494
46	9	10.52	0.31012
47	9	7.60	0.57518
48	9	7.12	0.62435
49	9	5.88	0.75234
50	9	8.78	0.45788
51	9	9.05	0.43230
52	9	5.08	0.82757
53	9	6.99	0.63785
54	9	6.01	0.73917
55	9	10.96	0.27876
56	9	6.53	0.68596
57	9	29.68	0.00050
58	9	10.45	0.31549
59	9	9.61	0.38336
60	9	10.20	0.33481
61	9	10.83	0.28722
62	9	11.67	0.23228
63	9	10.93	0.28030
64	9	6.31	0.70890
65	9	13.37	0.14653
66	9	16.22	0.06233
67	9	13.44	0.14379
68	9	3.48	0.94204
69	9	6.01	0.73859
70	9	4.66	0.86322
71	9	7.82	0.55289
72	9	10.62	0.30242
73	9	7.52	0.58302
74	9	6.61	0.67802
75	9	14.85	0.09507
76	9	7.68	0.56647
77	9	11.05	0.27250
78	9	5.28	0.80884
79	9	7.93	0.54113
80	9	13.87	0.12690
81	9	12.64	0.17961
82	9	7.44	0.59140
83	9	4.80	0.85166

84	9	6.47	0.69192
85	9	6.46	0.69303
86	9	15.22	0.08498
87	9	15.01	0.09068
88	9	11.51	0.24235
89	9	10.55	0.30806
90	9	8.60	0.47485
91	9	11.90	0.21910
92	9	9.64	0.38062
93	9	9.46	0.39554
94	9	7.97	0.53722
95	9	5.43	0.79580
96	9	12.56	0.18363
97	9	5.94	0.74636
98	9	10.15	0.33866
99	9	14.62	0.10205
100	9	9.97	0.35281
Combined P-value for all tests (Using KS method)			0.73536

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	3.42	0.90542
2	8	5.71	0.67912
3	8	6.88	0.55007
4	8	3.38	0.90863
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 (4) 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) Since the number of games played each month using 36 card decks is small, the number of samples available this month as well as a few previous months were insufficient to perform a meaningful statistical analysis. Hence the analysis performed this month was done using the cumulative data for the last 4 months - i.e May 2023 to August 2023.

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.	DOF	ChiSqr	P-Value
1	84	85.18	0.44354
2	84	67.69	0.90295
3	84	78.21	0.65761

4	84	75.28	0.74074
5	84	89.92	0.30934
6	84	68.30	0.89318
7	84	80.61	0.58438
8	84	65.51	0.93249
9	84	110.85	0.02652
10	84	99.06	0.12507
11	84	113.56	0.01754
12	84	69.55	0.87152
13	84	71.86	0.82487
14	84	76.95	0.69434
15	84	87.30	0.38107
16	84	76.41	0.70962
17	84	71.87	0.82465
18	84	89.80	0.31255
19	84	63.44	0.95402
20	84	99.63	0.11727
21	84	102.46	0.08343
22	84	51.09	0.99827
23	84	61.50	0.96911
24	84	70.40	0.85535
25	84	69.49	0.87268
26	84	99.51	0.11880
27	84	86.21	0.41284
28	84	80.86	0.57687
29	84	84.68	0.45880
30	84	79.18	0.62847
31	84	94.19	0.20977
32	84	75.50	0.73478
33	84	89.18	0.32884
34	84	110.13	0.02948
35	84	70.27	0.85784
36	84	82.11	0.53803
37	84	86.46	0.40551
38	84	69.45	0.87347
39	84	76.68	0.70211
40	84	84.29	0.47058
41	84	86.03	0.41825
42	84	79.17	0.62877
43	84	87.39	0.37864
44	84	113.45	0.01785
45	84	69.99	0.86326
46	84	87.81	0.36653
47	84	56.28	0.99135
48	84	82.10	0.53814
49	84	74.36	0.76495
50	84	78.47	0.64977
51	84	70.76	0.84816
52	84	85.42	0.43625
53	84	79.77	0.61025
54	84	101.32	0.09604
55	84	72.53	0.80970
56	84	82.49	0.52620
57	84	79.26	0.62594
58	84	89.74	0.31419
59	84	65.24	0.93560

60	84	101.10	0.09857
61	84	87.05	0.38840
62	84	111.76	0.02312
63	84	93.35	0.22749
64	84	83.81	0.48544
65	84	65.69	0.93037
66	84	77.27	0.68523
67	84	86.58	0.40181
68	84	92.11	0.25547
69	84	112.71	0.01999
70	84	93.78	0.21834
71	84	86.47	0.40523
72	84	82.26	0.53324
73	84	66.50	0.91991
74	84	81.26	0.56450
75	84	68.45	0.89074
76	84	81.78	0.54816
77	84	80.71	0.58143
78	84	77.97	0.66450
79	84	66.24	0.92343
80	84	86.87	0.39334
81	84	75.82	0.72614
82	84	94.12	0.21114
83	84	86.06	0.41717
84	84	71.06	0.84196
85	84	107.15	0.04507
86	84	61.26	0.97071
87	84	49.25	0.99911
88	84	122.39	0.00400
89	84	77.71	0.67240
90	84	82.47	0.52670
91	84	100.94	0.10050
92	84	94.05	0.21254
93	84	93.05	0.23400
94	84	84.58	0.46164
95	84	89.67	0.31597
96	84	69.84	0.86619
97	84	120.68	0.00541
98	84	84.00	0.47952
99	84	68.21	0.89468
100	84	58.92	0.98287
Combined P-value for all tests (Using KS method)			0.31664

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	52.81	0.59623
2	7	56	65.86	0.17245
3	7	56	42.23	0.91338
4	7	56	58.77	0.37429
5	7	56	53.25	0.57977
6	7	56	50.29	0.68972
7	7	56	44.08	0.87559
8	7	56	49.11	0.73123
9	7	56	51.61	0.64166
10	7	56	55.14	0.50755
11	7	56	56.58	0.45334
12	7	56	49.36	0.72261
13	7	56	75.17	0.04460
14	7	56	36.00	0.98267
15	7	56	76.11	0.03819
16	7	56	69.72	0.10281
Combined P-value for all tests (Using KS method)				0.87714

Notes:

- 1) Since the number of games played each month using 36 card decks is small, the number of samples available this month as well as a few previous months were insufficient to perform a meaningful statistical analysis. Hence the analysis performed this month was done using the cumulative data for the last 4 months - i.e May 2023 to August 2023.

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	17.60	0.67418
2	7	21	22.87	0.35084
3	7	21	18.33	0.62801
4	7	21	18.36	0.62615
5	7	21	16.44	0.74436
6	7	21	21.71	0.41651
7	7	21	23.15	0.33608
8	7	21	27.81	0.14560
9	7	21	11.81	0.94472
10	7	21	15.58	0.79302
11	7	21	20.75	0.47409
12	7	21	25.69	0.21849
13	7	21	24.70	0.26053
14	7	21	24.87	0.25277
15	7	21	24.04	0.29120
16	7	21	24.20	0.28359

17	7	21	21.40	0.43478
18	7	21	16.20	0.75859
19	7	21	18.91	0.59082
20	7	21	33.46	0.04132
21	7	21	27.07	0.16870
22	7	21	11.11	0.96070
23	7	21	28.06	0.13850
24	7	21	30.12	0.08968
25	7	21	27.68	0.14939
26	7	21	16.78	0.72427
27	7	21	34.44	0.03253
28	7	21	6.36	0.99910
29	7	21	18.87	0.59377
30	7	21	12.09	0.93722
31	7	21	21.86	0.40742
32	7	21	26.86	0.17553
33	7	21	17.74	0.66511
34	7	21	8.96	0.98949
35	7	21	25.35	0.23227
36	7	21	24.21	0.28287
37	7	21	35.32	0.02604
38	7	21	33.17	0.04434
39	7	21	14.43	0.85024
40	7	21	18.39	0.62400
41	7	21	14.76	0.83483
42	7	21	6.00	0.99942
43	7	21	22.96	0.34619
44	7	21	18.27	0.63194
45	7	21	22.91	0.34857
46	7	21	34.55	0.03159
47	7	21	13.74	0.88049
48	7	21	17.88	0.65678
49	7	21	14.62	0.84175
50	7	21	25.99	0.20665
51	7	21	12.50	0.92501
52	7	21	25.45	0.22806
53	7	21	14.86	0.82973
54	7	21	8.54	0.99239
55	7	21	18.88	0.59291
56	7	21	17.97	0.65075
57	7	21	33.92	0.03694
58	7	21	15.25	0.81027
59	7	21	27.71	0.14857
60	7	21	17.06	0.70716
61	7	21	21.15	0.44977
62	7	21	12.44	0.92682
63	7	21	13.89	0.87418
64	7	21	25.62	0.22127
65	7	21	32.80	0.04853
66	7	21	23.91	0.29758
67	7	21	16.46	0.74307
68	7	21	32.71	0.04957
69	7	21	25.93	0.20902
70	7	21	14.35	0.85413
71	7	21	23.69	0.30843
72	7	21	22.53	0.36977

73	7	21	19.49	0.55392
74	7	21	24.68	0.26112
75	7	21	9.03	0.98901
76	7	21	23.14	0.33635
77	7	21	31.14	0.07134
78	7	21	32.17	0.05627
79	7	21	12.86	0.91335
80	7	21	13.16	0.90292
81	7	21	14.42	0.85081
82	7	21	24.20	0.28336
83	7	21	18.54	0.61456
84	7	21	18.81	0.59710
85	7	21	20.49	0.49066
86	7	21	21.12	0.45141
87	7	21	20.50	0.48974
88	7	21	28.27	0.13264
89	7	21	15.68	0.78758
90	7	21	17.61	0.67381
91	7	21	14.04	0.86774
92	7	21	20.48	0.49102
93	7	21	15.59	0.79223
94	7	21	19.57	0.54876
95	7	21	12.79	0.91565
96	7	21	18.50	0.61734
97	7	21	21.41	0.43403
98	7	21	8.64	0.99179
99	7	21	14.02	0.86892
100	7	21	25.07	0.24415
Combined P-value for all tests (Using KS method)				0.68189

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	14.21	0.86050
2	7	21	27.94	0.14175
3	7	21	27.14	0.16640
4	7	21	19.66	0.54262
5	7	21	15.52	0.79599
6	7	21	10.61	0.96989
7	7	21	15.60	0.79169
8	7	21	19.42	0.55796
9	7	21	14.69	0.83828
10	7	21	18.47	0.61897
11	7	21	23.36	0.32509
12	7	21	17.09	0.70576
13	7	21	29.64	0.09946
14	7	21	16.16	0.76059
15	7	21	15.66	0.78822
16	7	21	30.15	0.08905
Combined P-value for all tests (Using KS method)				0.32207

Notes:

- 1) Since the number of games played each month using 36 card decks is small, the number of samples available this month as well as a few previous months were insufficient to perform a meaningful statistical analysis. Hence the analysis performed this month was done using the cumulative data for the last 4 months - i.e May 2023 to August 2023.

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	0.31664	0.94993
Suits Test	0.68189	1.00000
Hand Types Test	0.73536	1.00000
Combined P-Value using Holm's Method		0.94993

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 is 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	0.87714	1.00000
Suits Test	0.32207	1.00000
Hand Types Test 1	0.90542	1.00000
Hand Types Test 2	0.67912	1.00000
Hand Types Test 3	0.55007	1.00000
Hand Types Test 4	0.90863	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.
- 2) Since the number of games played each month using 36 card decks is small, the number of samples available this month as well as a few previous months were insufficient to perform a meaningful statistical analysis. Hence the analysis performed this month was done using the cumulative data for the last 4 months - i.e May 2023 to August 2023.

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

5. Conclusion

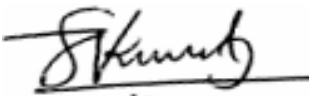
Analysis of actual data from game logs for 'Hand Types', 'Ranks' and 'Suits' for **52-card decks** and **36-card decks** indicated statistical randomness.

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 September 2023

Signed:



Alvin Rizaldi
Senior Consultant
iTech Labs Australia

Date: 14 September 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.