Poker Cards Analysis - December 2023

The Directors
Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **December 01, 2023** to **December 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	8.23	0.51080
2	9	2.74	0.97386
3	9	7.57	0.57800
4	9	5.55	0.78362
5	9	9.30	0.41049
6	9	12.05	0.21059
7	9	3.68	0.93128
8	9	9.23	0.41616
9	9	5.56	0.78329
10	9	9.39	0.40213
11	9	7.24	0.61201
12	9	16.69	0.05378
13	9	9.29	0.41058
14	9	7.81	0.55351
15	9	10.51	0.31043
16	9	11.21	0.26144
17	9	17.89	0.03644
18	9	13.11	0.15769
19	9	6.46	0.69356
20	9	16.26	0.06159
21	9	6.10	0.72978
22	9	10.60	0.30421
23	9	6.06	0.73401
24	9	6.36	0.70353
25	9	3.09	0.96071
26	9	10.05	0.34626
27	9	9.41	0.39989

28	9	6.48	0.69137
29	9	12.76	0.17382
30	9	9.29	0.41080
31	9	8.00	0.53421
32	9	19.19	0.02360
33	9	6.51	0.68830
34	9	3.38	0.94755
35	9	9.13	0.42578
36	9	2.20	0.98789
37	9	20.42	0.01551
38	9	3.91	0.91701
39	9	2.62	0.97734
40	9	5.94	0.74614
41	9	6.41	0.69813
42	9	10.57	0.30610
43	9	9.35	0.40584
44	9	8.86	0.45022
45	9	15.39	0.08082
46	9	7.56	0.57866
47	9	3.10	0.96033
48	9	5.52	0.78711
49	9	10.73	0.29492
50	9	10.43	0.31654
51	9	3.27	0.95250
52	9	15.55	0.07695
53	9	7.79	0.55497
54	9	4.42	0.88147
55	9	5.86	0.75402
56	9	6.43	0.69587
57	9	11.14	0.26651
58	9	10.75	0.29333
59	9	10.61	0.30321
60	9	2.58	0.97880
61	9	5.32	0.80598
62	9	8.87	0.44948
63	9	17.47	0.04184
64	9	5.22	0.81495
65	9	6.75	0.66267
66	9	14.49	0.10587
67	9	10.92	0.28137
68	9	2.54	0.97983
69	9	4.01	0.91066
70	9	7.40	0.59539
71	9	11.18	0.26334
72	9	18.77	0.02723
73	9	8.38	0.49617
74	9	12.05	0.21073
75	9	7.83	0.55175
76	9	8.81	0.45547
77	9	10.09	0.34318
78	9	2.88	0.96886
79	9	9.02	0.43559
80	9	2.87	0.96935
81	9	20.79	0.01361
82	9	7.12	0.62443
83	9	9.03	0.43466

84	9	3.22	0.95471
85	9	19.27	0.02300
86	9	11.37	0.25143
87	9	17.55	0.04078
88	9	7.59	0.57561
89	9	10.84	0.28711
90	9	11.37	0.25088
91	9	4.13	0.90260
92	9	11.15	0.26579
93	9	13.34	0.14795
94	9	5.83	0.75681
95	9	5.18	0.81872
96	9	8.55	0.47986
97	9	11.25	0.25883
98	9	10.07	0.34519
99	9	8.55	0.47963
100	9	4.78	0.85322
Combined P-value for all tests (Using KS method)			0.68090

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	7.28	0.50712
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 (3) 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 7 months - i.e June 2023 to December 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	91.74	0.26413
2	84	75.43	0.73682
3	84	92.93	0.23675
4	84	88.83	0.33835
5	84	82.80	0.51662

6	84	81.20	0.56628
7	84	88.48	0.34801
8	84	96.49	0.16597
9	84	88.09	0.35869
10	84	79.82	0.60874
11	84	83.67	0.48949
12	84	93.91	0.21555
13	84	109.89	0.03051
14	84	85.22	0.44228
15	84	91.25	0.27580
16	84	83.20	0.50405
17	84	72.44	0.81178
18	84	86.74	0.39738
19	84	72.77	0.80418
20	84	120.42	0.00565
21	84	67.65	0.90353
22	84	83.10	0.50711
23	84	65.83	0.92867
24	84	82.74	0.51829
25	84	77.24	0.68583
26	84	61.43	0.96960
27	84	103.08	0.07721
28	84	91.66	0.26589
29	84	87.31	0.38069
30	84	83.58	0.49247
31	84	57.80	0.98705
32	84	82.47	0.52680
33	84	72.69	0.80605
34	84	80.05	0.60171
35	84	126.86	0.00176
36	84	71.96	0.82269
37	84	73.26	0.79236
38	84	88.76	0.34033
39	84	54.99	0.99400
40	84	80.59	0.58521
41	84	94.89	0.19571
42	84	87.02	0.38916
43	84	77.01	0.69246
44	84	84.64	0.45988
45	84	90.05	0.30604
46	84	74.08	0.77214
47	84	94.22	0.20907
48	84	83.27	0.50195
49	84	89.87	0.31081
50	84	97.04	0.15645
51	84	76.02	0.72065
52	84	70.65	0.85047
53	84	81.66	0.55196
54	84	75.15	0.74415
55	84	76.96	0.69405
56	84	84.70	0.45800
57	84	110.28	0.02885
58	84	82.91	0.51302
59	84	118.22	0.00824
60	84	72.19	0.81741
61	84	69.41	0.87413

62	84	105.52	0.05626
63	84	77.33	0.68343
64	84	69.72	0.86835
65	84	90.10	0.30481
66	84	96.39	0.16763
67	84	68.34	0.89262
68	84	88.92	0.33597
69	84	101.94	0.08896
70	84	96.77	0.16106
71	84	91.40	0.27220
72	84	102.66	0.08143
73	84	74.30	0.76649
74	84	85.36	0.43804
75	84	108.83	0.03557
76	84	81.48	0.55746
77	84	74.40	0.76398
78	84	80.30	0.59401
79	84	87.64	0.37151
80	84	83.23	0.50310
81	84	89.33	0.32479
82	84	78.24	0.65655
83	84	86.88	0.39306
84	84	76.00	0.72107
85	84	87.68	0.37017
86	84	93.41	0.22623
87	84	66.00	0.92648
88	84	70.82	0.84697
89	84	114.18	0.01592
90	84	76.83	0.69771
91	84	85.18	0.44350
92	84	82.51	0.52556
93	84	91.35	0.27350
94	84	96.18	0.17140
95	84	71.63	0.82982
96	84	88.49	0.34771
97	84	97.53	0.14847
98	84	105.06	0.05982
99	84	65.02	0.93814
100	84	108.92	0.03516
Combined P-value for all tests (Using KS method)			0.64133

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	67.26	0.14406
Combined P-value for all tests (Using KS method)				0.48686

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 7 months - i.e June 2023 to December 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	19.17	0.57424
2	7	21	28.54	0.12549
3	7	21	29.47	0.10312
4	7	21	31.89	0.06008
5	7	21	21.54	0.42643
6	7	21	19.35	0.56251
7	7	21	24.86	0.25324
8	7	21	13.76	0.87987
9	7	21	8.31	0.99369
10	7	21	19.29	0.56674
11	7	21	20.86	0.46748
12	7	21	11.48	0.95271
13	7	21	15.68	0.78711
14	7	21	15.57	0.79330
15	7	21	21.14	0.45021
16	7	21	23.99	0.29372
17	7	21	26.00	0.20650
18	7	21	16.37	0.74848
19	7	21	12.98	0.90920
20	7	21	21.70	0.41687

21	7	21	16.81	0.72244
22	7	21	13.11	0.90464
23	7	21	10.34	0.97415
24	7	21	15.32	0.80631
25	7	21	21.50	0.42887
26	7	21	18.98	0.58627
27	7	21	13.08	0.90584
28	7	21	16.86	0.71973
29	7	21	14.33	0.85495
30	7	21	11.93	0.94154
31	7	21	27.80	0.14598
32	7	21	35.59	0.02430
33	7	21	30.70	0.07874
34	7	21	12.81	0.91523
35	7	21	16.68	0.73031
36	7	21	11.15	0.95979
37	7	21	16.91	0.71635
38	7	21	28.28	0.13236
39	7	21	24.77	0.25712
40	7	21	23.51	0.31752
41	7	21	16.27	0.75412
42	7	21	14.63	0.84093
43	7	21	15.56	0.79403
44	7	21	19.62	0.54572
45	7	21	22.79	0.35525
46	7	21	25.99	0.20665
47	7	21	22.13	0.39219
48	7	21	19.45	0.55605
49	7	21	20.09	0.51533
50	7	21	13.57	0.88746
51	7	21	22.43	0.37489
52	7	21	25.40	0.23033
53	7	21	28.75	0.12024
54	7	21	20.69	0.47813
55	7	21	19.04	0.58234
56	7	21	22.89	0.34984
57	7	21	20.32	0.50126
58	7	21	21.48	0.42996
59	7	21	23.16	0.33539
60	7	21	11.74	0.94643
61	7	21	22.97	0.34569
62	7	21	31.04	0.07307
63	7	21	26.68	0.18153
64	7	21	17.68	0.66930
65	7	21	27.66	0.15002
66	7	21	24.88	0.25260
67	7	21	23.24	0.33139
68	7	21	15.37	0.80390
69	7	21	23.38	0.32419
70	7	21	19.62	0.54567
71	7	21	20.97	0.46102
72	7	21	12.41	0.92786
73	7	21	22.46	0.37342
74	7	21	30.00	0.09206
75	7	21	23.76	0.30491
76	7	21	18.59	0.61127

77	7	21	20.22	0.50714
78	7	21	17.73	0.66629
79	7	21	14.56	0.84434
80	7	21	15.53	0.79536
81	7	21	25.43	0.22887
82	7	21	16.60	0.73492
83	7	21	14.30	0.85645
84	7	21	12.09	0.93706
85	7	21	32.15	0.05654
86	7	21	25.72	0.21744
87	7	21	21.18	0.44816
88	7	21	11.40	0.95438
89	7	21	28.88	0.11694
90	7	21	15.32	0.80674
91	7	21	27.60	0.15177
92	7	21	22.60	0.36579
93	7	21	14.53	0.84571
94	7	21	24.67	0.26170
95	7	21	9.21	0.98750
96	7	21	21.94	0.40318
97	7	21	17.73	0.66621
98	7	21	29.55	0.10151
99	7	21	13.52	0.88924
100	7	21	13.51	0.88960
Combined P-value for all tests (Using KS method)				0.41734

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	30.82	0.07676
Combined P-value for all tests (Using KS method)				0.41746

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 7 months - i.e June 2023 to December 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	0.64133	1.00000
Suits Test	0.41734	1.00000
Hand Types Test	0.68090	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 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	0.48686	1.00000
Suits Test	0.41746	1.00000
Hand Types Test 1	0.90542	1.00000
Hand Types Test 2	0.67912	1.00000
Hand Types Test 3	0.50712	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 7 months - i.e June 2023 to December 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:	**Signed:**
Alvin Rizaldi **Chief Executive Officer** **iTech Labs** Date: 18 January 2024	**Divya Bhargava** **Project Manager** **iTech Labs** Date: 18 January 2024

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.