Poker Cards Analysis - October 2023

The Directors
Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **October 01, 2023** to **October 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	5.59	0.78021
2	9	3.99	0.91211
3	9	12.92	0.16642
4	9	9.01	0.43629
5	9	12.04	0.21097
6	9	12.29	0.19759
7	9	19.87	0.01871
8	9	5.50	0.78840
9	9	1.47	0.99738
10	9	9.14	0.42437
11	9	8.51	0.48322
12	9	6.96	0.64148
13	9	5.81	0.75905
14	9	8.04	0.53041
15	9	21.81	0.00951
16	9	1.73	0.99501
17	9	16.75	0.05278
18	9	5.57	0.78177
19	9	5.51	0.78824
20	9	6.12	0.72824
21	9	2.67	0.97589
22	9	4.98	0.83607
23	9	6.44	0.69497
24	9	12.77	0.17338
25	9	12.53	0.18523
26	9	11.08	0.27046
27	9	9.53	0.38984

28	9	6.45	0.69465
29	9	12.93	0.16564
30	9	12.21	0.20162
31	9	6.08	0.73155
32	9	7.70	0.56453
33	9	7.05	0.63222
34	9	6.94	0.64388
35	9	14.82	0.09597
36	9	2.24	0.98712
37	9	7.20	0.61676
38	9	8.28	0.50587
39	9	16.33	0.06030
40	9	4.49	0.87597
41	9	6.34	0.70515
42	9	4.50	0.87543
43	9	10.85	0.28597
44	9	10.90	0.28264
45	9	8.38	0.49603
46	9	6.96	0.64130
47	9	8.67	0.46782
48	9	5.60	0.77882
49	9	8.54	0.48085
50	9	7.67	0.56771
51	9	10.18	0.33614
52	9	8.13	0.52077
53	9	2.10	0.98975
54	9	12.79	0.17254
55	9	11.22	0.26091
56	9	8.61	0.47413
57	9	7.25	0.61086
58	9	11.30	0.25601
59	9	8.96	0.44056
60	9	4.56	0.87059
61	9	4.19	0.89845
62	9	5.21	0.81579
63	9	8.02	0.53259
64	9	9.97	0.35320
65	9	5.47	0.79166
66	9	8.87	0.44976
67	9	15.16	0.08666
68	9	9.52	0.39093
69	9	13.11	0.15758
70	9	14.19	0.11572
71	9	7.50	0.58490
72	9	9.82	0.36554
73	9	4.06	0.90753
74	9	5.55	0.78409
75	9	9.33	0.40780
76	9	8.45	0.48974
77	9	9.61	0.38307
78	9	5.68	0.77186
79	9	5.60	0.77941
80	9	7.92	0.54271
81	9	14.55	0.10419
82	9	15.35	0.08178
83	9	5.47	0.79177

84	9	8.67	0.46810
85	9	14.92	0.09310
86	9	10.98	0.27682
87	9	12.98	0.16341
88	9	6.24	0.71580
89	9	15.91	0.06888
90	9	14.77	0.09746
91	9	12.62	0.18081
92	9	15.09	0.08850
93	9	10.35	0.32278
94	9	7.93	0.54127
95	9	12.48	0.18750
96	9	5.38	0.79960
97	9	4.28	0.89184
98	9	13.30	0.14966
99	9	6.10	0.72967
100	9	10.14	0.33962
Combined P-value for all tests (Using KS method)			0.95677

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	1.97	0.98200
2	8	6.47	0.59482
3	8	5.86	0.66241
4	8	5.15	0.74165
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 5 months - i.e April 2023 to August 2023 and October 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	79.83	0.60853

2	84	86.20	0.41304
3	84	95.24	0.18893
4	84	84.24	0.47213
5	84	90.92	0.28411
6	84	77.37	0.68218
7	84	92.89	0.23767
8	84	87.62	0.37196
9	84	81.20	0.56628
10	84	103.84	0.07008
11	84	58.27	0.98540
12	84	64.54	0.94332
13	84	83.04	0.50919
14	84	77.70	0.67252
15	84	72.62	0.80751
16	84	84.72	0.45759
17	84	110.39	0.02838
18	84	62.08	0.96511
19	84	76.60	0.70419
20	84	60.46	0.97544
21	84	84.78	0.45569
22	84	71.26	0.83771
23	84	106.54	0.04904
24	84	90.23	0.30152
25	84	78.65	0.64431
26	84	60.55	0.97496
27	84	91.89	0.26062
28	84	79.12	0.63030
29	84	94.09	0.21173
30	84	99.80	0.11489
31	84	77.00	0.69282
32	84	108.31	0.03833
33	84	73.52	0.78594
34	84	101.62	0.09255
35	84	91.82	0.26210
36	84	57.56	0.98782
37	84	90.62	0.29147
38	84	95.36	0.18650
39	84	79.49	0.61887
40	84	109.35	0.03304
41	84	92.07	0.25632
42	84	84.63	0.46034
43	84	67.89	0.89976
44	84	106.36	0.05027
45	84	84.15	0.47496
46	84	80.33	0.59329
47	84	69.20	0.87797
48	84	80.95	0.57402
49	84	72.29	0.81520
50	84	73.36	0.78992
51	84	80.82	0.57818
52	84	69.11	0.87953
53	84	70.18	0.85974
54	84	73.49	0.78679
55	84	66.69	0.91739
56	84	70.06	0.86202
57	84	121.73	0.00449

58	84	71.72	0.82794
59	84	70.44	0.85450
60	84	72.90	0.80093
61	84	94.08	0.21189
62	84	86.95	0.39115
63	84	84.05	0.47805
64	84	99.26	0.12232
65	84	111.63	0.02359
66	84	70.78	0.84766
67	84	94.20	0.20956
68	84	85.18	0.44351
69	84	95.27	0.18827
70	84	106.53	0.04911
71	84	100.32	0.10814
72	84	110.40	0.02832
73	84	79.96	0.60442
74	84	91.49	0.27003
75	84	77.94	0.66536
76	84	105.90	0.05345
77	84	79.52	0.61817
78	84	59.61	0.97980
79	84	95.37	0.18637
80	84	82.68	0.52032
81	84	77.51	0.67813
82	84	81.60	0.55390
83	84	92.03	0.25731
84	84	82.11	0.53809
85	84	77.29	0.68450
86	84	66.38	0.92156
87	84	83.10	0.50724
88	84	105.52	0.05623
89	84	96.55	0.16485
90	84	84.43	0.46633
91	84	100.60	0.10460
92	84	65.11	0.93710
93	84	86.04	0.41789
94	84	79.99	0.60354
95	84	72.43	0.81209
96	84	115.78	0.01233
97	84	72.74	0.80474
98	84	71.10	0.84117
99	84	70.86	0.84615
100	84	71.64	0.82955
Combined P-value for all tests (Using KS method)			0.43445

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	53.41	0.57359
2	7	56	35.43	0.98560
3	7	56	43.38	0.89094
4	7	56	34.44	0.98969
5	7	56	58.90	0.36993
6	7	56	68.83	0.11650
7	7	56	61.11	0.29748
8	7	56	55.53	0.49252
9	7	56	56.23	0.46609
10	7	56	54.24	0.54191
11	7	56	68.37	0.12424
12	7	56	57.44	0.42159
13	7	56	52.96	0.59075
14	7	56	60.91	0.30362
15	7	56	49.09	0.73184
16	7	56	67.77	0.13463
17	7	56	52.94	0.59129
Combined P-value for all tests (Using KS method)				0.95226

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 5 months - i.e April 2023 to August 2023 and October 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	24.11	0.28752
2	7	21	20.31	0.50187
3	7	21	12.89	0.91254
4	7	21	28.66	0.12243
5	7	21	13.66	0.88390
6	7	21	27.20	0.16445
7	7	21	12.81	0.91528
8	7	21	30.09	0.09020
9	7	21	14.42	0.85105
10	7	21	27.67	0.14979
11	7	21	13.57	0.88746
12	7	21	18.78	0.59952
13	7	21	19.73	0.53838
14	7	21	12.13	0.93596
15	7	21	26.22	0.19824

16	7	21	18.97	0.58728
17	7	21	34.46	0.03233
18	7	21	16.21	0.75746
19	7	21	20.27	0.50426
20	7	21	17.72	0.66642
21	7	21	21.12	0.45172
22	7	21	21.31	0.44037
23	7	21	26.55	0.18613
24	7	21	24.88	0.25223
25	7	21	9.86	0.98064
26	7	21	13.42	0.89329
27	7	21	25.17	0.24009
28	7	21	27.04	0.16962
29	7	21	12.88	0.91276
30	7	21	19.70	0.54047
31	7	21	14.84	0.83070
32	7	21	21.77	0.41267
33	7	21	13.46	0.89171
34	7	21	31.44	0.06670
35	7	21	27.89	0.14329
36	7	21	14.44	0.84985
37	7	21	22.13	0.39200
38	7	21	15.11	0.81753
39	7	21	14.43	0.85028
40	7	21	18.44	0.62085
41	7	21	14.68	0.83880
42	7	21	34.41	0.03272
43	7	21	17.67	0.66949
44	7	21	22.13	0.39213
45	7	21	28.46	0.12752
46	7	21	20.58	0.48509
47	7	21	25.74	0.21648
48	7	21	20.64	0.48131
49	7	21	25.15	0.24086
50	7	21	26.45	0.18965
51	7	21	21.93	0.40360
52	7	21	23.55	0.31554
53	7	21	20.30	0.50217
54	7	21	14.82	0.83182
55	7	21	29.47	0.10314
56	7	21	11.56	0.95069
57	7	21	24.27	0.28026
58	7	21	15.00	0.82290
59	7	21	26.50	0.18816
60	7	21	19.32	0.56441
61	7	21	15.70	0.78616
62	7	21	20.53	0.48769
63	7	21	39.44	0.00869
64	7	21	25.05	0.24495
65	7	21	34.67	0.03067
66	7	21	17.52	0.67929
67	7	21	8.76	0.99095
68	7	21	21.23	0.44501
69	7	21	21.54	0.42622
70	7	21	20.69	0.47780
71	7	21	19.48	0.55451

72	7	21	20.91	0.46464
73	7	21	17.82	0.66032
74	7	21	14.15	0.86297
75	7	21	17.00	0.71121
76	7	21	22.75	0.35746
77	7	21	15.88	0.77610
78	7	21	18.33	0.62814
79	7	21	23.97	0.29435
80	7	21	14.72	0.83652
81	7	21	24.71	0.26004
82	7	21	20.73	0.47547
83	7	21	19.06	0.58128
84	7	21	16.96	0.71348
85	7	21	11.50	0.95207
86	7	21	20.27	0.50418
87	7	21	12.50	0.92500
88	7	21	23.23	0.33207
89	7	21	23.73	0.30631
90	7	21	11.14	0.96009
91	7	21	21.16	0.44913
92	7	21	21.78	0.41251
93	7	21	12.38	0.92885
94	7	21	17.78	0.66273
95	7	21	10.29	0.97495
96	7	21	23.66	0.30984
97	7	21	16.71	0.72874
98	7	21	32.33	0.05414
99	7	21	23.23	0.33169
100	7	21	29.56	0.10129
Combined P-value for all tests (Using KS method)				0.56801

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	27.22	0.16356
2	7	21	24.06	0.28997
3	7	21	22.18	0.38943
4	7	21	25.42	0.22927
5	7	21	21.58	0.42429
6	7	21	17.86	0.65810
7	7	21	22.16	0.39034
8	7	21	11.30	0.95671
9	7	21	22.17	0.38988
10	7	21	15.12	0.81688
11	7	21	17.54	0.67765
12	7	21	21.16	0.44921
13	7	21	22.60	0.36567
14	7	21	21.61	0.42239
15	7	21	20.26	0.50460
16	7	21	16.74	0.72698
17	7	21	15.06	0.81988

Combined P-value for all tests (Using KS method)	0.53144

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 5 months - i.e April 2023 to August 2023 and October 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	0.43445	1.00000
Suits Test	0.56801	1.00000
Hand Types Test	0.95677	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	0.95226	1.00000
Suits Test	0.53144	1.00000
Hand Types Test 1	0.98200	1.00000
Hand Types Test 2	0.59482	1.00000
Hand Types Test 3	0.66241	1.00000
Hand Types Test 4	0.74165	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 5 months - i.e April 2023 to August 2023 and October 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: 23 November 2023	**Divya Bhargava** **Project Manager** **iTech Labs** Date: 23 November 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.