Poker Cards Analysis – January 2024

The Directors
Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **January 01, 2024** to **January 31, 2024** 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	6.70	0.66796
2	9	10.83	0.28743
3	9	19.44	0.02169
4	9	9.64	0.38034
5	9	7.47	0.58820
6	9	5.25	0.81181
7	9	6.15	0.72499
8	9	10.70	0.29704
9	9	9.17	0.42167
10	9	6.22	0.71780
11	9	8.29	0.50501
12	9	13.33	0.14814
13	9	3.22	0.95502
14	9	10.50	0.31168
15	9	8.18	0.51598
16	9	16.47	0.05773
17	9	15.43	0.07977
18	9	14.52	0.10501
19	9	11.94	0.21662
20	9	3.23	0.95449
21	9	3.48	0.94236
22	9	13.55	0.13917
23	9	9.33	0.40695
24	9	6.66	0.67270
25	9	7.67	0.56811
26	9	17.70	0.03880
27	9	5.06	0.82915

28	9	15.62	0.07519
29	9	4.04	0.90885
30	9	15.77	0.07191
31	9	10.18	0.33649
32	9	5.56	0.78310
33	9	9.74	0.37199
34	9	10.86	0.28566
35	9	3.07	0.96131
36	9	4.72	0.85794
37	9	12.90	0.16727
38	9	10.04	0.34737
39	9	9.41	0.40030
40	9	3.49	0.94182
41	9	7.20	0.61664
42	9	5.58	0.78120
43	9	8.22	0.51220
44	9	4.71	0.85852
45	9	5.16	0.82039
46	9	8.82	0.45365
47	9	3.04	0.96274
48	9	5.55	0.78415
49	9	10.12	0.34056
50	9	4.03	0.90973
51	9	7.82	0.55195
52	9	6.35	0.70472
53	9	8.17	0.51758
54	9	12.69	0.17719
55	9	6.72	0.66671
56	9	7.15	0.62191
57	9	8.02	0.53167
58	9	7.59	0.57607
59	9	6.27	0.71247
60	9	2.91	0.96765
61	9	15.50	0.07816
62	9	3.73	0.92848
63	9	11.61	0.23613
64	9	7.37	0.59822
65	9	7.05	0.63197
66	9	18.28	0.03211
67	9	6.53	0.68592
68	9	3.04	0.96278
69	9	13.05	0.16024
70	9	7.50	0.58481
71	9	11.18	0.26356
72	9	6.60	0.67825
73	9	21.90	0.00919
74	9	7.83	0.55126
75	9	9.43	0.39818
76	9	4.62	0.86573
77	9	14.07	0.11995
78	9	3.76	0.92640
79	9	8.80	0.45565
80	9	22.44	0.00758
81	9	6.84	0.65337
82	9	3.19	0.95614
83	9	16.58	0.05564

84	9	15.08	0.08881
85	9	8.53	0.48179
86	9	5.31	0.80679
87	9	7.67	0.56762
88	9	2.49	0.98124
89	9	9.40	0.40103
90	9	8.59	0.47587
91	9	4.21	0.89707
92	9	12.66	0.17839
93	9	6.87	0.65089
94	9	10.84	0.28671
95	9	8.94	0.44267
96	9	11.04	0.27288
97	9	6.00	0.74006
98	9	7.51	0.58398
99	9	3.62	0.93472
100	9	3.25	0.95352
Combined P-value for all tests (Using KS method)			0.71529

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	5.31	0.72365
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 (2) 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 6 months - i.e July 2023 to January 2024.

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	100.95	0.10038
2	84	109.51	0.03225
3	84	80.64	0.58354
4	84	65.24	0.93564
5	84	105.67	0.05517
6	84	78.18	0.65846

7	84	78.22	0.65734
8	84	78.51	0.64856
9	84	101.21	0.09733
10	84	68.83	0.88444
11	84	92.11	0.25542
12	84	66.96	0.91357
13	84	88.53	0.34669
14	84	81.85	0.54616
15	84	85.29	0.44025
16	84	82.38	0.52971
17	84	105.23	0.05846
18	84	79.72	0.61191
19	84	105.34	0.05759
20	84	90.67	0.29025
21	84	91.46	0.27077
22	84	79.70	0.61246
23	84	75.31	0.73985
24	84	81.73	0.54965
25	84	88.11	0.35818
26	84	91.52	0.26928
27	84	78.41	0.65167
28	84	89.16	0.32939
29	84	71.46	0.83349
30	84	77.86	0.66783
31	84	98.45	0.13406
32	84	60.70	0.97406
33	84	66.55	0.91933
34	84	75.13	0.74465
35	84	105.82	0.05401
36	84	75.38	0.73808
37	84	72.32	0.81448
38	84	88.63	0.34388
39	84	93.81	0.21760
40	84	88.72	0.34137
41	84	71.38	0.83525
42	84	81.14	0.56812
43	84	100.33	0.10797
44	84	80.90	0.57571
45	84	76.82	0.69799
46	84	79.17	0.62865
47	84	71.64	0.82955
48	84	87.38	0.37876
49	84	98.85	0.12817
50	84	89.06	0.33207
51	84	88.32	0.35243
52	84	89.13	0.33025
53	84	85.30	0.44004
54	84	90.69	0.28977
55	84	84.26	0.47156
56	84	74.29	0.76680
57	84	88.20	0.35563
58	84	70.45	0.85435
59	84	83.83	0.48467
60	84	63.06	0.95734
61	84	80.22	0.59662
62	84	74.39	0.76413

63	84	78.49	0.64922
64	84	82.01	0.54102
65	84	73.46	0.78747
66	84	104.21	0.06684
67	84	96.18	0.17147
68	84	98.94	0.12690
69	84	71.87	0.82470
70	84	77.52	0.67794
71	84	86.47	0.40516
72	84	62.15	0.96460
73	84	60.78	0.97359
74	84	97.68	0.14602
75	84	91.38	0.27273
76	84	93.74	0.21915
77	84	64.66	0.94210
78	84	101.20	0.09734
79	84	84.15	0.47474
80	84	103.11	0.07698
81	84	95.10	0.19155
82	84	111.64	0.02356
83	84	76.77	0.69933
84	84	72.77	0.80406
85	84	87.57	0.37347
86	84	73.96	0.77510
87	84	85.05	0.44742
88	84	79.21	0.62758
89	84	92.79	0.23978
90	84	82.80	0.51671
91	84	72.83	0.80259
92	84	85.78	0.42541
93	84	106.09	0.05214
94	84	81.58	0.55456
95	84	81.67	0.55154
96	84	86.22	0.41259
97	84	110.19	0.02923
98	84	70.97	0.84380
99	84	83.03	0.50944
100	84	91.96	0.25881
Combined P-value for all tests (Using KS method)			0.98081

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	54.44	0.53421
Combined P-value for all tests (Using KS method)				N/A (Insufficient data)

Notes:

1) As the total number of tests (8) 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) 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 6 months - i.e July 2023 to January 2024.

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	17.83	0.65995
2	7	21	24.22	0.28235
3	7	21	18.49	0.61808
4	7	21	18.32	0.62882
5	7	21	18.66	0.60688
6	7	21	27.89	0.14319
7	7	21	19.94	0.52496
8	7	21	23.69	0.30820
9	7	21	20.95	0.46184
10	7	21	20.38	0.49753
11	7	21	25.69	0.21857
12	7	21	17.85	0.65875
13	7	21	16.05	0.76667
14	7	21	8.19	0.99426
15	7	21	12.46	0.92635
16	7	21	12.91	0.91167
17	7	21	23.19	0.33393
18	7	21	27.03	0.16988
19	7	21	22.96	0.34626
20	7	21	17.66	0.67014
21	7	21	30.43	0.08363
22	7	21	15.59	0.79231
23	7	21	15.35	0.80477

24	7	21	19.61	0.54584
25	7	21	21.53	0.42692
26	7	21	9.56	0.98412
27	7	21	20.30	0.50219
28	7	21	28.75	0.12003
29	7	21	24.42	0.27333
30	7	21	39.00	0.00983
31	7	21	22.10	0.39359
32	7	21	16.54	0.73868
33	7	21	16.22	0.75714
34	7	21	18.67	0.60631
35	7	21	28.49	0.12672
36	7	21	20.94	0.46246
37	7	21	28.15	0.13582
38	7	21	25.72	0.21740
39	7	21	27.75	0.14750
40	7	21	18.89	0.59248
41	7	21	24.15	0.28608
42	7	21	14.28	0.85736
43	7	21	38.43	0.01147
44	7	21	14.19	0.86118
45	7	21	18.67	0.60646
46	7	21	38.61	0.01092
47	7	21	22.22	0.38716
48	7	21	22.23	0.38647
49	7	21	21.96	0.40182
50	7	21	33.24	0.04365
51	7	21	19.63	0.54465
52	7	21	31.82	0.06100
53	7	21	30.21	0.08780
54	7	21	20.68	0.47876
55	7	21	17.10	0.70528
56	7	21	19.77	0.53599
57	7	21	16.96	0.71327
58	7	21	21.03	0.45683
59	7	21	23.93	0.29644
60	7	21	9.54	0.98429
61	7	21	16.69	0.72951
62	7	21	16.70	0.72934
63	7	21	31.32	0.06844
64	7	21	22.13	0.39216
65	7	21	34.80	0.02971
66	7	21	25.49	0.22674
67	7	21	11.93	0.94141
68	7	21	19.00	0.58513
69	7	21	13.08	0.90587
70	7	21	18.56	0.61335
71	7	21	16.09	0.76436
72	7	21	16.81	0.72261
73	7	21	21.94	0.40275
74	7	21	13.18	0.90213
75	7	21	27.53	0.15389
76	7	21	29.70	0.09819
77	7	21	14.33	0.85479
78	7	21	15.12	0.81663
79	7	21	13.81	0.87747

80	7	21	14.17	0.86236
81	7	21	21.91	0.40449
82	7	21	23.31	0.32784
83	7	21	15.54	0.79491
84	7	21	21.56	0.42536
85	7	21	12.92	0.91156
86	7	21	22.59	0.36612
87	7	21	16.48	0.74194
88	7	21	22.56	0.36784
89	7	21	21.11	0.45226
90	7	21	29.80	0.09615
91	7	21	25.64	0.22062
92	7	21	16.86	0.71975
93	7	21	17.05	0.70781
94	7	21	23.22	0.33238
95	7	21	15.82	0.77992
96	7	21	18.09	0.64322
97	7	21	13.25	0.89976
98	7	21	22.61	0.36502
99	7	21	21.12	0.45138
100	7	21	10.00	0.97896
Combined P-value for all tests (Using KS method)				0.88226

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	23.93	0.29642
Combined P-value for all tests (Using KS method)				N/A (Insufficient data)

Notes:

1) As the total number of tests (8) 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) 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 July 2023 to January 2024.

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	0.98081	1.00000
Suits Test	0.88226	1.00000
Hand Types Test	0.71529	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 1	0.59623	1.00000
Ranks Test 2	0.17245	1.00000
Ranks Test 3	0.91338	1.00000
Ranks Test 4	0.37429	1.00000
Ranks Test 5	0.57977	1.00000
Ranks Test 6	0.68972	1.00000
Ranks Test 7	0.87559	1.00000
Ranks Test 8	0.53421	1.00000
Suits Test 1	0.86050	1.00000
Suits Test 2	0.14175	1.00000
Suits Test 3	0.16640	1.00000
Suits Test 4	0.54262	1.00000
Suits Test 5	0.79599	1.00000
Suits Test 6	0.96989	1.00000
Suits Test 7	0.79169	1.00000
Suits Test 8	0.29642	1.00000
Hand Types Test 1	0.90542	1.00000
Hand Types Test 2	0.72365	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 July 2023 to January 2024.

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: 26 February 2024	**Divya Bhargava** **Project Manager** **iTech Labs** Date: 26 February 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.