Poker Cards Analysis – September 2024

The Directors
Entain Plc

This is to confirm that iTech Labs has examined the game logs for Poker games for the period **September 01, 2024,** to **September 30, 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	5.22	0.81430
2	9	11.59	0.23731
3	9	10.47	0.31399
4	9	6.79	0.65935
5	9	10.49	0.31217
6	9	5.88	0.75225
7	9	9.06	0.43196
8	9	9.43	0.39822
9	9	3.60	0.93556
10	9	4.77	0.85352
11	9	6.32	0.70730
12	9	7.13	0.62359
13	9	9.50	0.39255
14	9	7.49	0.58577
15	9	5.86	0.75407
16	9	4.22	0.89615
17	9	16.55	0.05616
18	9	7.77	0.55718
19	9	5.96	0.74360
20	9	9.49	0.39348
21	9	11.51	0.24214
22	9	3.21	0.95547
23	9	8.57	0.47807
24	9	6.36	0.70357
25	9	6.59	0.67986
26	9	9.25	0.41481
27	9	12.32	0.19570

28	9	4.95	0.83880
29	9	5.87	0.75250
30	9	3.82	0.92256
31	9	6.51	0.68824
32	9	8.71	0.46449
33	9	11.33	0.25395
34	9	7.71	0.56345
35	9	5.63	0.77651
36	9	8.47	0.48709
37	9	15.81	0.07092
38	9	11.46	0.24518
39	9	4.04	0.90873
40	9	11.78	0.22571
41	9	5.07	0.82854
42	9	11.97	0.21493
43	9	14.25	0.11366
44	9	10.67	0.29865
45	9	15.71	0.07319
46	9	11.46	0.24579
47	9	13.17	0.15505
48	9	8.49	0.48532
49	9	13.68	0.13419
50	9	11.05	0.27251
51	9	3.82	0.92300
52	9	10.13	0.34007
53	9	7.82	0.55189
54	9	6.13	0.72681
55	9	8.13	0.52125
56	9	3.88	0.91919
57	9	9.01	0.43637
58	9	5.88	0.75174
59	9	10.04	0.34708
60	9	7.44	0.59102
61	9	7.19	0.61687
62	9	7.25	0.61118
63	9	9.48	0.39438
64	9	8.12	0.52238
65	9	9.30	0.41004
66	9	6.06	0.73408
67	9	5.05	0.82981
68	9	8.04	0.52971
69	9	6.50	0.68906
70	9	10.79	0.29073
71	9	7.12	0.62417
72	9	13.45	0.14327
73	9	13.11	0.15783
74	9	4.88	0.84425
75	9	5.45	0.79326
76	9	11.26	0.25841
77	9	6.61	0.67772
78	9	6.75	0.66297
79	9	8.48	0.48611
80	9	2.86	0.96964
81	9	14.94	0.09266
82	9	2.45	0.98222
83	9	14.80	0.09658

84	9	9.46	0.39602
85	9	6.10	0.72938
86	9	23.04	0.00610
87	9	7.83	0.55175
88	9	14.32	0.11130
89	9	3.65	0.93295
90	9	6.49	0.68967
91	9	5.42	0.79602
92	9	4.36	0.88616
93	9	6.25	0.71451
94	9	12.40	0.19147
95	9	4.04	0.90887
96	9	14.84	0.09543
97	9	3.51	0.94059
98	9	6.18	0.72166
99	9	4.76	0.85435
100	9	7.18	0.61833
Combined P-value for all tests (Using KS method)			0.34287

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.

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.
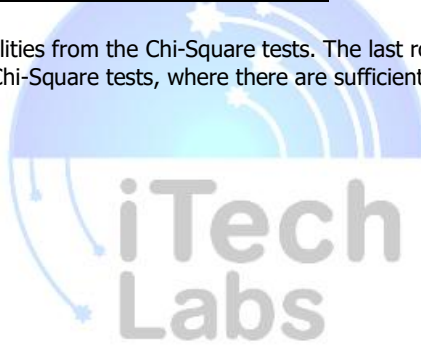
2.1 Poker rank statistics for 52 cards deck:

Test No.	DOF	ChiSqr	P-Value
1	84	76.92	0.69517
2	84	75.49	0.73500
3	84	69.36	0.87504
4	84	78.12	0.66018
5	84	68.13	0.89601
6	84	105.81	0.05408
7	84	58.02	0.98632
8	84	83.51	0.49463
9	84	63.44	0.95407
10	84	79.14	0.62972
11	84	79.38	0.62235
12	84	90.33	0.29874
13	84	70.84	0.84646
14	84	86.76	0.39671
15	84	66.53	0.91958
16	84	75.61	0.73182
17	84	73.48	0.78694
18	84	67.38	0.90761
19	84	78.33	0.65381
20	84	102.31	0.08506
21	84	70.16	0.86009
22	84	88.86	0.33752
23	84	93.64	0.22126

24	84	107.79	0.04121
25	84	61.56	0.96870
26	84	80.06	0.60162
27	84	85.13	0.44492
28	84	101.35	0.09568
29	84	110.18	0.02925
30	84	70.92	0.84491
31	84	89.35	0.32427
32	84	76.18	0.71617
33	84	91.27	0.27546
34	84	69.80	0.86684
35	84	78.91	0.63655
36	84	76.75	0.70009
37	84	73.61	0.78378
38	84	89.68	0.31577
39	84	62.47	0.96212
40	84	95.17	0.19025
41	84	82.70	0.51976
42	84	98.07	0.13989
43	84	67.95	0.89885
44	84	88.68	0.34235
45	84	117.69	0.00901
46	84	107.65	0.04208
47	84	75.79	0.72680
48	84	73.70	0.78161
49	84	83.59	0.49214
50	84	75.77	0.72732
51	84	96.04	0.17388
52	84	98.90	0.12750
53	84	114.31	0.01560
54	84	79.31	0.62435
55	84	77.37	0.68212
56	84	80.52	0.58734
57	84	80.36	0.59213
58	84	61.14	0.97146
59	84	86.74	0.39717
60	84	108.88	0.03536
61	84	73.68	0.78210
62	84	104.99	0.06035
63	84	67.83	0.90077
64	84	98.56	0.13247
65	84	82.41	0.52880
66	84	65.05	0.93786
67	84	94.74	0.19850
68	84	75.50	0.73476
69	84	98.08	0.13968
70	84	57.20	0.98892
71	84	64.77	0.94085
72	84	81.05	0.57100
73	84	91.23	0.27647
74	84	78.13	0.65991
75	84	85.45	0.43541
76	84	106.17	0.05158
77	84	82.61	0.52236
78	84	63.10	0.95702
79	84	79.66	0.61384

80	84	63.13	0.95674
81	84	81.64	0.55253
82	84	71.10	0.84122
83	84	83.96	0.48077
84	84	77.36	0.68252
85	84	80.79	0.57906
86	84	108.02	0.03995
87	84	79.75	0.61091
88	84	83.76	0.48679
89	84	74.74	0.75508
90	84	83.22	0.50349
91	84	77.76	0.67087
92	84	56.63	0.99047
93	84	89.51	0.32008
94	84	65.95	0.92715
95	84	79.81	0.60930
96	84	82.10	0.53844
97	84	108.35	0.03813
98	84	70.74	0.84862
99	84	101.09	0.09866
100	84	91.91	0.26013
Combined P-value for all tests (Using KS method)			0.05976

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	12.78	0.91611
2	7	21	30.86	0.07594
3	7	21	23.05	0.34121
4	7	21	22.92	0.34800
5	7	21	25.69	0.21859
6	7	21	19.22	0.57134
7	7	21	30.24	0.08732
8	7	21	23.28	0.32920
9	7	21	13.71	0.88190
10	7	21	27.75	0.14745
11	7	21	32.72	0.04945
12	7	21	19.52	0.55166
13	7	21	11.20	0.95874
14	7	21	14.75	0.83540
15	7	21	13.24	0.90000
16	7	21	16.28	0.75352
17	7	21	18.28	0.63120
18	7	21	17.53	0.67831
19	7	21	25.51	0.22578
20	7	21	17.59	0.67454
21	7	21	15.98	0.77066
22	7	21	14.23	0.85953
23	7	21	30.51	0.08212
24	7	21	25.47	0.22724
25	7	21	26.27	0.19623
26	7	21	22.34	0.38043
27	7	21	24.81	0.25557
28	7	21	23.12	0.33779
29	7	21	16.74	0.72655
30	7	21	16.04	0.76746
31	7	21	23.38	0.32414
32	7	21	17.60	0.67416
33	7	21	15.07	0.81961
34	7	21	24.62	0.26382
35	7	21	18.98	0.58647
36	7	21	18.39	0.62452
37	7	21	20.61	0.48323
38	7	21	16.27	0.75451
39	7	21	24.54	0.26775
40	7	21	21.46	0.43101
41	7	21	17.10	0.70501
42	7	21	12.25	0.93267
43	7	21	27.37	0.15898

44	7	21	17.74	0.66558
45	7	21	18.75	0.60097
46	7	21	12.46	0.92648
47	7	21	25.52	0.22540
48	7	21	24.95	0.24934
49	7	21	11.45	0.95329
50	7	21	25.13	0.24151
51	7	21	27.09	0.16774
52	7	21	18.01	0.64808
53	7	21	23.90	0.29815
54	7	21	19.40	0.55957
55	7	21	24.01	0.29278
56	7	21	15.96	0.77207
57	7	21	13.55	0.88808
58	7	21	7.38	0.99726
59	7	21	13.84	0.87656
60	7	21	10.88	0.96510
61	7	21	24.93	0.25008
62	7	21	13.84	0.87631
63	7	21	22.14	0.39162
64	7	21	24.03	0.29180
65	7	21	23.18	0.33470
66	7	21	19.72	0.53884
67	7	21	19.49	0.55360
68	7	21	26.76	0.17899
69	7	21	29.08	0.11204
70	7	21	20.33	0.50074
71	7	21	17.52	0.67930
72	7	21	30.75	0.07785
73	7	21	10.79	0.96679
74	7	21	18.64	0.60851
75	7	21	18.63	0.60902
76	7	21	22.12	0.39277
77	7	21	22.64	0.36332
78	7	21	19.11	0.57826
79	7	21	29.44	0.10386
80	7	21	26.50	0.18805
81	7	21	42.27	0.00389
82	7	21	18.38	0.62491
83	7	21	16.04	0.76753
84	7	21	27.26	0.16241
85	7	21	16.46	0.74329
86	7	21	22.31	0.38186
87	7	21	15.70	0.78640
88	7	21	22.91	0.34879
89	7	21	25.95	0.20855
90	7	21	30.75	0.07787
91	7	21	22.45	0.37380
92	7	21	18.46	0.61959
93	7	21	14.37	0.85297
94	7	21	40.62	0.00624
95	7	21	23.47	0.31930
96	7	21	13.87	0.87509
97	7	21	12.02	0.93902
98	7	21	17.55	0.67751
99	7	21	16.73	0.72710

100	7	21	21.20	0.44653
Combined P-value for all tests (Using KS method)				0.94703

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.
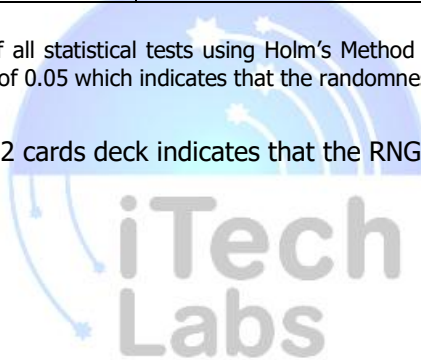
The combined p-value produced using the Holm's method is used as indication for statistical randomness.

Combination of p-values using Holm's Method		
Test	**P-Value**	**P-Adjusted**
Ranks Test	0.05976	0.17928
Suits Test	0.94703	0.94703
Hand Types Test	0.34287	0.68574
Combined P-Value using Holm's Method		0.17928

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. Conclusion

Analysis of actual data from game logs for 'Hand Types, 'Ranks' and 'Suits' for **52-card decks** indicated statistical randomness. Since there is no data in the case of 36 card deck, this report does not contain the details of 36 card deck.

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:

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Alvin Rizaldi
Chief Executive Officer
iTech Labs
Date: 13 November 2024

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Divya Bhargava
Project Manager
iTech Labs
Date: 13 November 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.