GAMING LABORATORIES INTERNATIONAL®

GLI®

GLI Europe BV
Diakenhuisweg 29-35
2033 AP Haarlem
The Netherlands

Tel +31 (0)88 220 6600
www.gaminglabs.com

Chamber of Commerce
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RvA Registration Number of Accreditation applicable to this Report	
Testing	L372

Report Type	Evaluation
Date of Report	18th January 2019
Issuing Laboratory	GLI Europe B.V.
Evaluating Laboratory	GLI Europe B.V.
Recipient	Netgame Entertainment N.V. Heelsumstraat 51 E-Commerce Park E-Zone Vredenberg Curaçao
Tested against Requirements	GLI 11 - Gaming Devices in Casinos v3.0
Jurisdiction	Non Jurisdictional
Manufacturer	Netgame Entertainment N.V. Heelsumstraat 51 E-Commerce Park E-Zone Vredenberg Curaçao
Submitter	Netgame Entertainment N.V. Heelsumstraat 51 E-Commerce Park E-Zone Vredenberg Curaçao
Product Name	**NetgameRNG1.0**
Description of the Product Tested	**librng.core.so**
Requested Date	As requested per manufacturer's letter received on 10th December 2018
Evaluation Period	11th December 2018 / 14th January 2019
Internal Reference	RN-332-NGE-18-01-123
Result	Pass (See Comments/Conditions section of this Report)

Comments/Conditions

Comments

The program Verify+ 2.5 by Kobetron™ was used to generate all signatures listed in the Software Product Details section of this report.

A request was made to conduct an evaluation against the Random Number Generator requirements as specified in GLI-11 with no reference to any particular jurisdictional requirements. Upon request for transfer of this evaluation to a specific jurisdiction, GLI Europe B.V. will process this in accordance with the jurisdictional requirements as required.

This report is issued for the evaluation of the RNG only and covers the game ranges supplied in the report.

Please note that the numbering format used in this Report utilizes the comma symbol (,) for the thousands separator and the decimal point (.) as a fractional separator (example: 1,000.30 = one thousand point thirty).

Conditions

The tested RNG may only be used in connection to games, which call the RNG with numbers within the ranges as specified in this report.

Software Product Details

Please refer to the RNG Analysis section.

Applied Tests

Product ID	Reference Nº	Results	Additional Details
librng.core.so	WI-MA-006	Pass	Internal Reference: RN-332-NGE-18-01-123

Product Characteristics

Product ID	Characteristics
librng.core.so	This file contains the RNG under evaluation.

Technical Evaluation authorized by:

Martin Britton
Managing Director

RNG Evaluation

RANDOMNESS REPORT FOR THE NETGAMERNG1.0

The intent of this report is to indicate that **Gaming Laboratories International**, **LLC** (GLI) has completed its evaluation of the NetgameRNG1.0 random number generator (RNG) provided by Netgame Entertainment N.V.

SECTION I - SCOPE OF TESTING

Netgame Entertainment N.V. submitted the required materials to GLI in order to conduct a random number generator analysis on the NetgameRNG1.0. The scope of this analysis was limited to software verification, source code review, and data analysis. The RNG was tested for its ability to randomly produce outcomes for the Slot games.

The NetgameRNG1.0 was evaluated against the RNG-specific requirements of the following technical standards:

- GLI 11 v3.0. Gaming Devices in Casinos

The software being certified herein contains a cryptographically strong Random Number Generator (RNG) and as such, obsoletes the necessity of background cycling to maintain unpredictability when in use.

SECTION I - SOFTWARE VERIFICATION

Verify+ by Kobetron™ signatures for the NetgameRNG1.0 are as follows:

File	Type	Signature
librng.core.so	Kobe4	HF03
	MD5	BE54C2D6EE7D3BBD7348F773B3530ED1
	SHA-1	395B48C288ADDBC0582041B15C4E2F333114413A
	Kobe40	32C396U65UA6C08H060P79305687P0428175P120
	CDCK	6C5B

Table 1. Digital Signatures

SECTION II - SOURCE CODE REVIEW

Netgame Entertainment N.V. submitted appropriate documentation and full source code which pertains to the generation of random numbers. GLI reviewed the source code provided by tracing the path of the RNG application from the initiation of the draw to the selected output of random numbers. GLI inspected the source code, where practicable, in an attempt to find any undisclosed switches or parameters having a possible influence on randomness and fair play. GLI assessed the ability of the RNG to produce all numbers within the desired range.

RNG Evaluation

SECTION III - DATA ANALYSIS

The game configuration and parameters for the data obtained and tested are listed in Table 2. GLI performed a data format check on each data set listed in order to confirm that the game parameters were correctly represented in the data analyzed.

GLI conducted a statistical analysis of sufficient scope to test the RNG for selecting as many as 5 winners from a pool size as large as 1,058 as described in Table 2. The selection of test cases took into account broad coverage of range sizes, weights, and selections.

A set of numbers is said to be drawn *with replacement* if a number can be selected multiple times within the same draw.

Data Set	Range	Positions	Replacement	Draws
General Certification - non weighted reels	Up to and including 1,058	3 and 5	Yes	①
General Certification - weighted reels	Up to and including 1,058	3 and 5	Yes	①
General Certification - weighted multi-reels	Up to and including 1,058	3 and 5	Yes	①
Binary Data	0- 18,446,744,073,709,551,615	1	N/A	1,500,000

Table 2. Game Parameters

① Data sets of different ranges and draw sizes were collected and analyzed to cover the scope of this general certification.

For a summary of the statistical tests applied to each data set, see *Appendix A*. For a description of the overall test methodology and a description of each test used, see *Appendix B*.

Overall, the RNG passed the battery of tests for each configuration at the 95%, 98%, and 99% confidence levels.

SECTION V - SUMMARY

Overall Evaluation of the Random Number Generator

GLI's conclusion based upon the tests applied to the NetgameRNG1.0 data is that this random number generator has exhibited random behavior and is suitable for the applications as described herein. If a game utilizes different ranges or a different number of selections from those included in Table 2, the RNG should be resubmitted to test that set of parameters.

RNG Evaluation

APPENDIX A: Statistical Test Summary

					Test Names											
Data Set	**Range**	**Positions**	**Replacement**	**Draws**	**Runs**	**Serial Corr.**	**Interplay Corr.**	**Adj. Max-Min**	**Adj. High-Low**	**Coupon Collector's**	**Duplicates**	**Overlaps**	**Count of Counts**	**Tot. Dist.**	**Tot. Dist. by Pos.**	**DieHard**
General Certification - non weighted reels	Up to and including 1,058	3 and 5	Yes	①	X	X	X	X	X	X	X	X	X	X		
General Certification - weighted reels	Up to and including 1,058	3 and 5	Yes	①	X	X								X	X	
General Certification - weighted multi-reels	Up to and including 1,058	3 and 5	Yes	①	X	X								X	X	
Binary data	0-18,446,744,073,709,551,615	1	N/A	1,500,000												X

① Data sets of different ranges and draw sizes were collected and analyzed to cover the scope of this general certification

Table A 1. Tests Applied

RNG Evaluation

APPENDIX B: Test Descriptions

B.1 **Definitions.** The following terms apply to the below test descriptions. Randomness Device or Random Number Generator (RNG) output may be collected multiple numbers at a time. Each set of numbers is called a draw. Each individual number has a particular order within the *draw*. This is referred to as the number *position*.

B.2 **Distribution Comparisons.** Many of the tests compare an observed numerical distribution with an expected distribution. Unless otherwise specified, this is done by means of a statistical chi-square goodness-of-fit test. The value chi-square is computed in the standard way. If k is a possible value, o_k is the observed count of that value, and e_k is the expected count:

$$\chi^2 = \sum_k \frac{(o_k - e_k)^2}{e_k}$$

In the case where expected counts are too small for accurate use of the above formula, values are 'binned' together to ensure an appropriate minimum expected count. The resultant value for chi-square is compared against the distribution for the appropriate number of degrees of freedom. Unusually high (distribution mismatch) or unusually low (insufficient randomness) chi-square values can be causes for data failure.

B.3 **Meta-testing**. Evaluation of groups of *p*-values may include a meta-test for extremity of high or low *p*-values, a meta-test for frequency of high or low *p*-values, and a meta-test for uniformity of *p*-values, as appropriate.

B.4 **Confidence Level**. The statistical tests conducted by GLI are done at a particular *confidence level*. Common confidence levels used include 95%, 98%, and 99%, depending on jurisdictional requirements, and intended use of the RNG. High confidence level testing has low risk of mistakenly failing a good RNG, but higher risk of passing a bad RNG. Lower confidence level testing has increased power of detecting bad RNGs, while also increasing the risk of false failures of good RNGs. Specifically, the confidence level represents the probability that an ideal source of randomness would pass the testing. If an RNG passes statistical tests at a given confidence level, passage at all *higher* confidence levels is implied.

B.5 **Tests**. Some tests are only applicable to certain types of data. Some tests may be applied only to a portion of the data. Some tests may require that the data be parsed, binned, or otherwise transformed, as necessitated by data format.

RNG Evaluation

APPENDIX B: Test Descriptions

Adjacency High-Low:
For each draw, the number of local extrema ('highs' and 'lows') in the data is recorded and compared with the expected distribution. These are also referred to as 'turning points'.

For example, if a draw consists of the numbers

$$1, 3, 5, 7, 2, 9$$

there would be one local maximum (7) and one local minimum (2). The resulting statistic would be 2.

Adjacency Max-Min:
For each draw, the difference between the maximum and minimum values is calculated and recorded. This is compared with the expected theoretical distribution.

For example, if a draw consists of the numbers

$$2, 3, 6, 7, 4$$

the resulting statistic would be 5, the difference between the maximum value (7) and the minimum value (2).

Count of Counts:
The Count of Counts test first counts the occurrences of each value in each position of the data. These counts are then tallied and compared with the expected distribution of counts for the draw size and range of values.

Coupon Collector's:
The Coupon Collector's Test is applied positionally. The data is parsed until all possible values have been observed, then the number of values checked is recorded and the count is restarted. This is compared with the expected distribution.

For example, if the set of all possible values is {0, 1, 2} and the first position of each draw is

$$1, 0, 1, 0, 2, 0, 1, 2, \ldots$$

then all values are observed in the first position by the fifth draw. All values are then observed within the next 3 draws, so the first two statistics for the first position would be 5 and 3.

RNG Evaluation

DieHard:
The DieHard Battery of Tests is a standard assessment of the randomness in raw outcomes generated from an RNG. The collection, designed by George Marsaglia, tests for a variety of patterns in the individual binary bits of RNG output. GLI uses a custom implementation to conduct DieHard testing.

Duplicates:
The Duplicates Test counts the number of times a draw is exactly duplicated in the data. In the case that a particular draw is repeated more than twice, every possible way to generate a duplicate is counted. This is compared against the theoretical distribution to verify that the number of duplicate draws falls within expected bounds.

For example, consider the dataset consisting of the following draws of two numbers each.

$$a)\ 1, 3$$
$$b)\ 4, 1$$
$$c)\ 1, 3$$
$$d)\ 1, 3$$
$$e)\ 4, 1$$
$$f)\ 3, 1$$

The duplicate pairs are (*a*,*c*), (*a, d*), (*c, d*), and (*b, e*), for a total of 4 duplicates. *(f)* is not counted as a duplicate since the draw must match in order as well as values.

Interplay Correlation:
The Interplay Correlation Test measures statistical correlation between different positions of the same draw. For each pair of positions, statistical correlation is calculated as in the Serial Correlation Test. In the case of without replacement data, an adjustment is made to account for the expected resulting negative correlation.

Overlaps:
The Overlaps Test compares consecutive draws for overlapping values. The number of overlapping values is recorded for each pair of draws. This observed distribution of overlaps is then compared against the expected distribution.

For example, if the following draws are observed consecutively,

$$a)\ 1, 4, 5, 6$$
$$b)\ 4, 1, 7, 6$$

the number of overlaps would be 3, representing the values 1, 4, and 6.

RNG Evaluation

Runs:
The Wald-Wolfowitz Runs Test is applied to each position within the draw. A center is established, typically the data median, and the number of 'runs' above and below the center are tallied. Values exactly equal to the center are discarded. This is compared to the expected distribution, which depends on the number of values above and below the center.

For example, if the numbers drawn at a particular position were

$$2, 3, 1, 5, 4, 7, 3, 2, 3, 2, 3, 2, 6, 7, 3, 5$$

and the established center were the data median of 3, the data would be parsed for runs above 3 and runs below 3.

$$\underbrace{2, 3, 1}, \overbrace{5, 4, 7, 3}, \underbrace{2, 3, 2, 3, 2}, \overbrace{6, 7, 3, 5}$$

This would be counted as 4 runs.

Serial Correlation:
The Serial Correlation Test measures statistical correlation between consecutive draws of the same position. For each position, the sample Pearson correlation coefficient is calculated. If *X* represents the first number, and *Y* the number that follows, then the coefficient is

$$r = \frac{cov(X, Y)}{s_X s_Y}$$

where *s* denotes the sample standard deviation. The coefficients are used to generate a *p*-value for each position.

Total Distribution:
The Total Distribution Test is a simple tally of all observed values throughout the data. This is compared with the expected distribution. Typically the expected distribution is a uniform distribution. In the case of unequal weighting of values, an appropriate discrete distribution is used.

Total Distribution by Position:
The Total Distribution by Position Test tallies the observed distribution of values for each position within the draw. Each of these distributions is then compared with the expected.