TEST REPORT

Jurisdiction:	Sweden
Authority:	Swedish Gambling Authority
Customer:	Eyecon Alderney Limited Inchalla, Le Val Alderney GY9 3UL
Manufacturer:	Eyecon Alderney Limited
Submission Reference:	Submission received 14 June 2017 for project EYECON.1004
Evaluated Product:	Eyecon RNG
Issued By:	BMM Testlabs
Location(s) of Evaluation:	BMM Testlabs Level 3, 810 Whitehorse Road Box Hill, Victoria 3128 Australia
Project Number:	EYECON.1007
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Dates(s) of Evaluation:	27 May 2019
Standards Tested:	SMFS 2018:8 The Swedish Gambling Authority's regulations and general advice on technical requirements and accreditation of bodies for inspection, testing and certification of gambling service providers
Compliance Certification:	BMM hereby certifies that the Eyecon RNG complies with the standards listed above.
Signed:	
	Christopher Van Prooije, Senior Systems Consultant, Mathematics **(Approved NATA Signatory)**

NATA Accredited Laboratory Number: 15122
Accredited for compliance with ISO/IEC 17025 - Testing

1. PURPOSE:

Eyecon Alderney Limited has requested BMM to evaluate the random number generator (RNG) used in the Eyecon RNG for operation in Sweden.

2. EVALUATION METHOD:

The evaluation was conducted using the BMM testing procedures designed to ensure compliance to the applicable technical standards and ISO/IEC 17025.

The full details of the tests are stored in the Quality Management System.

3. DESCRIPTION OF RNG:

The RNG uses an instance of the cryptographically secure Java SecureRandom class. This uses the SHA-1 hash algorithm and a 160-bit state to securely generate random values.

3.1 SOURCE CODE REVIEW:

The following sections describe the implementation of the RNG in the source code.

3.1.1 Seeding

The RNG is seeded using its own internal seeding mechanisms which draw on multiple hardware and software sources of entropy, ensuring the state is entirely unpredictable.

3.1.2 Unpredictability

The RNG uses the SHA-1 secure hashing algorithm that makes it unpredictable without knowledge of the applied algorithm, implementation and initial values.

3.1.3 Scaling

Methods are provided to produce random numbers in target ranges in a uniform distribution without introducing any bias.

3.1.4 Monitoring

A monitor service runs tests on numbers drawn from the RNG once every minute to detect failures.

3.1.5 Thread Safety

The implementation was verified by inspection to be thread safe.

4. FILE SIGNATURES:

The following file is used by the RNG.

File(s)	Type*	Signature
eyecon-rng-1.0.1.jar	SHA1	D2BFE8EF8FB4F0C33D2988F9A2A030FD66A295F9

5. TEST RESULTS

Each test tests the hypothesis that the RNG is a random source of numbers. A “p-value” is produced for each test run, which is the probability that a truly random process would produce the same or a more extreme result. P-values are expected to be uniformly distributed between 0 and 1. Each test is performed at least 100 times, and the p-values for each test are evaluated using an Anderson-Darling test. This produces a single p-value, which is the probability that the individual p-values have been produced from a uniform distribution.

Finally, the p-values from each test in the same test suite are combined using the Holm-Bonferroni method to provide an overall p-value. This process adjusts each p-value to ensure that the overall probability of accepting the RNG as random matches the confidence interval used. The overall p-value, equal to the minimum of the adjusted p-values, is compared to a specific alpha value to determine if the RNG is accepted or rejected as being random for a specific confidence interval. For a 95% confidence interval, the alpha value used is 0.05. Similarly, the alpha value is 0.01 for a 99% confidence interval. Both 95% and 99% confidence intervals were considered for this evaluation.

The following tables summarise the test results. See Appendix A for a description of the statistical tests used.

5.1 EMPIRICAL TESTS

Test	P-values	95% Confidence	99% Confidence
Frequency Test	1.000000	PASS	PASS
Serial Correlation Test	1.000000	PASS	PASS
Runs Test	1.000000	PASS	PASS
Gap Test	1.000000	PASS	PASS
Coupon Collector Test	1.000000	PASS	PASS
Subsequences Test	0.762371	PASS	PASS
Poker Test	1.000000	PASS	PASS
Overall	**0.762371**	**PASS**	**PASS**

Conclusion: The RNG is **ACCEPTED** as random at the 95% confidence interval.
Conclusion: The RNG is **ACCEPTED** as random at the 99% confidence interval.

5.2 DIEHARD TESTS

Test	P-values	95% Confidence	99% Confidence
Binary Rank 32x32 Test	1.000000	PASS	PASS
Binary Rank 6x8 Test	1.000000	PASS	PASS
Birthday Spacings Test	0.929823	PASS	PASS
Bitstream Test	0.969203	PASS	PASS
Count The 1's Stream Test	1.000000	PASS	PASS
Count The 1's Specific Test	1.000000	PASS	PASS
Runs Test	1.000000	PASS	PASS
Squeeze Test	1.000000	PASS	PASS
Overall	**0.929823**	**PASS**	**PASS**

Conclusion: The RNG is **ACCEPTED** as random at the 95% confidence interval.
Conclusion: The RNG is **ACCEPTED** as random at the 99% confidence interval.

5.3 NIST TESTS

Test	P-values	95% Confidence	99% Confidence
Approximate Entropy Test	1.000000	PASS	PASS
Block Frequency Test	1.000000	PASS	PASS
Cumulative Sums Test	1.000000	PASS	PASS
Discrete Fourier Transform Test	1.000000	PASS	PASS
Frequency Test	1.000000	PASS	PASS
Linear Complexity Test	1.000000	PASS	PASS
Longest Run of Ones Test	1.000000	PASS	PASS
Non-Overlapping Template Matchings Test	1.000000	PASS	PASS
Overlapping Template Matchings Test	1.000000	PASS	PASS
Random Excursions Test	1.000000	PASS	PASS
Random Excursions Variant Test	1.000000	PASS	PASS
Rank Test	1.000000	PASS	PASS
Runs Test	1.000000	PASS	PASS
Serial Test	1.000000	PASS	PASS
Universal Test	1.000000	PASS	PASS
Overall	**1.000000**	**PASS**	**PASS**

Conclusion: The RNG is **ACCEPTED** as random at the 95% confidence interval.
Conclusion: The RNG is **ACCEPTED** as random at the 99% confidence interval.

6. NON-COMPLIANCES:

None.

7. CONDITIONS:

None.

8. ADDITIONAL INFORMATION:

None.

9. CONCLUSION

As a result of statistical testing and source code review, BMM believes that the Eyecon RNG provides uniformly random data suitable for its intended application. This RNG complies with the applicable requirements for operation in Sweden.

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APPENDIX A. STATISTICAL TESTS

The following tests were used to test the statistical properties of the RNG.

A1. EMPIRICAL TESTS

The Empirical Tests are based on the tests described by Donald Knuth in The Art of Computer Programming Volume 2: Seminumerical Algorithms (1968, revised in 1997). They test sequences of numbers scaled to specific ranges.

Frequency Test	Counts of each number occurring across the sample set.
Serial Correlation Test	Counts of non-overlapping groups of numbers occurring together. Group sizes of two, three, and four are tested separately.
Runs Test	Counts of ascending and descending sequences of numbers. Note that this is a different test to the Runs Test in the Diehard and NIST Tests.
Gap Test	Counts of the size of gaps between successive occurrences of a given number. Each number in the range is tested separately.
Coupon Collector Test	Counts of sequence lengths required to complete a full set of each number in the range.
Subsequences Test	Similar to the Serial Correlation Test for pairs of numbers, except looking at numbers separated by a specific gap. Step sizes of 5, 10, 15, and 20 are tested separately.
Poker Test	The sequence is split into groups of five. The number of unique values in each group is counted.

A2. DIEHARD TESTS

The Diehard Tests are based on the test suite published by George Marsaglia in 1995. They test sequences of raw binary output from the RNG.

Binary Rank 32x32 Test	Matrices are created using 32 32-bit words. The ranks of the resulting matrices are counted.
Binary Rank 6x8 Test	Same as the Binary Rank 32x32 Test, except each matrix is formed using 6 values, each taking 8 bits from successive 32-bit words with a specific offset. All possible offsets are tested separately.
Birthday Spacings Test	26-bit values are taken from successive 32-bit words with a specific offset. The values are sorted, and the spacings between them calculated. The number of spacings of the same size are counted. All possible offsets are tested separately.
Bitstream Test	Blocks of 2^18 values are treated as a stream of overlapping 20-bit values. The number of possible 20-bit values that are not found in each block is counted.
Count The 1's Stream Test	8-bit values are taken and assigned a “letter” based on the number of one’s appearing in the binary representation of each value. Overlapping groups of 5 “letters” are counted.
Count The 1's Specific Test	Similar to the Count The 1’s Stream Test, except 8-bit values are taken from successive 32-bit words with a specific offset. All possible offsets are tested separately.
Runs Test	Counts sequences of increasing and decreasing 32-bit words. Note that this is a different test to the Runs Test in the Empirical and NIST Tests.
Squeeze Test	A value of 2^31 is repeatedly multiplied by 32-bit words, dividing by 2^32 and taking the ceiling of the result each time. The number of successive words that are required to reduce the value down to 1 is counted. The value is reset to 2^31 and the process is repeated.

A3. NIST TESTS

The NIST Tests are based on the suite of tests released by the National Institute of Standards and Technology in Special Publication 800-22, Revision 1a (revised April 2010). They test sequences of raw binary output from the RNG.

Approximate Entropy Test	Similar to the Serial Test, count each possible m-bit value, except it does so for two adjacent m bit lengths and compares the two.
Block Frequency Test	Similar to the Frequency Test, except the data is split into equally sized blocks. The number of ones and zeroes in each block is counted.
Cumulative Sums Test	Random walks are created by converting the data to +1 / -1 for 1 / 0 respectively and summing consecutive values.
Discrete Fourier Transform Test	The data is transformed using a Discrete Fourier Transform. The number of peaks within the 95% threshold are counted.
Frequency Test	The number of ones and zeroes in the binary output is counted.
Linear Complexity Test	The length of the linear complexity of the random sequence is determined.
Longest Run of Ones Test	The data is split into equally sized blocks. The longest run of ones in each block is determined and counted.
Non-Overlapping Template Matchings Test	The data is split into equally sized blocks. Each block is searched for a specific pattern of bits and counted. A separate test is run for various bit patterns. Each bit pattern searched does not overlap with itself. That is, when the pattern is matched, the end of the pattern cannot be the start of another match.
Overlapping Template Matchings Test	Similar to the Non-Overlapping Template Matchings Test, except only one pattern is searched, which may overlap with itself.
Random Excursions Test	As with the Cumulative Sums Test, random walks are created by converting the data to +1 / -1 for 1 / 0 respectively and summing consecutive values. The number of times a given state is visited between returns to zero are counted. Separate tests are run for various states from -4 to +4, not including 0.
Random Excursions Variant Test	Similar to the Random Excursions Test, except the number of times the given state is visited is counted for the entire sequence. Separate tests are run for various states from -9 to +9, not including 0.
Rank Test	Matrices are created using 32 32-bit words. The ranks of the resulting matrices are counted. Note that this is fundamentally the same test as the Binary Rank 32x32 Test in the Diehard Tests, although the implementation may differ.
Runs Test	Runs of consecutive bits of the same value of various lengths are counted.
Serial Test	Counts of each possible m-bit values. Separate tests are run for various m bit lengths.
Universal Test	Distances between repeated patterns of bits are counted.

--- END OF REPORT ---