**Comprehensive RNG Speed Comparison**

**1. Software RNGs (CPU-based)**

| **RNG Type** | **Speed** | **Keys/ms (256-bit)** | **vs SQEF** |
| --- | --- | --- | --- |
| **SQEF** | **273 MB/s** | **9,943** | **Baseline** |
| Mersenne Twister | 500 MB/s | 15,625 | 1.6x faster |
| PCG | 2 GB/s | 62,500 | 6.3x faster |
| xoshiro256++ | 3 GB/s | 93,750 | 9.4x faster |
| ChaCha20 | 2-3 GB/s | 78,125 | 7.9x faster |
| AES-CTR (with AES-NI) | 10-15 GB/s | 390,625 | 39x faster |

**2. Hardware RNGs**

| **RNG Type** | **Speed** | **Keys/ms (256-bit)** | **vs SQEF** |
| --- | --- | --- | --- |
| Intel RDRAND | 500 MB/s - 3 GB/s | 15,625-93,750 | 1.6-9.4x faster |
| Intel RDSEED | 100-500 MB/s | 3,125-15,625 | 0.3-1.6x |
| VIA Padlock | 30 MB/s | 937 | 0.09x slower |
| TPM 2.0 | 1-10 MB/s | 31-312 | 0.003-0.03x slower |
| USB Hardware RNG | 1-100 Mbps | 4-390 | 0.0004-0.04x slower |
| PCIe RNG Card | 1-10 Gbps | 3,906-39,062 | 0.4-4x |

**3. Quantum RNGs**

| **QRNG Type** | **Speed** | **Keys/ms (256-bit)** | **vs SQEF** |
| --- | --- | --- | --- |
| ID Quantique | 4-16 Mbps | 16-62 | 0.002-0.006x slower |
| QuintessenceLabs | 1 Gbps | 3,906 | 0.4x slower |
| NIST Quantum RNG | 8.5 Gbps | 33,203 | 3.3x faster |
| Cambridge QRNG | 1-10 Gbps | 3,906-39,062 | 0.4-4x |
| Research QRNGs | Up to 100 Gbps | 390,625 | 39x faster |

**4. Cloud RNG Services**

| **Service** | **Typical Throughput** | **Keys/ms (256-bit)** | **vs SQEF** |
| --- | --- | --- | --- |
| AWS KMS | 10-50 keys/sec | 0.01-0.05 | 200,000x slower |
| Google Cloud KMS | 100 keys/sec | 0.1 | 100,000x slower |
| Azure Key Vault | 10-20 keys/sec | 0.01-0.02 | 500,000x slower |
| Cloudflare (API) | 1000 req/sec | 1 | 10,000x slower |