1. Purpose and Scope

The Convergence Authorization Test (CAT-72) is the formal evidentiary procedure establishing that an autonomous system operates within its declared Operational Design Domain (ODD) with ENVELO-compliant enforcement. CAT-72 completion is mandatory for ODDC determination.

CAT-72 serves three functions:

- Evidentiary demonstration that the system maintains bounded operation across operational regimes
- Verification that ENVELO-compliant enforcement mechanisms activate correctly on boundary approach
- Generation of cryptographically sealed audit records suitable for underwriting review and incident reconstruction

This procedure applies to all applicants seeking initial ODDC determination or renewal. No waivers are issued. Partial completion does not satisfy requirements.

2. Test Duration and Continuity

2.1 Minimum Duration

CAT-72 requires a minimum 72-hour (4,320 minute) continuous demonstration period. The test period begins upon initiation of evidentiary recording and concludes only after uninterrupted completion of the full duration.

2.2 Continuity Requirements

The demonstration must be continuous. Any of the following events constitute an interruption requiring test restart:

- System shutdown, restart, or power cycle (planned or unplanned)
- Loss of evidentiary recording for any duration
- Manual override or intervention by operators (except emergency safety stops)
- ENVELO enforcement activation resulting in system halt (indicates ODD violation)
- Loss of communication with Sentinel Authority witness infrastructure (if remote witnessed)
- Any modification to system configuration, ODD parameters, or enforcement settings

2.3 Extended Duration

Sentinel Authority may require extended test duration (up to 168 hours) based on operational domain risk profile, ODD complexity, or applicant history. Extended duration requirements are specified during scope assessment.

3. Demonstration Requirements

3.1 Convergence Demonstration

The system must demonstrate sustained operation within declared ODD bounds across the full test period. Convergence is measured by:

- Mean operating point stability within declared tolerance bands
- Variance bounded within declared limits for all critical state variables

- No excursions beyond declared ODD boundaries
- Consistent behavior across repeated operational cycles

3.2 Multi-Regime Stress Testing

The demonstration must include verified performance across operational regimes:

- Nominal operating conditions (minimum 60% of test duration)
- Edge conditions approaching ODD boundaries (minimum 20% of test duration)
- Regime transitions between operating modes (minimum 10 transitions)
- Load variations spanning declared operational range
- Environmental variations within declared ODD scope (if applicable)

3.3 Fail-Closed Verification

The demonstration must include verification of ENVELO fail-closed behavior:

- Intentional boundary approach triggering enforcement activation (minimum 3 events)
- Verified halt or safe-state transition within declared response time
- No action execution beyond declared ODD boundaries
- Proper logging of all enforcement events

NOTE
Fail-closed verification events do not interrupt the test if the system returns to nominal operation within declared recovery parameters.

3.4 Evidentiary Record Integrity

All demonstration data must be recorded with cryptographic integrity:

- Hash-chain linking of all log entries (SHA-256 minimum)
- Timestamp synchronization to UTC (±100ms accuracy)
- Continuous recording with no gaps (verified by hash-chain continuity)
- Sentinel Authority witness signature at test completion

4. Tolerance Declaration

4.1 Declaration Requirements

Applicants must declare operational tolerances as part of their ODD specification prior to CAT-72 commencement. Tolerance declarations define the quantitative boundaries within which the system must operate.

Each tolerance declaration must specify:

- State variable or parameter being bounded
- Nominal operating value or range
- Upper and lower tolerance limits (absolute values)

- Measurement method and sensor specifications
- Sampling rate for compliance verification

4.2 Tolerance Basis

Sentinel Authority does not prescribe universal tolerances. Tolerances are domain-specific and determined by the applicant based on:

- Equipment manufacturer specifications and rated operating limits
- Regulatory requirements applicable to the operational domain
- Risk profile and consequence severity for boundary excursions
- Industry standards and established best practices
- Actuarial requirements from underwriting review (if applicable)

4.3 Tolerance Immutability

Tolerance declarations cannot be modified during the CAT-72 test period. Post-test modifications to declared tolerances require new CAT-72 completion. This ensures that conformance determination reflects actual declared operating parameters.

5. Evidence Recording Requirements

5.1 Mandatory Data Elements

The evidentiary record must capture the following at minimum sampling rates:

- All declared ODD state variables (minimum 1 Hz, 10 Hz recommended for critical variables)
- All control outputs and actuator commands (minimum 1 Hz)
- ENVELO enforcement layer state (continuous, event-triggered logging)
- Boundary proximity metrics for all ODD constraints (minimum 1 Hz)
- System health and diagnostic status (minimum 0.1 Hz)

5.2 Format Requirements

Evidentiary records must conform to the following format requirements:

- Primary format: JSON with schema validation
- Timestamps: UTC ISO 8601 with millisecond precision
- Numeric values: IEEE 754 double precision
- Hash algorithm: SHA-256 for all integrity verification
- Compression: Optional GZIP, uncompressed size limit 10 GB

5.3 Chain of Custody

The evidentiary record must maintain verifiable chain of custody:

- Sealed at test completion with Sentinel Authority witness signature

- Hash of complete record published to Sentinel Authority registry
- Original record retained by applicant for conformance term plus 3 years
- Copy retained by Sentinel Authority for conformance term plus 7 years

6. Architectural Evidence Requirements

CAT-72 evidentiary records must demonstrate architectural consonance between the system's learned control policy and its safety enforcement mechanisms. This requirement ensures that autonomous behavior is bounded by physics-validated constraints derived from consistent modeling assumptions.

6.1 Simulation Identification

The evidentiary record must identify the physics-based simulation environment used for system development:

- Simulation platform name, vendor, and version number
- Governing equations implemented (e.g., Navier-Stokes, Kirchhoff's laws, Newton-Euler, finite element formulation)
- Numerical solver type, configuration parameters, and convergence criteria
- Spatial discretization method and mesh specifications (element count, resolution)
- Temporal discretization and time-stepping parameters
- Facility/system geometry model reference and version
- Material properties and physical constants used

6.2 Training Data Provenance

The evidentiary record must demonstrate that synthetic training data for the control model was generated from the identified simulation:

- Hash (SHA-256) of simulation configuration file at time of data generation
- Hash (SHA-256) of complete synthetic training dataset
- Mapping table between simulated sensor points and physical sensor locations
- Noise injection parameters and distribution specifications matching physical sensor characteristics
- Data generation timestamp range and total sample count
- Signed attestation of training data provenance by responsible engineer

6.3 Safety Envelope Derivation

The evidentiary record must demonstrate that the safe operational envelope was derived from the same simulation instance:

- Hash (SHA-256) of simulation configuration at time of envelope computation
- Documentation of envelope boundary derivation methodology
- Correspondence mapping between envelope constraints and simulation output variables
- Safety margin calculations and justification
- Envelope derivation timestamp

- Signed attestation of envelope derivation provenance by responsible engineer

6.4 Consonance Verification

The evidentiary record must include verification that training data and safety envelope share a common simulation origin:

- Matching simulation configuration hashes between 6.2 and 6.3 submissions
- Attestation of common governing equations, boundary conditions, and solver parameters
- Attestation that no independent simulation was used for either component
- Documentation of any simulation updates and corresponding re-derivation procedures

Architectural consonance ensures that the learned control policy operates within a state space inherently bounded by the same physics model that defines safety constraints. Derivation from independent simulations introduces model-safety mismatch that compromises runtime enforcement integrity.

6.5 Simulation Update Protocol

If the physics-based simulation is updated after initial ODDC:

- Both training data and safety envelope must be re-derived from the updated simulation
- New CAT-72 completion is required with updated architectural evidence
- Prior conformance is suspended until successful re-determination
- Suspension is noted in the Sentinel Authority registry

Partial updates (e.g., re-deriving envelope from updated simulation while retaining training data from prior simulation) do not satisfy architectural consonance requirements and will result in conformance denial.

7. Witness Requirements

7.1 Witness Options

CAT-72 may be witnessed through one of the following methods:

- On-site witness: Sentinel Authority representative present at test facility for full duration
- Remote witness: Real-time telemetry streaming to Sentinel Authority monitoring infrastructure
- Hybrid witness: Remote monitoring with on-site presence for test initiation and completion

7.2 Witness Responsibilities

The Sentinel Authority witness is responsible for:

- Verification of test configuration against declared ODD specification
- Confirmation of evidentiary recording initiation and integrity
- Observation of fail-closed verification events
- Documentation of any anomalies or concerns during test period
- Cryptographic sealing of evidentiary record at test completion

7.3 Witness Fees

On-site witness services incur additional fees: $5,000 base fee plus travel and accommodation expenses. Remote witness capability requires applicant infrastructure meeting Sentinel Authority technical specifications.

8. Completion Criteria

CAT-72 is complete when all of the following criteria are satisfied:

1. Full test duration (minimum 72 hours) concludes without interruption
2. All demonstration requirements (Section 3) are satisfied
3. Tolerance compliance verified for all declared parameters
4. Architectural consonance verified (Section 6)
5. Evidentiary record integrity verified (continuous hash-chain)
6. Sentinel Authority witness signature applied to sealed record

Failure to satisfy any criterion results in test failure. Applicants may re-attempt CAT-72 after addressing deficiencies. No limit on re-attempts, but each attempt incurs standard fees.

9. Renewal Requirements

CAT-72 completion is required for both initial ODDC determination and periodic renewal.

9.1 Conformance Terms

Conformance terms range from 6-24 months depending on:

- Operational domain risk profile (higher risk = shorter term)
- ODD complexity and boundary count
- Applicant conformance history
- Underwriter or regulatory requirements

9.2 Renewal Process

Renewal requires full CAT-72 re-completion. Streamlined renewal is available for applicants with:

- No conformance violations during prior term
- No modifications to ODD specification or enforcement architecture
- No updates to underlying simulation (architectural consonance maintained)

Streamlined renewal permits 48-hour test duration (vs. standard 72 hours) at Sentinel Authority discretion.

9.3 Waivers

Waivers are not issued. All conformance determinations require CAT-72 completion. Extensions may be granted (up to 30 days) for renewal applicants experiencing scheduling constraints, but conformance lapses if CAT-72 is not completed within extension period.