



INERTRA™

Technical Brief

Mechanical Interface Retention & Flow Architectures

This brief provides a technical introduction to INERTRA™ Retention and Flow architectures: two patent-protected mechanical frameworks addressing rotational back-off, preload decay, and vapor dispersion in high-vibration, cyclic load, and biomechanical environments. For qualified engineering evaluation teams.

PATENTS:

US 9,422,969 B2 · US 8,398,349 B2 · US 8,226,158 B1

Issued U.S. patents · Inventor and owner of record: Allen Forrest Jackson · Licensed through Ireland Design Company, LLC

INTENDED AUDIENCE:

Mechanical Engineers · Design Engineers · Systems Integration Teams

01 • THE PROBLEM

Interface Instability in Dynamic Assemblies.

In vibration-intensive operating environments (wind turbines, heavy equipment drivetrains, military ground vehicles, rail bogies, and biomechanical implant systems), small relative motions occur between mating surfaces under cyclic excitation. Over extended load cycles, these motions reduce clamp load, increase interface wear, and elevate the probability of rotational back-off. Frequency exposure, transient shock loads, thermal cycling, and field maintenance variability compound these effects across the platform service life.

8.3 FAILURES PER OFFSHORE WIND TURBINE PER YEAR [4] Carroll et al., 2016	\$125K PER HOUR, TYPICAL INDUSTRIAL OUTAGE [3] ABB, 2023	~1M BIOMECHANICAL LOAD CYCLES PER YEAR	3 ISSUED U.S. PATENTS IN PORTFOLIO
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Failure-rate and downtime figures are all-cause benchmarks, not specific to fastener loosening. Sources on page 6.

Failure Mode Taxonomy: Four Primary Mechanisms

Mode 01 Vibration Loosening	Progressive micro-rotation under cyclic torque causes clamp load loss long before visible joint failure. Transverse slip is the established mechanism of vibration-induced self-loosening (Junker, SAE 690055, 1969). Observed in wind nacelle structures, mining equipment, and military ground vehicle drivetrain interfaces.
Mode 02 Preload Decay	Thermal cycling, load variability, and material relaxation compound over operating life. Thread-lockers treat symptoms rather than the rotational mechanics driving loosening.
Mode 03 Cyclic Fatigue	Fretting, micro-movement, and repeated load cycles degrade joint integrity incrementally across millions of cycles, including biomechanical load cycles in orthopedic fixation systems.
Mode 04 Vapor Dispersion	Wheel-generated airflow at highway speed drives fluid mist toward adjacent systems and roadways. Active suppression adds weight, complexity, and maintenance burden.

Two Patent Families. One Platform.

INERTRA™ addresses rotational constraint and flow behavior at the structural level, integrated into the assembly rather than applied afterward. No adhesives. No cure variability.

INERTRA™ Retention: US 9,422,969 B2 / US 8,398,349 B2

Mechanical interlock against back-off rotation.

INERTRA™ retention architectures are engineered to maintain clamp load stability in bolted interfaces operating in vibration-intensive, cyclic load environments common to heavy equipment, transportation platforms, and military ground vehicles. A nut threads onto the stud and an opposite-hand bolt threads into the stud's internal bore, its head seated in notches on the nut. The turn that would loosen the nut tightens the bolt, so no thread-locking compound is required.

MECHANISM

Opposite-hand threads that lock against each other within the fastener assembly. Mechanical, not chemical.

ENVIRONMENTS

Heavy equipment • Wind energy • Rail • Military ground vehicles • Biomechanical fixation.

SERVICEABLE

Supports controlled removal and reinstallation across service cycles. No adhesive contamination.

NO ADHESIVES

No thread-lockers or adhesives. Some embodiments add a retaining pin.

INERTRA™ Flow: US 8,226,158 B1

Passive vapor & disturbance control architecture.

Geometry-directed airflow channeling that redirects motion-generated vapor and disturbance behavior through passive structural architecture. No active components. No energy input.

ENVIRONMENT

Commercial transport • Rail • Mobile equipment in wet-weather operating conditions.

ADVANTAGE

No weight penalty from active systems. No power consumption.

ARCHITECTURE

Passive geometric redirection: no moving parts and no active control.

APPLICATION

Wheel-driven vapor and mist dispersion at highway speed. Tire-adjacent aerodynamics.

03 • TECHNICAL SPECIFICATIONS

Interface Engineering Parameters.

The following parameters describe the operating environment context for INERTRA™ architecture evaluation. Specific integration geometry, load profiles, and material compatibility are addressed in confidential technical materials available to qualified partners under executed NDA.

Architecture Type	Mechanical: geometry-based constraint integrated at the interface level. No chemical bonding, no active components, no thermal activation required.
Primary Failure Mode Addressed	Rotational back-off (Retention family) and motion-driven vapor dispersion (Flow family). Root cause treatment at the interface, not symptom suppression downstream.
Retention Load Environment	High-vibration assemblies, cyclic torque exposure, thermal cycling, shock loading, and biomechanical physiological loading in regulated medical fixation environments.
Cycle Resistance	Designed for extended load-cycle exposure. Directly applicable to biomechanical environments accumulating approximately 1 million physiological cycles per year across implant service life.
Serviceability	Architecture supports controlled disengagement and reinstallation. Compatible with standard field maintenance procedures. Does not require destructive removal.
Chemistry	No chemical compounds required for function. No anaerobic adhesives, epoxies, or reactive agents. Biocompatibility depends on material selection and is the licensee's responsibility.
Flow Environment	Commercial highway transport, rail, and mobile equipment. Wheel-adjacent aerodynamics at operating speed. Passive performance with no active control.
Patent Coverage	US 9,422,969 B2 (Primary: Industrial + Medical) • US 8,398,349 B2 (Parent: Industrial) • US 8,226,158 B1 (Flow: Vehicle Mist Suppression). Issued United States patents only.

04 • APPLICATION ENVIRONMENTS

Target Industries & Interface Contexts.

Interface instability appears wherever bolted assemblies operate under sustained dynamic load. The table below maps each industry context to the relevant INERTRA™ family and primary failure mode.

INDUSTRY	INTERFACE ENVIRONMENT	INERTRA™ FAMILY	PRIMARY FAILURE MODE
Offshore Energy & Oil/Gas	Nacelle, hub, tower flange, pumps, compressors, skid systems; vessel/crane access	Retention	Rotational back-off, preload decay
Heavy Equipment	Mining, construction, off-highway; shock & vibration	Retention	Vibration loosening, cyclic fatigue
Military Ground Vehicles	Drivetrain interfaces; MIL-SPEC environments	Retention	Rotational constraint under shock & vibration
Rail & Transport	Bogies, axles, commercial highway vehicle interfaces	Retention + Flow	Cyclic fatigue / Spray dispersion
Industrial Automation	Drives, gearboxes, precision assemblies; high cycle	Retention	Preload decay, positional drift
Aerospace & Defense	High-reliability structural interfaces; AS9100/MIL qualification	Retention	Vibration loosening, retention
Medical & Biomechanical	Orthopedic fixation, implant systems; ISO 13485	Retention	Cyclic fixation integrity, load-cycle retention

NEXT STEP • LICENSING INQUIRY**From Technical Reference to Structured Evaluation.**

Where a patent family appears relevant to a real application, the next step is a qualified inquiry with enough context (interface description, operating environment, failure mode) to determine whether confidential technical review is warranted. Confidential claim mapping and supplemental engineering materials are available after NDA execution with qualified partners.

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Trademark	INERTRA™ is a trademark of Timothy J. Fore, used under license by Ireland Design Company, LLC. A patent license does not include trademark rights.
Website	ireland-design.com
Patents	US 9,422,969 B2 • US 8,398,349 B2 • US 8,226,158 B1. All available at patents.google.com
Note	IDC does not manufacture or distribute products. All implementations, testing, validation, and regulatory approvals are the responsibility of the licensee.

SOURCES

1. Siemens / Senseye, *The True Cost of Downtime 2022*. Oil & gas: almost \$500,000 per hour of unplanned downtime; \$149M per facility per year.
2. Siemens, *The True Cost of Downtime 2024*. Large heavy-industry plant: about \$59M per year; Fortune Global 500: about \$1.4 trillion per year, 11% of revenue.
3. ABB, *Value of Reliability* survey, October 2023 (3,215 plant maintenance decision-makers). Typical business: close to \$125,000 per hour.
4. Carroll, McDonald & McMillan, "Failure rate, repair time and unscheduled O&M cost analysis of offshore wind turbines," *Wind Energy* 19(6), 2016, pp. 1107-1119. doi:10.1002/we.1887.

All figures are all-cause downtime or failure benchmarks, not specific to fastener loosening. Full links: ireland-design.com/economics.html#sources