DIAMOND COATINGS
FOR INDUSTRIAL COMPONENTS

Expanding the Performance Capabilities of Rotating Equipment
ADVANCED DIAMOND TECHNOLOGIES DELIVERS PERFORMANCE TECHNOLOGY FOR REAL-WORLD APPLICATIONS

UNCD® IN INDUSTRIAL MACHINERY

Ultrananocrystalline Diamond (UNCD®) coatings are extremely thin (0.5-20μm) real diamond films. When applied to carbide wear surfaces, UNCD® significantly expands the performance capabilities of rotating equipment such as pumps and mixers.

DEMONSTRATED VALUE IN THE FIELD

- More than 35,000 UNCD®-coated components have been deployed in operations on six continents
- Industry-leading manufacturers are now specifying UNCD® coatings for high-wear applications
- A wide variety of industries — including Oil & Gas, Chemical, Water Treatment, Power, Pharmaceutical and Mining — have adopted UNCD® as a preferred solution for critical field applications

ADT & UNCD® HAVE BEEN RECOGNIZED WITH NUMEROUS INDUSTRY AWARDS

ADT’S WORLD-CLASS SUPPLY SERVICES INCLUDE:

- Engineering and design capabilities for unique OEM applications
- Quick-turnaround design, production, and delivery
- Wear analysis and performance testing
- Global service and availability through more than 180 partner service centers

UNCD®’s Unique Performance Characteristics Deliver Enhanced Reliability, Superior Severe-Service Performance, & Increased Efficiency

Seals and bearings in industrial applications can be subjected to enormous pressures and severe operating environments.

UNCD’s superior performance over standard materials is based on the ability to resist wear (both mechanical and chemical) and to minimize friction and heat.

UNCD®’s Unique Performance Characteristics Deliver Enhanced Reliability, Superior Severe-Service Performance, & Increased Efficiency

ADT IS THE WORLD’S LEADING SUPPLIER OF THIN DIAMOND COATINGS FOR HIGH-WEAR SURFACES IN ROTATING EQUIPMENT.

For more than 15 years, ADT has partnered with OEMs and major industrial end-users to improve the performance and reliability of their critical components.

UNCD® IN INDUSTRIAL MACHINERY

HIDRODYNAMIC BEARINGS

MECHANICAL SEAL FACES

Engineering and design capabilities for unique OEM applications
Quick-turnaround design, production, and delivery
Wear analysis and performance testing
Global service and availability through more than 180 partner service centers
UNCD® IMPROVES PUMP RELIABILITY

THE CORRECT DESIGN AND EQUIPMENT CAN ONLY TAKE MTBF SO FAR. MORE THAN 25% OF PUMP FAILURES ARE DUE TO SEAL FAILURE FROM NON-STANDARD OPERATIONAL DEMANDS.

OVER 2/3 OF PUMP FAILURES ARE DUE TO SEAL FAILURE

ADT’S UNCD® SEAL FACES CAN WITHSTAND A WIDER RANGE OF OPERATING PARAMETERS. THIS LEADS TO EXTENDED SEAL (AND PUMP) LIFE AND SUPERIOR PERFORMANCE IN SEVERE SERVICE APPLICATIONS.

THE LARGEST % OF THOSE FAILURES ARE RELATED TO NON-STANDARD OPERATIONS

UNCD® POWERS THROUGH LOW-LUBRICITY CONDITIONS

ONE OF THE MOST COMMON HIGH WEAR APPLICATIONS FOR MECHANICAL SEALS IS PUMPING MEDIA WITH LOW LUBRICITY CHARACTERISTICS SUCH AS: HOT WATER, LIGHT HYDROCARBONS, AND FLUIDS WITH ENTRAINED GASES. UNCD® COATED FACES PERFORM SUBSTANTIALLY BETTER THAN CONVENTIONAL ALTERNATIVES.

UNCD® IMPROVES ROOT CAUSE OF SEAL FAILURE

PUMP FAILURE BY COMPONENT

Seals 69%
Bearing 10%
Mechanical 12%
System Design 19%
Static Joints 9%
Miscellaneous 8%
Other 12%

ROOT CAUSE OF SEAL FAILURE

Operational 40%
Seal Components 9%
Mechanical 12%
System Design 19%
Static Joints 9%
Miscellaneous 8%

TEST RESULTS - HOT WATER

(250°F Water at 100 PSI)

FACE WEAR

SEAL FACE SURFACE CONDITION AFTER TESTING

UNCD/C

SIC/C

TEST RESULTS - ENTRAINED GAS

Diamond combinations ran an average of 67°F (37°C) cooler than SIC vs. SIC and exhibited substantially lower wear.

TEST RESULTS - DRY RUNNING

In dry running cycle testing, UNCD running against a SIC counterface continues to successfully seal after having been exposed to 35 dry running cycles of 5 minutes each. SIC running against a SIC counterface fails consistently after the first 90 seconds of dry running.

UNCD® DURING PUMP START-UP AND INTERMITTENT DRY RUNNING

ADT has specifically designed UNCD® to perform in intermittent dry running conditions. While absolute run times depend on a given set of conditions, the data shown on the right replicates typical severe conditions. UNCD® tested in customer trials showed up to 20 times longer MTBF.

IMPROVEMENTS IN PUMP MTBF CAN DELIVER MILLIONS IN SAVINGS

THE AVG. REFINERY OR CHEMICAL PROCESSING FACILITY OPERATES ~1,200 PUMPS

IMPROVEMENTS IN MTBF RESULTS IN = $1.4-1.8M IN ANNUAL SAVINGS

Avg. MTBF of 2.5 years = 480 pump repairs per year
Avg. pump maintenance cost of $12-15K/unit = Avg. pump maintenance cost of $6-7M/year
Avg. downtime cost of $3-3.5M/year: (9% of total LCC)

25% IMPROVEMENT IN MTBF RESULTS IN = $1.4-1.8M IN ANNUAL SAVINGS

The correct design and equipment can only take MTBF so far. More than 25% of pump failures are due to seal failure from non-standard operational demands.

Over 2/3 of pump failures are due to seal failure. The largest % of those failures are related to non-standard operations.

ADT’s UNCD® seal faces can withstand a wider range of operating parameters. This leads to extended seal (and pump) life and superior performance in severe service applications.

One of the most common high wear applications for mechanical seals is pumping media with low lubricity characteristics such as: hot water, light hydrocarbons, and fluids with entrained gases. UNCD® coated faces perform substantially better than conventional alternatives.

UNCD® improves pump reliability.

Improvements in pump MTBF can deliver millions in savings.

The average refinery or chemical processing facility operates ~1,200 pumps.

Improvements in MTBF results in $1.4-1.8M in annual savings.

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Test results - hot water (250°F water at 100 PSI).

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Test results - entrained gas.

Diamond combinations ran an average of 67°F (37°C) cooler than SIC vs. SIC and exhibited substantially lower wear.

Test results - dry running.

In dry running cycle testing, UNCD running against a SIC counterface continues to successfully seal after having been exposed to 35 dry running cycles of 5 minutes each. SIC running against a SIC counterface fails consistently after the first 90 seconds of dry running.

UNCD® improves root cause of seal failure.

Pump failure by component:
- Seals: 69%
- Bearings: 10%
- Mechanical: 12%
- System Design: 19%
- Static Joints: 9%
- Miscellaneous: 8%
- Other: 12%

Root cause of seal failure:
- Operational: 40%
- Seal Components: 9%
- Mechanical: 12%
- System Design: 19%
- Static Joints: 9%
- Miscellaneous: 8%

Test results - dry running.

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Test results - dry running.
The coefficient of friction (CoF) of UNCD® components running against SiC primaries has been measured between 0.018 and 0.04, which is significantly lower than a comparable measurement of SiC against resin-bonded carbon or SiC against SiC (see graph above).

**UNCD® REDUCES EXCESSIVE SEAL WEAR AND FAILURE IN SEVERE CONDITIONS**

**INTERMITTENT DRY RUNNING CONDITIONS**
- Transfer pumps
- Water/air multi-phase operation
- Applications with cavitation or air-entrainment

**LOW-LUBRICITY APPLICATIONS**
- Light hydrocarbons
- Hot condensate
- Boiler feed water

**CORROSIVE MEDIA**
- Sulphuric acid
- Caustics

**EXTREME TEMPERATURE**
- Heat transfer fluids
- Off-spec vacuum tower bottoms
- Cryogenic applications

**ABRASIVE SLURRIES**
- Flue gas desulphurization slurry
- Water w/coke fines
- Alumina slurry
- Fibrous slurry

**THE BENEFITS OF LESS FRICTION**

According to the U.S. Department of Energy, pumping systems account for 25-50% of the energy usage in certain industrial plant operations. ADT field data indicates that incorporating UNCD® seal faces into these systems results in up to 5% less energy usage. An average refinery or chemical production facility could realize over $500,000 in energy savings alone.

**REDUCED ENERGY USAGE**
- In 100 hour tests on water with entrained gases, UNCD faces averaged 50% (67°F) cooler than SiC faces and exhibited substantially lower wear.
- In partial dry running conditions, seals with a single UNCD face ran anywhere from 40°F to 110°F cooler over the life of the test, depending on conditions.

UNCD faces are a cost-effective solution for applications with short MTBF due to poor lubricating conditions.

**OPTIONS FOR ADDRESSING SHORT MTBF DUE TO POOR LUBRICATION CONDITIONS**

<table>
<thead>
<tr>
<th>Application Type</th>
<th>UNCD® Faces</th>
<th>Custom Seal</th>
<th>Plan 32</th>
<th>Dual Seal</th>
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<tbody>
<tr>
<td><strong>INITIAL COST</strong></td>
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<td>Moderate</td>
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<tr>
<td><strong>OPERATING COST</strong></td>
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<td>Cooling Water Costs</td>
<td>Cooling Water Costs</td>
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<td>Maintenance Cost</td>
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<td>Barrier Fluid, labor on Auxiliary Equipment</td>
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<tr>
<td><strong>TOTAL COST</strong></td>
<td>Lowest Cost</td>
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<td>Significant</td>
<td>Significant</td>
</tr>
</tbody>
</table>

Low friction enables UNCD® components to be paired with silicon carbide (SiC) primaries in applications that would otherwise require weaker, less chemically stable, carbon faces due to intermittent dry operation or temperature-sensitive media. UNCD’s lower friction can provide more robust single-seal solutions in applications that might otherwise require additional cooling equipment costs and maintenance issues associated with more complex seal plans.

**UNCD® PROVIDES EFFICIENT OPERATION THROUGH A LOWER COEFFICIENT OF FRICTION**

**FIELD SUCCESS STORIES**

**APPLICATION:** A high-volume Australian mineral refinery required a custom-engineered mechanical seal to assist in the movement of an alumina slurry by-product.

**RESULTS:** UNCD® has demonstrated 20x longer seal run times than competing products in severe, dry-run conditions, eclipsing the life of previously installed seals.

**APPLICATION:** Constant seal failure in its reactors prompted a major aerospace component manufacturer to seek an alternative to its traditional double-seal system.

**RESULTS:** The new UNCD® seals were more durable, able to withstand intermittent dry-run conditions, and lasted more than 30x longer than the previously used traditional seals.

**APPLICATION:** A remote desert mine was consuming upwards of 1 million gallons of water per year, per pump, just to lubricate the packing gland in their slurry pumps.

**RESULTS:** Integrating UNCD® into the mechanical seals eliminated this water-and-energy-intensive lubrication practice, directly reducing the mine’s operating costs by millions of dollars.

**DESIGN FLEXIBILITY**

**WATER SAVINGS**

**REDUCED HEAT GENERATION**

**WATER SAVINGS**
- Alternatives for a typical cartridge seal with SiC faces and 11 month MTBF

**THE BENEFITS OF LESS FRICTION**

- Less heat generation (results from Flowserve analysis)
- In 100 hour tests on water with entrained gases, UNCD faces averaged 50% (67°F) cooler than SiC faces and exhibited substantially lower wear.
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Leveraging exclusively licensed patented technology developed at Argonne National Laboratories, ADT builds on advances in nanotechnology and chemical vapor deposition processes to deliver micron level diamond coatings with highly engineered surface properties.

With more than 35,000 UNCD® seal faces in use around the world, ADT helps major OEMs and end-users in a variety of industries through our commitment to continuous innovation, process control, and supply-chain value.

**APPLICATION BY INDUSTRY:**

**OIL & GAS**
- Produced water
- Crude oil pipelines
- Multiphase pumps

**MINING & GENERAL SLURRIES**
- Fibrous slurries
- Abrasive slurries
- Batch processes

**REFINERIES**
- Dirty of light hydrocarbons
- Tower bottoms
- High Viscosity fluids

**CHEMICAL**
- Loading/unloading pumps
- Fluids with entrained gases
- Solutions with abrasives

**POWER**
- Boiler feed water
- FGD slurries
- River water

Pump, mixers and agitators are vital to up-time. ADT’s UNCD® coated components help this equipment deliver reliable performance in severe-service conditions such as low lubricity and dry-running.

For more information visit: www.thindiamond.com
or contact: sales@thindiamond.com

Advanced Diamond Technologies, Inc.
48 East Belmont Drive, Romeoville, IL 60446
815.293.0900 | sales@thindiamond.com