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Marine Applications of Thermal Spray Technology

Hard Chrome Alternatives Team Meeting

San Diego, CA 25 January 2006

Jim Galvin, President, Thermal Spray & Machine, Inc.

Dave Donohue, Corporate Technical Director, TSM, Inc.

Charlie Hurd, West Coast Representative, TSM, Inc.

Chris Nichols, Vice President, Sales & Marketing, TSM, Inc.

Report Documentation Page				Form Approved OMB No. 0704-0188	
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a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			



Thermal Spray & Machine Inc.

CUSTOMER BASE

- **Approx. 40-45% of Overall Sales Volume – U.S. Military**
Navy – Army – Coast Guard – Military Sealift Command

- **Support Center For Shipyards, Manufacturing Plants, Electrical, Hydraulic, and Mechanical Repair Facilities and Original Equipment Manufacturers**

- **Commercial Customers**
Anheuser-Busch – Dupont – Weyerhaeuser – Alcoa
Georgia Pacific - International Paper - Phillip Morris
Honeywell Performance Fibers ... and a host of others..! !

Thermal Spray & Machine, Inc. - CERTIFICATIONS

1. **SUPERVISOR OF SHIPBUILDING, CONVERSION & REPAIR, US NAVY, PORTSMOUTH, VA** Certification of Facilities in accordance with NAVSEA MIL-STD 1687A
2. **COMMANDER NAVAL SEA SYSTEMS COMMAND (SEA 05M2)** Approval of TSM's Thermal Spray Coating Procedure FP-WC-01 for HVOF Application of Tungsten Carbide
3. **COMMANDER NAVAL SEA SYSTEMS COMMAND (SEA 05M2)** Approval of TSM's Thermal Spray Coating Procedure for HVOF Application of Alloy 625
4. **NAVAL SURFACE WARFARE CENTER, CRANE DIVISION** Certification of Facility IAW NAVSEA S9320-AM-PRO-030/MLDG Rev 02, Vol. III
5. **COMMANDING OFFICER, SUBMEPP** NAVSEA Qualification to Manufacture MIL-C-24231 Connector Plugs for Submarine Cables
6. **AMERICAN BUREAU OF SHIPPING** Certificate of Type Approval No. NN498634 of TSM's Thermal Spray Coatings Including Main Propulsion Shafting Applications
7. **AMERICAN BUREAU OF SHIPPING** Certificate of Design Assessment No. 04-HS410093/2-PDA of TSM's Process F/P WC-01 for Repair and Restoration of Marine Machinery Components
8. **AMERICAN BUREAU OF SHIPPING** Certificate of Manufacturing Assessment No. NN498634 of TSM's Facilities and Associated Quality Procedures to Apply Coatings That Meet ABS Designated Standards
9. **LLOYD'S REGISTER** Certificate of Approval No. MNDE/REP/0001/01 of TSM's Arc Spraying and HVOF Spraying Procedures



U.S. Department of Defense

Office of the Assistant Secretary of Defense (Public Affairs)

News Release

No. 851-04

IMMEDIATE RELEASE

September 1, 2004

DoD Issues Green Procurement Policy

The Department of Defense today announced an important step forward in its efforts to align mission and environmental stewardship by issuing a new “green procurement” policy. The policy affirms a goal of 100 percent compliance with federal laws and executive orders requiring purchase of environmentally friendly, or “green” products and services.

Thermal Spray Process And Coatings Comply With DoD Green Procurement Policy...

- **NO** Hexavalent Chrome !
- **NO** Phosphates !
- **NO** Cadmium !
- **NO** Halogens !
- **NO** Lead !
- **NO** Volatile Organic Compounds (VOC's) !

Applications of HVOF Thermal Spray

- **Bearing & Seal Journals**
- **Manufacturing Rolls**
- **Compressor Parts**
- **Pump Shafts**
- **Blower Shafts**
- **Armature Shafts**
- **Hydraulic Rods**
- **Gear Fits**
- **Pump Casings**
- **Impellers**
- **Centrifuges**
- **Turbine Shafts**
- **Sleeves**
- **Axle Shafts**
- **Camshaft Journals**
- **Pistons/Piston Rods**
- **Crankshafts**
- **Bow Thruster Shafts**
- **Bearing Fits**
- **Propeller Shafts**
- **Rudder Posts**
- **Valve Stems**
- **Main Propulsion Shafts**
- **Plungers**
- **Mandrels**
- **Packing Glands**



MARINE APPLICATIONS

INNOVATION ! EXPERIENCE ! QUALITY !



HARD CHROME REPLACEMENT

INNOVATION ! EXPERIENCE ! QUALITY !

HYDRAULIC CYLINDER ROD

Shaft Coated With HVOF Applied Tungsten Carbide



**HVOF Applied Tungsten Carbide Coatings Are An Approved
Alternative For Hard Chrome Replacement ! !**

**These coatings are hard, dense, well bonded, wear resistant, seal
friendly, and protect against corrosion !**

HYDRAULIC CYLINDER ROD

Shaft Coated With HVOF Applied Tungsten Carbide

**HVOF Applied Tungsten Carbide Coatings Are An Approved
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**These coatings are hard, dense, well bonded, wear resistant,
seal friendly, and protect against corrosion !**

WEAPONS ELEVATOR CYLINDER ROD – USS WASP

Entire Rod Repaired With HVOF Applied Tungsten Carbide As Hard Chrome Replacement



Custom Designed TSM "Superfinisher" In Action



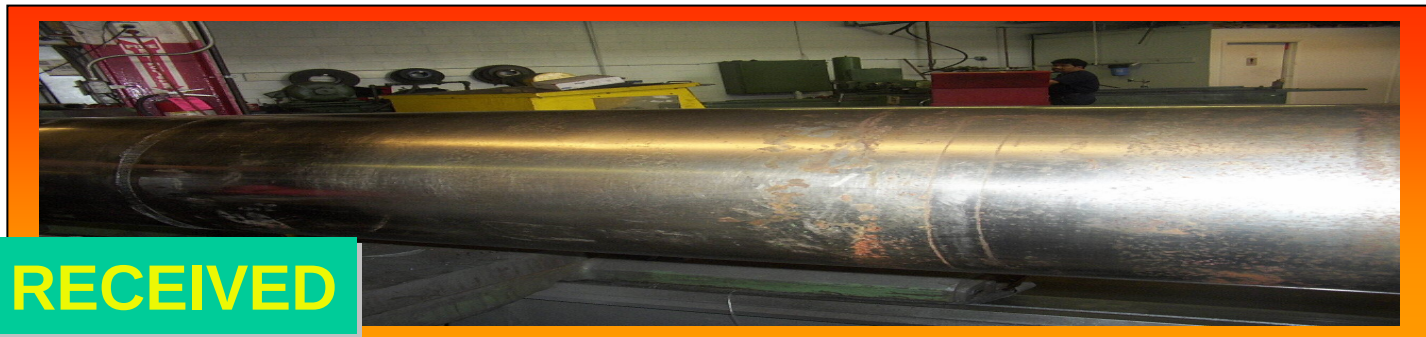
Superfinished to Customer Specifications of 6 Ra



**OVERALL ROD DIMENSIONS
10" Diameter X 24' Long**

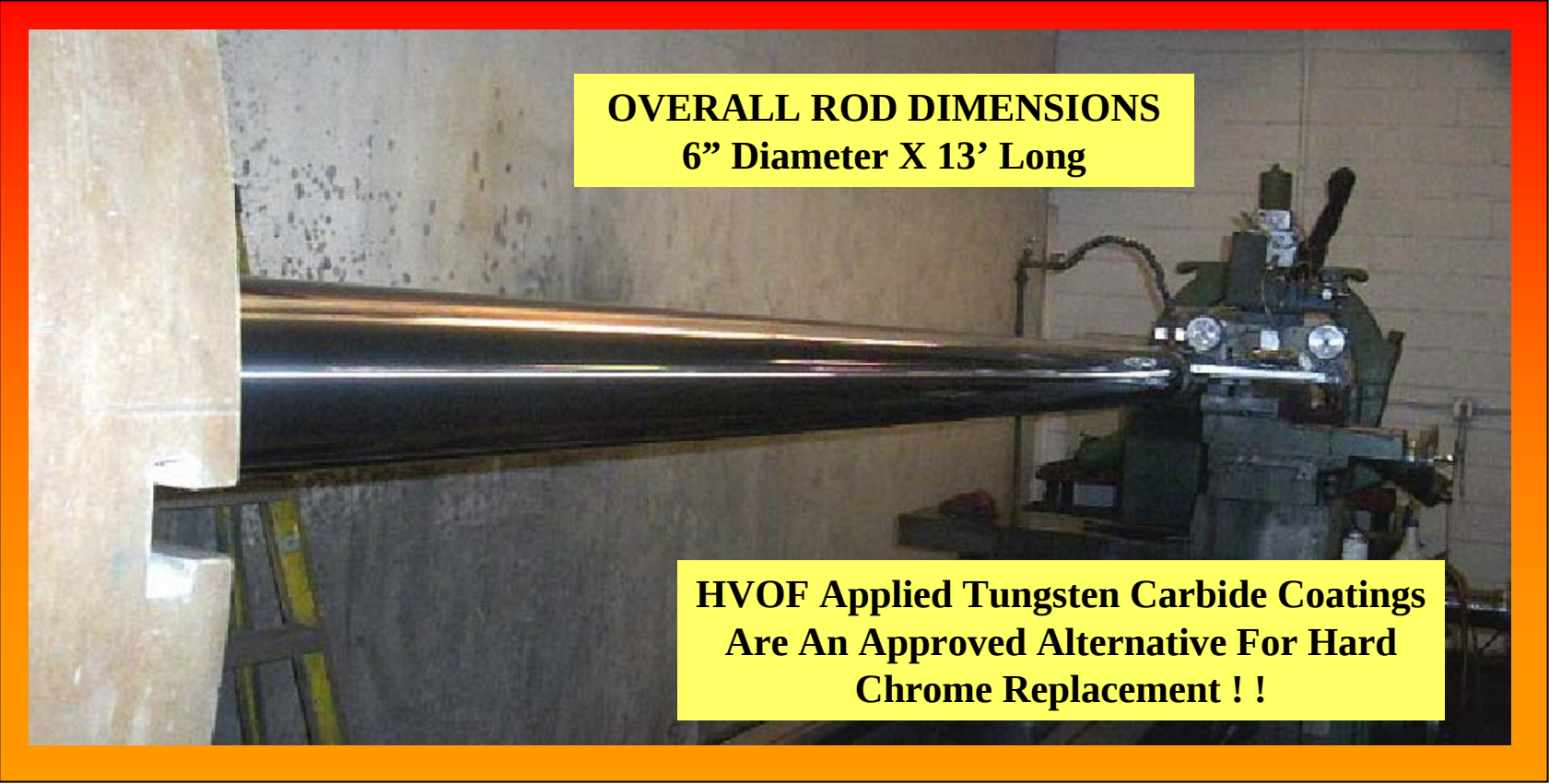
**HVOF Applied Tungsten Carbide Coatings
Are An Approved Alternative For Hard
Chrome Replacement !!**

USS BOONE (FFG-25) – STEERING ENGINE RUDDER RAM REPAIRED WITH TUNGSTEN CARBIDE-COBALT REPLACING THE ORIGINAL HARD CHROME



STERN GATE HYDRAULIC CYLINDER ROD - USS ASHLAND

Entire Rod Coated With HVOF Applied Tungsten Carbide As Hard Chrome Replacement

A photograph of a long, polished hydraulic cylinder rod in a workshop. The rod is positioned horizontally, extending from the left side of the frame towards the right, where it is held by a lathe. The rod has a highly reflective, mirror-like finish. The background shows a workshop environment with a concrete wall and various mechanical components. The entire image is framed by a thick orange border.

**OVERALL ROD DIMENSIONS
6" Diameter X 13' Long**

**HVOF Applied Tungsten Carbide Coatings
Are An Approved Alternative For Hard
Chrome Replacement !!**

NAVY and COAST GUARD

HVOF APPLICATIONS

INNOVATION ! EXPERIENCE ! QUALITY !

U.S. Navy Landing Craft (LCAC)

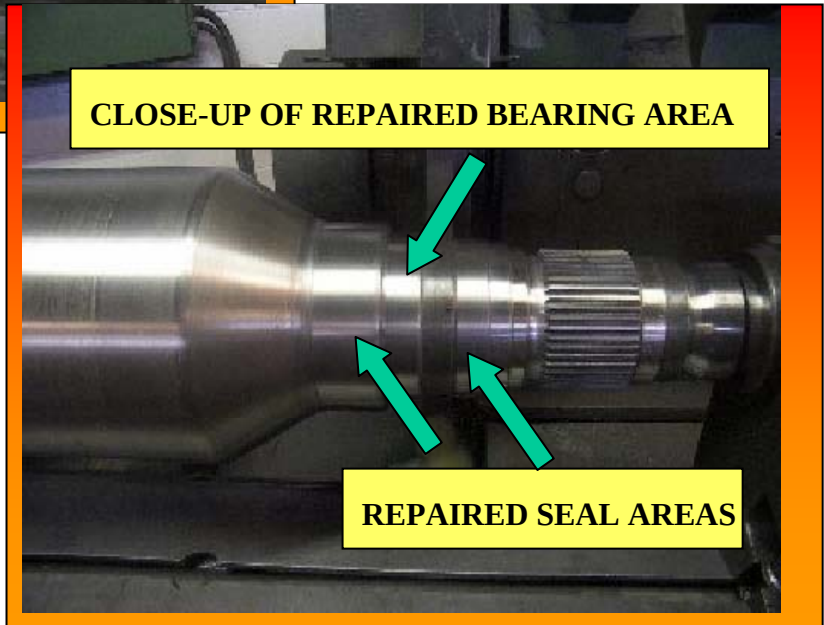


LIFT FAN SHAFTS

We have coated the bearing journals on more than 600 LCAC lift fan shafts extending the service life from 100 hours (1 Year) to over 700 hours (7 Years) and still counting !!

PROJECTED SAVINGS: \$20.1M Over 15 Year Service Life !

CLOSE-UP OF REPAIRED BEARING AREA

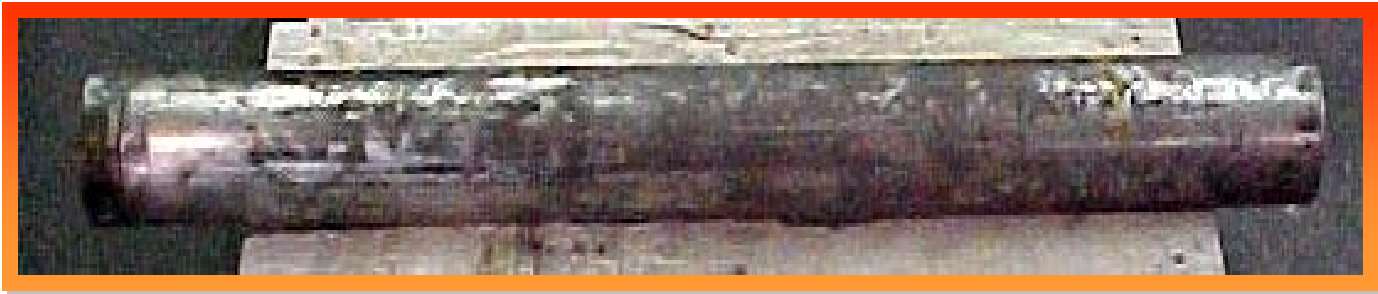


REPAIRED SEAL AREAS

HVOF Applied Tungsten Carbide Cobalt/Nickel Coatings (TSM-0010)

Thermal Spray Coating (TSM-0010) not only increases corrosion protection but also increases surface hardness resulting in a substantial increase in material life. Normal carbon steel hardness is 22 on the Rockwell C Scale, by coating with Tungsten Carbide the hardness is increased to 64, almost three (3) times the hardness of the original material.

AIRCRAFT CARRIER ELEVATOR STANCHIONS



BEFORE



AFTER

AIRCRAFT CARRIER FLIGHT DECK ELEVATOR LOCKING PIN

Coated With HVOF Applied Tungsten Carbide For Increased Wear Resistance



USS Detroit - 63 Ton Rudder Post

Bearing and Seal Areas Repaired with HVOF Applied Inconel 625



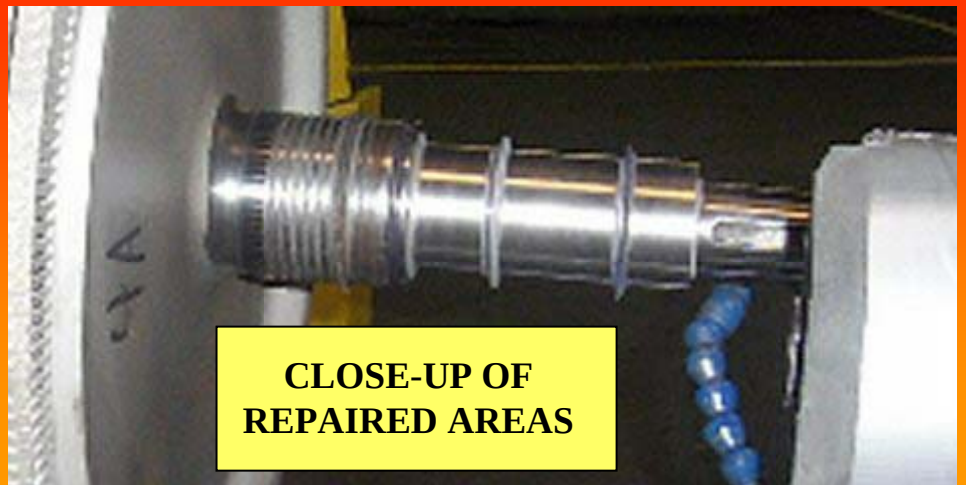
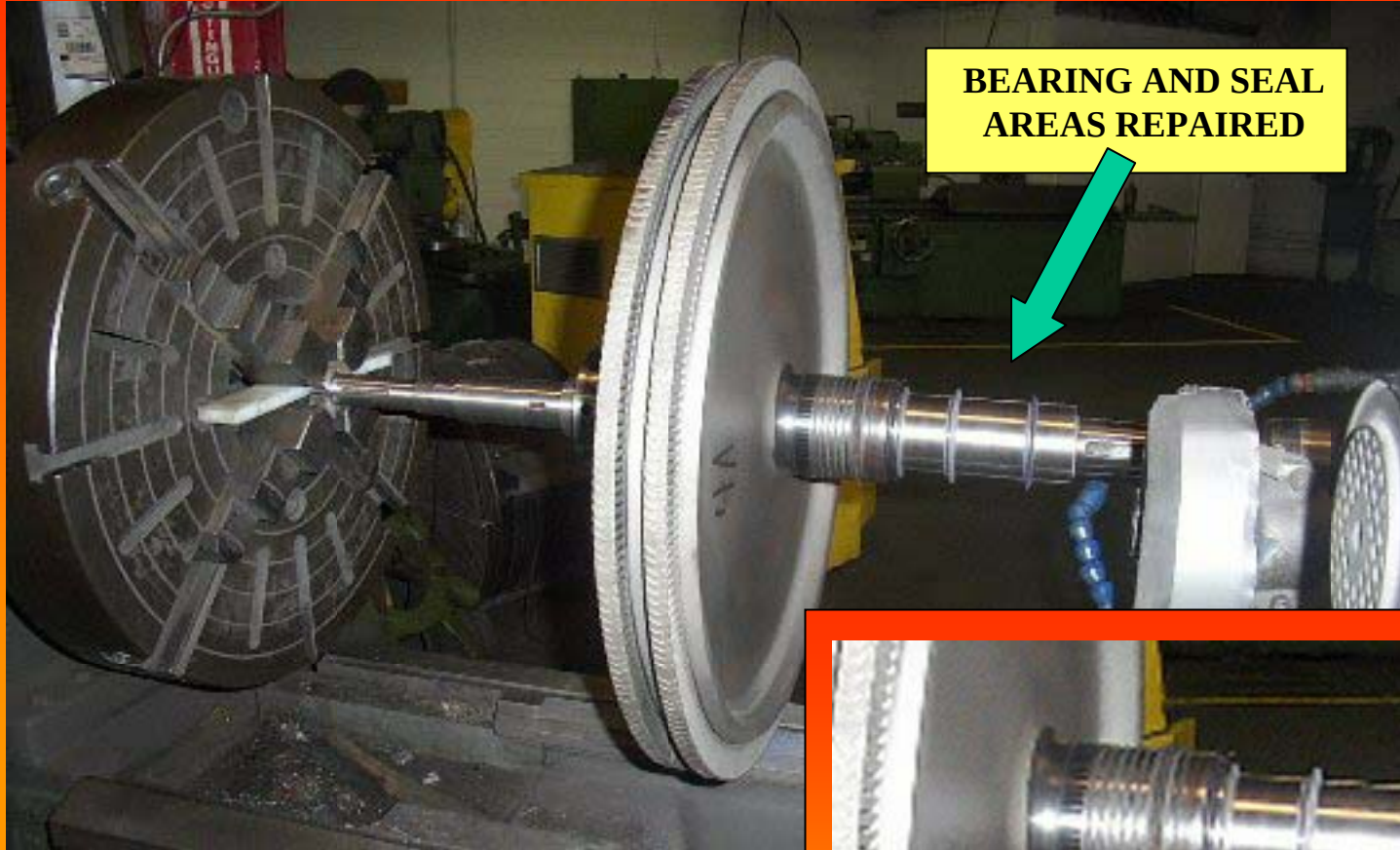
Yes, that was 63 TONS (126,000 lbs.) !!



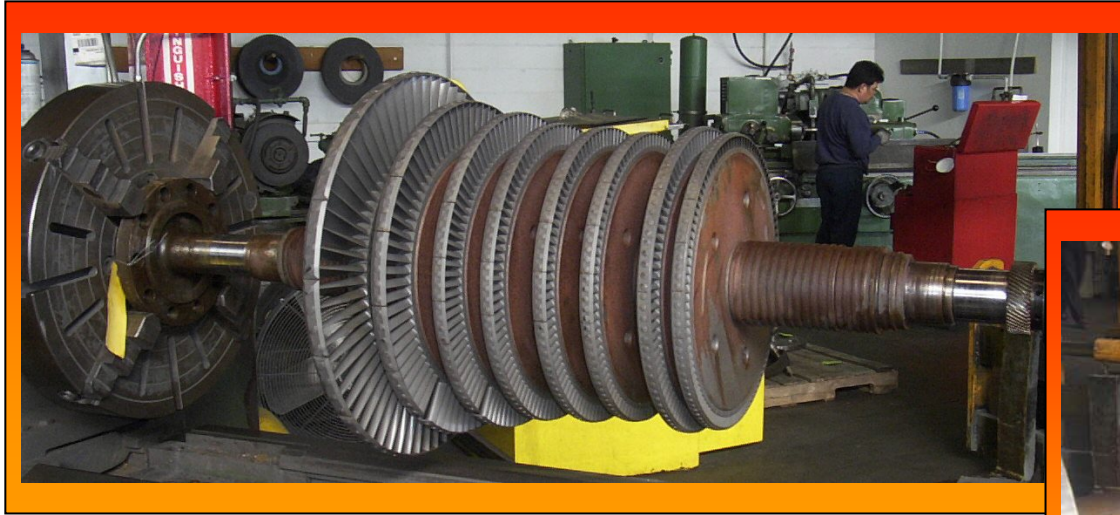
Saved the customer \$193,000.00 and 25 schedule days

USS KENNEDY – MAIN FEED PUMP TURBINE

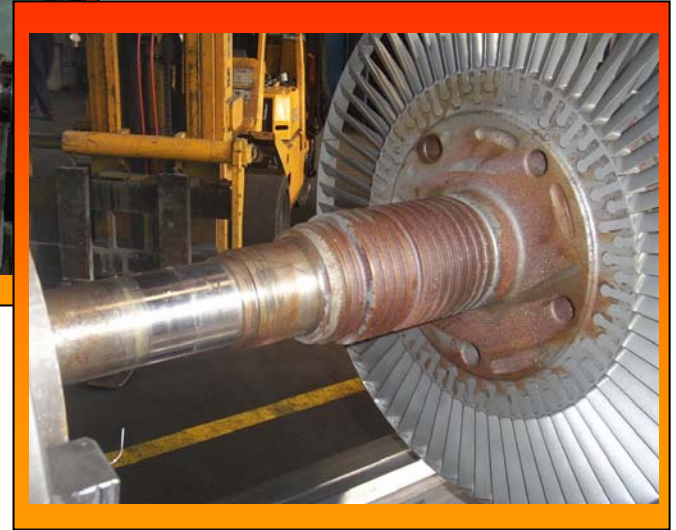
Bearing and Seal Areas Repaired With HVOF Applied Tungsten Carbide



USS KENNEDY – SHIP'S SERVICE TURBINE GENERATOR



← **BEFORE**



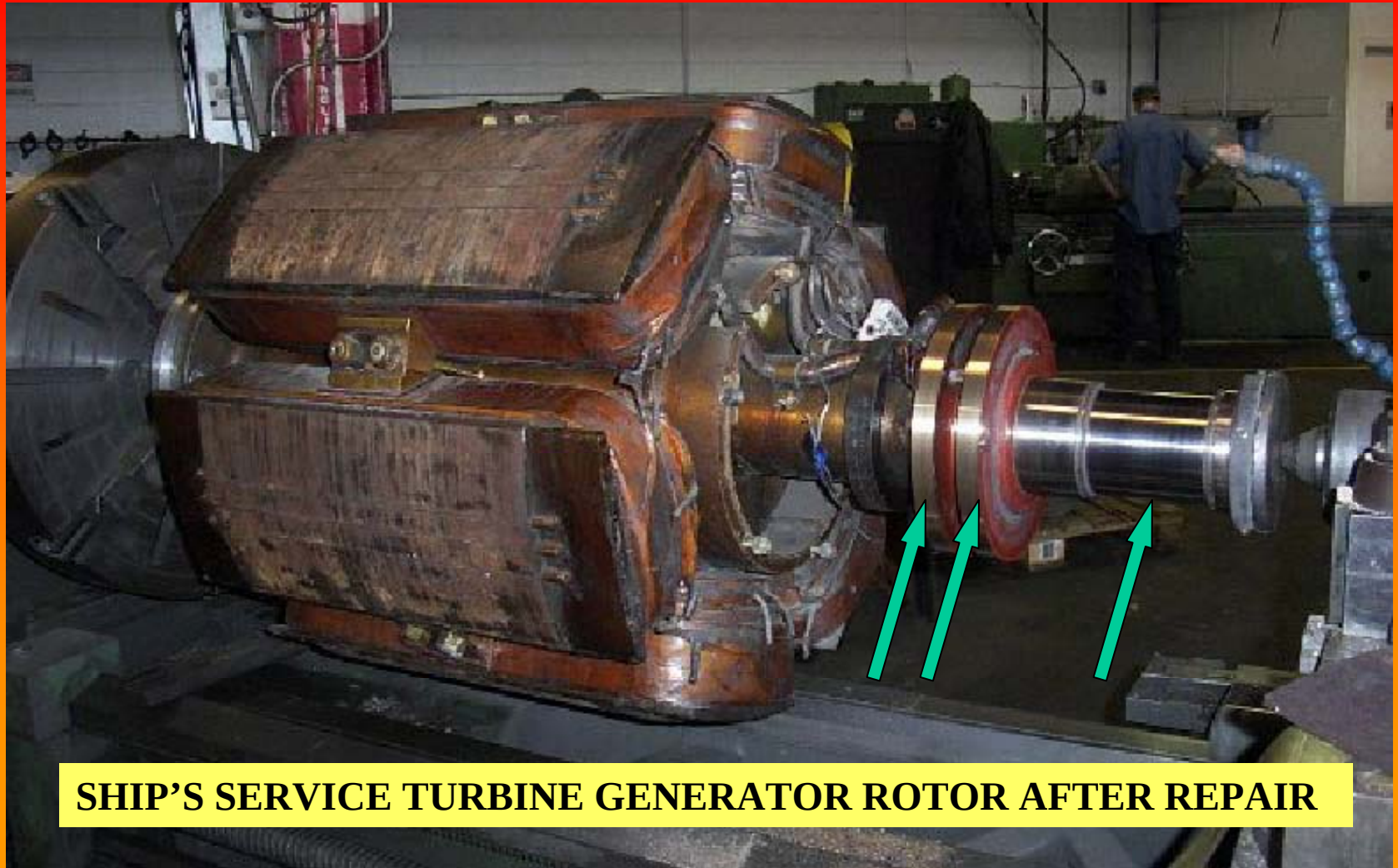
AFTER →

Bearing Areas Repaired with HVOF
Applied Tungsten Carbide



USS NASHVILLE – SHIP'S SERVICE TURBINE GENERATOR ROTOR

Bearing Area Repaired With HVOF Applied Tungsten Carbide And Collector Rings Dressed

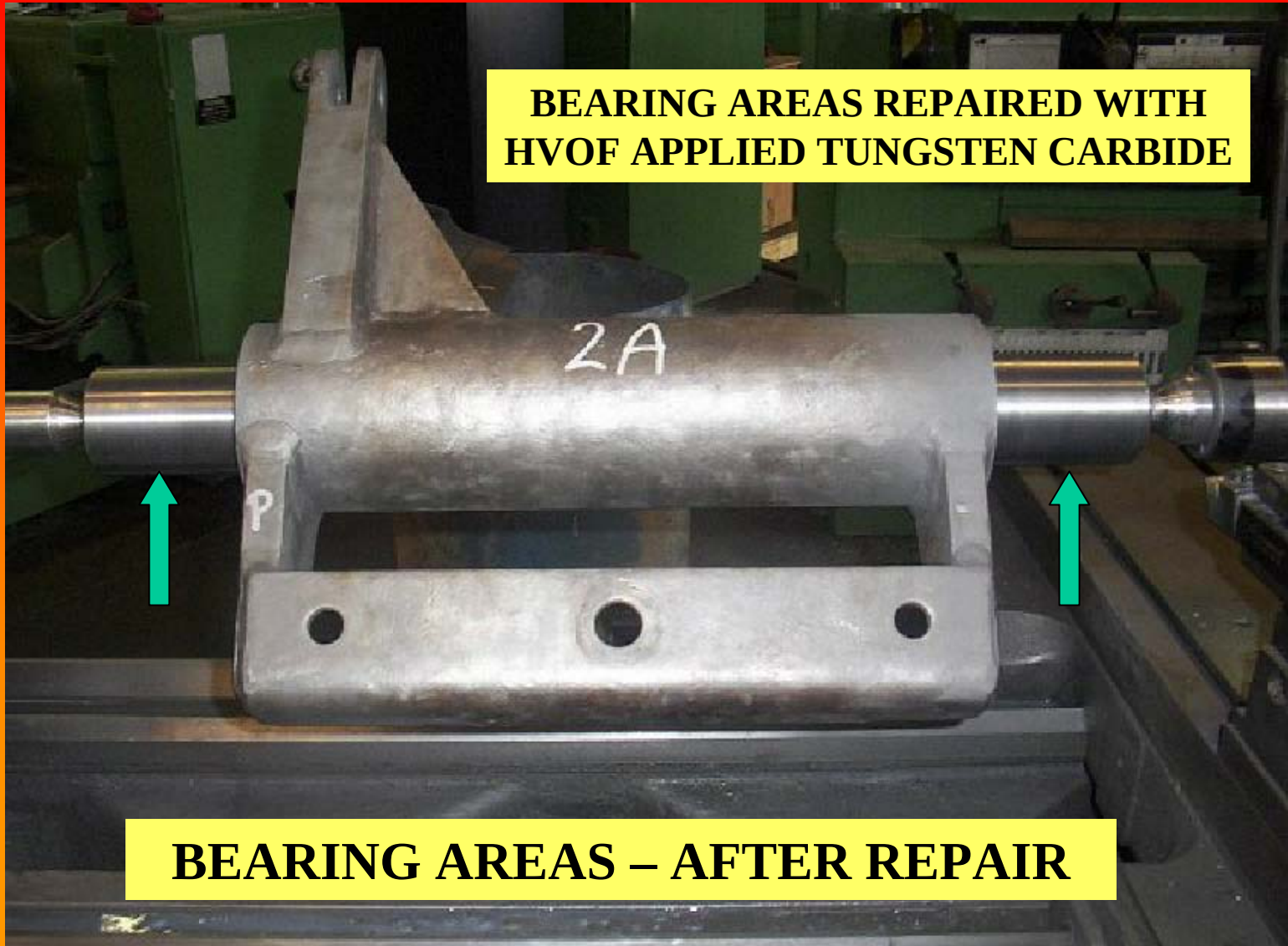


SHIP'S SERVICE TURBINE GENERATOR ROTOR AFTER REPAIR

CONTROL ARM LEVER

SHIP'S SERVICE TURBINE GENERATOR – USS NASHVILLE (LPD-14)

**BEARING AREAS REPAIRED WITH
HVOF APPLIED TUNGSTEN CARBIDE**

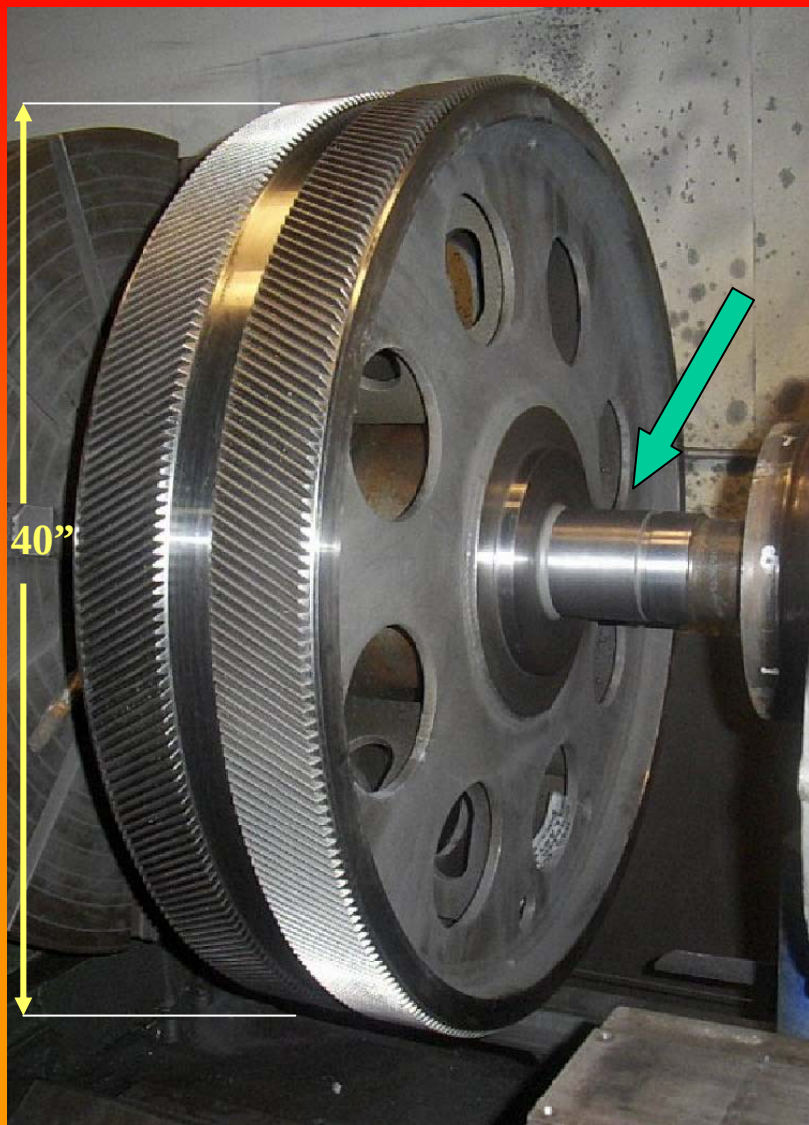


BEARING AREAS – AFTER REPAIR

USS PONCE (LPD-15)

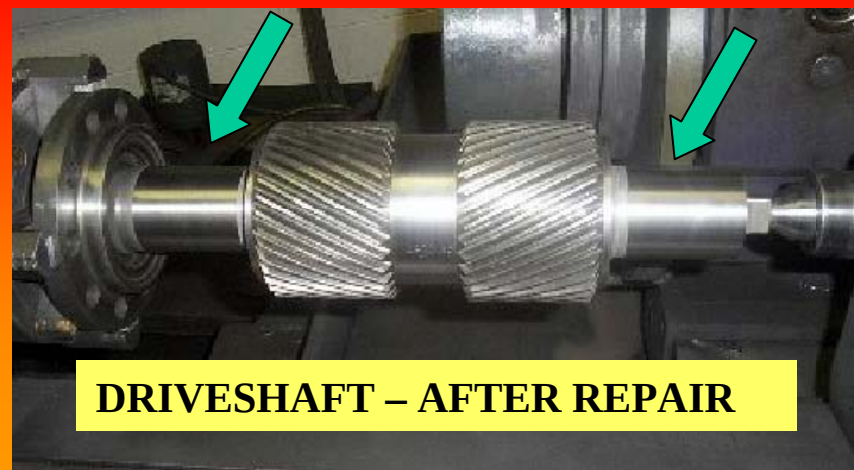
TURBINE GENERATOR REDUCTION GEAR AND DRIVESHAFT

**Bearing Areas Repaired With HVOF
Applied Tungsten Carbide**



REDUCTION GEAR

**CLOSE-UP OF BEARING
AREA AFTER REPAIR**



DRIVESHAFT – AFTER REPAIR

SUBMARINE ELECTRIC MOTOR ROTOR

Bearing Areas Repaired With HVOF Applied Tungsten Carbide



NOTE: This Is A Special Rotor Designed For Submarine Applications And The Finished Machining Tolerance Was .0002” Over The Entire Length Of The Shaft For Noise Reduction.

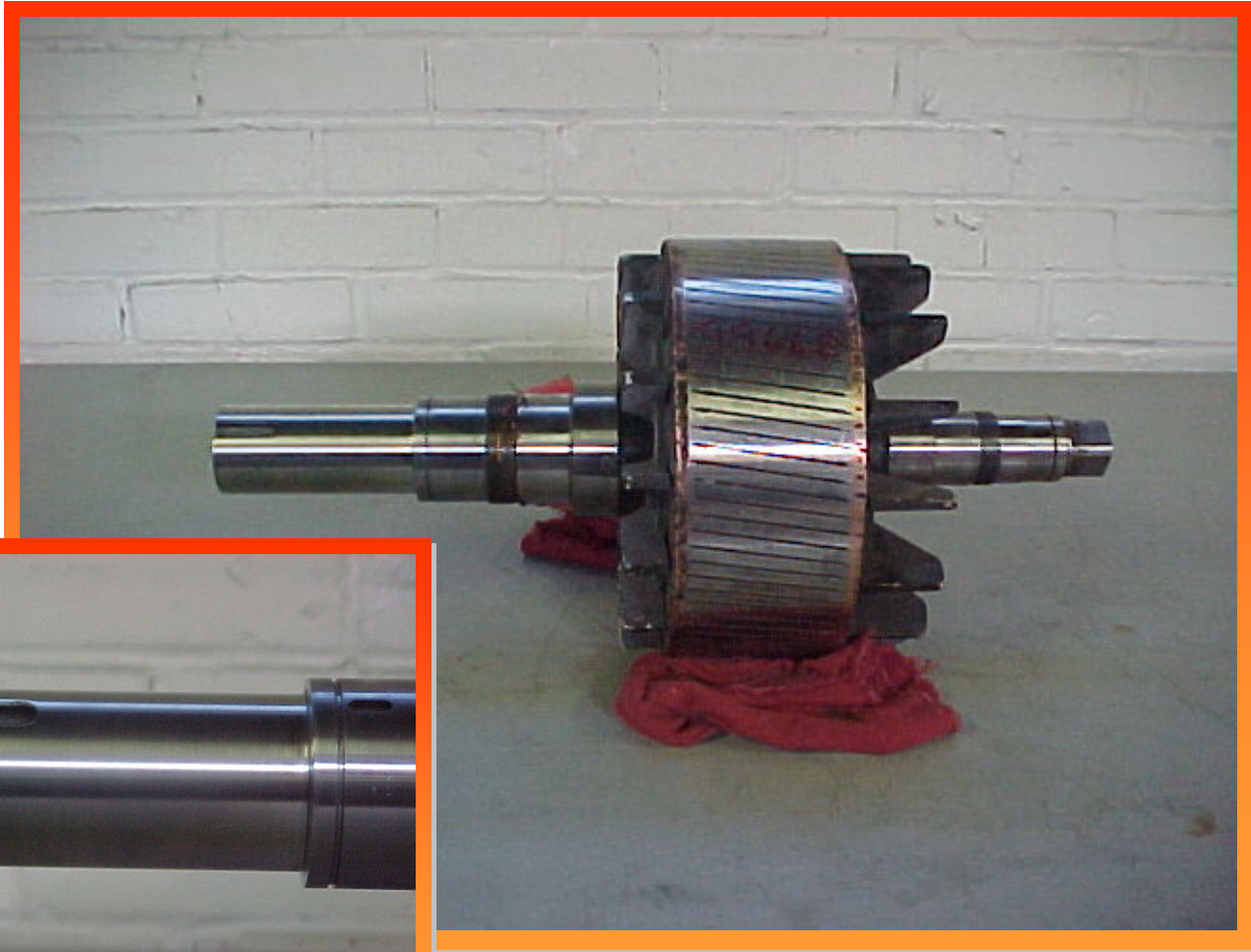
U.S. COAST GUARD – 110 CLASS RUDDER AND POST

Packing, Bearing, and Seal Areas Repaired With HVOF Applied Tungsten Carbide



Submarine Vacuum Pump Shaft

Bearing Area Repaired with HVOF Applied WCCo/Ni



USS WASP - STEERING ENGINE RUDDER RAM TUNGSTEN CARBIDE COBALT/NICKEL COATING



BEFORE

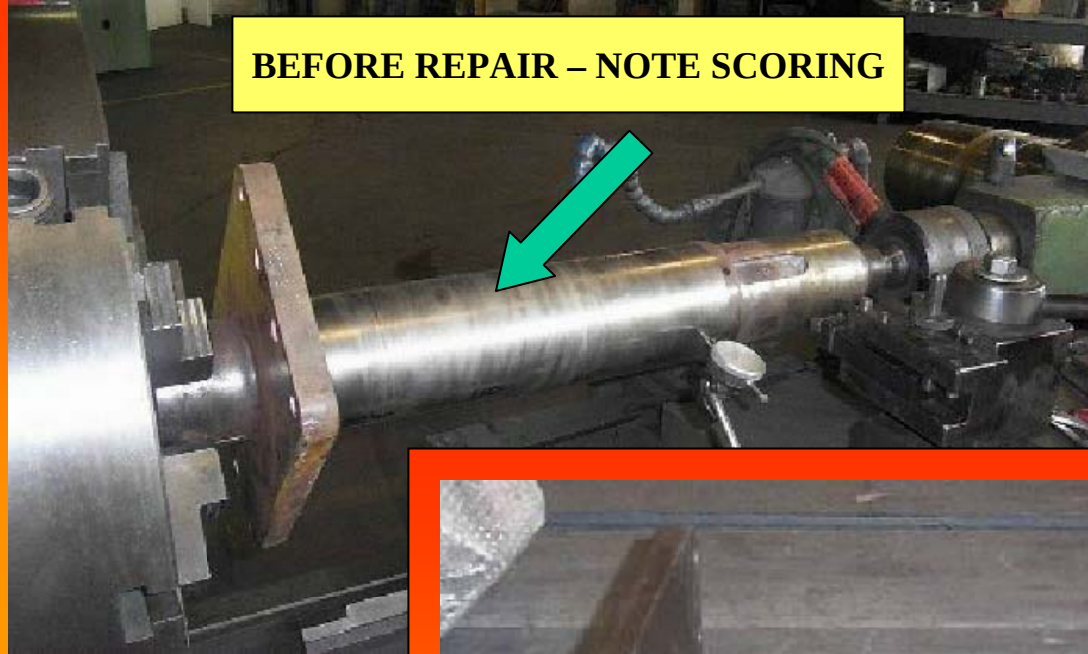


AFTER

FIN STABILIZER SHAFT

Bearing and Seal Area Repaired With HVOF Applied Tungsten Carbide

BEFORE REPAIR – NOTE SCORING

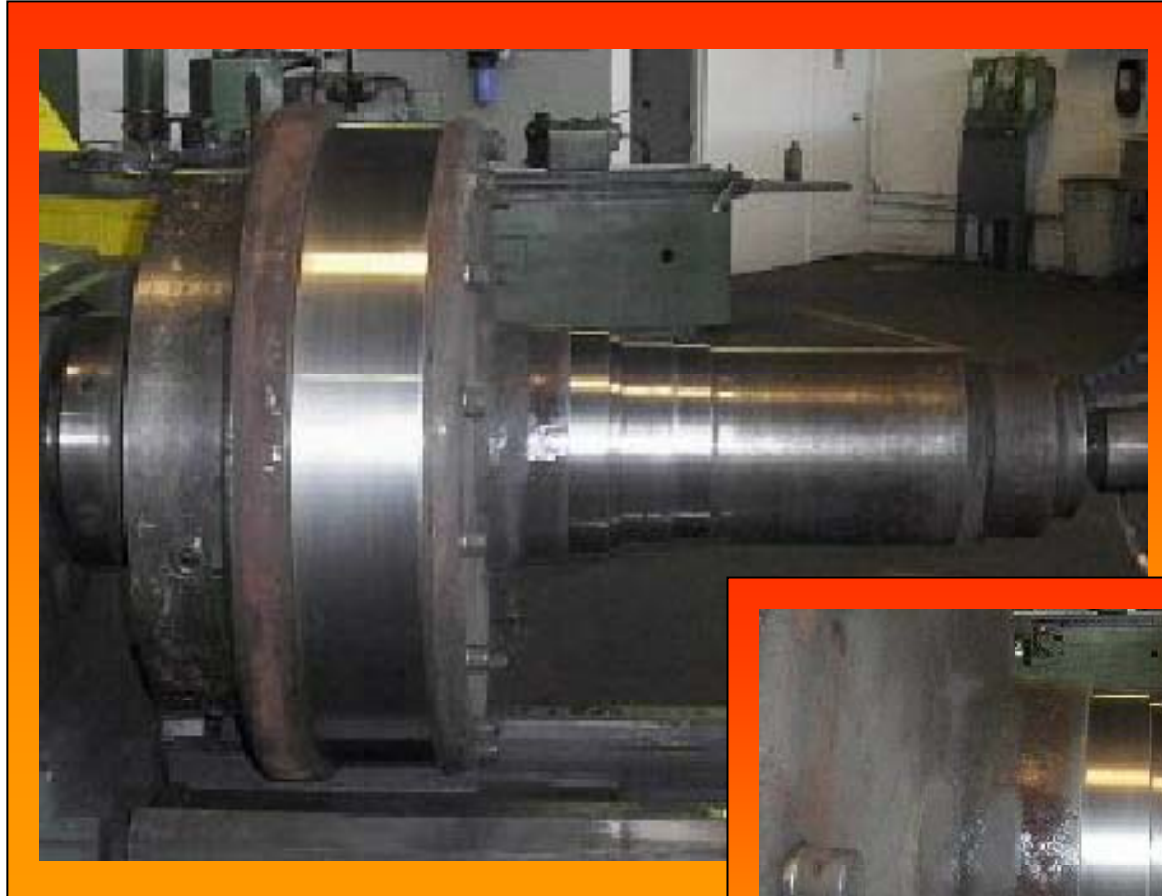


BEARING AND SEAL AREA AFTER REPAIR



COAST GUARD ANCHOR WINDLASS DRUM

Seal Areas Repaired With HVOF Applied Tungsten Carbide



CLOSE-UP OF REPAIRED AREA

NUCLEAR SUBMARINE SNORKEL INNER PIPE

Entire Snorkel Surface Repaired with HVOF Applied Tungsten Carbide Coating



CLOSE-UP
OF WORN
AREA



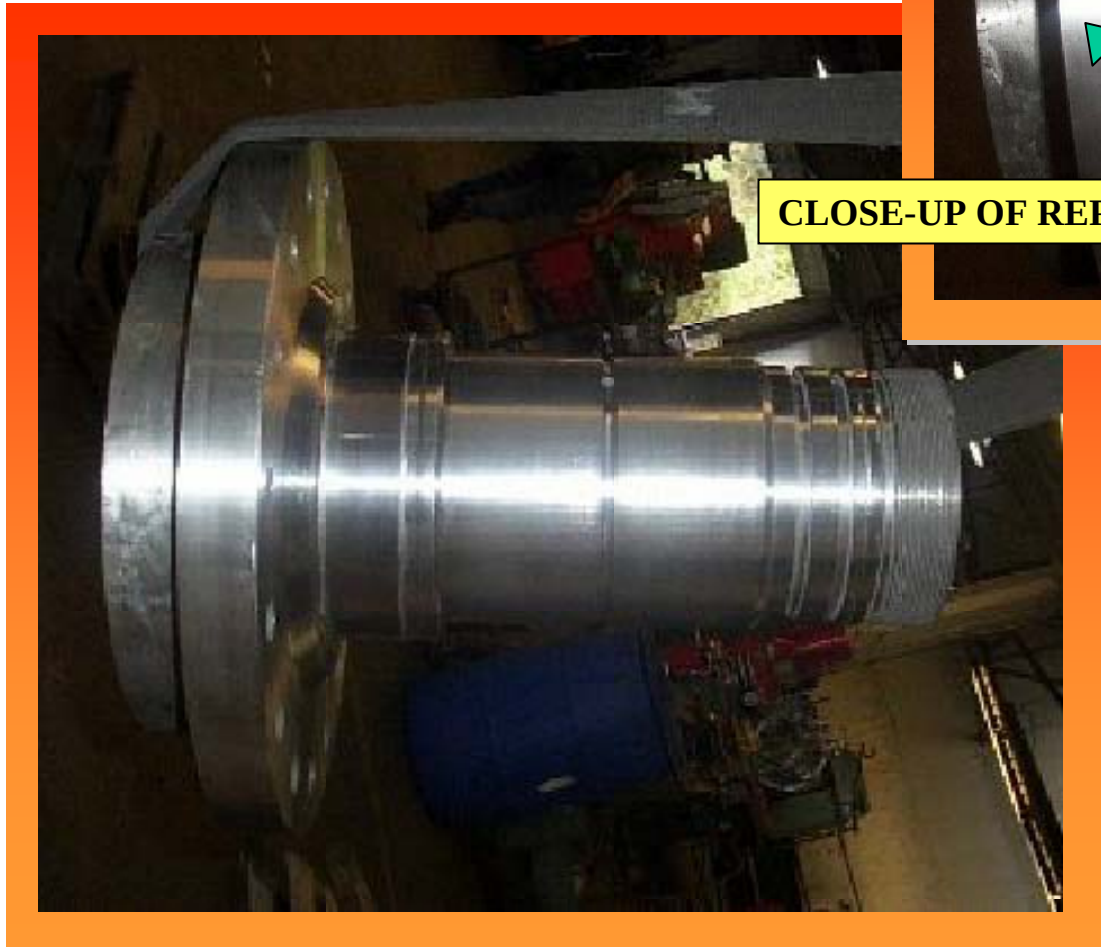
BEFORE



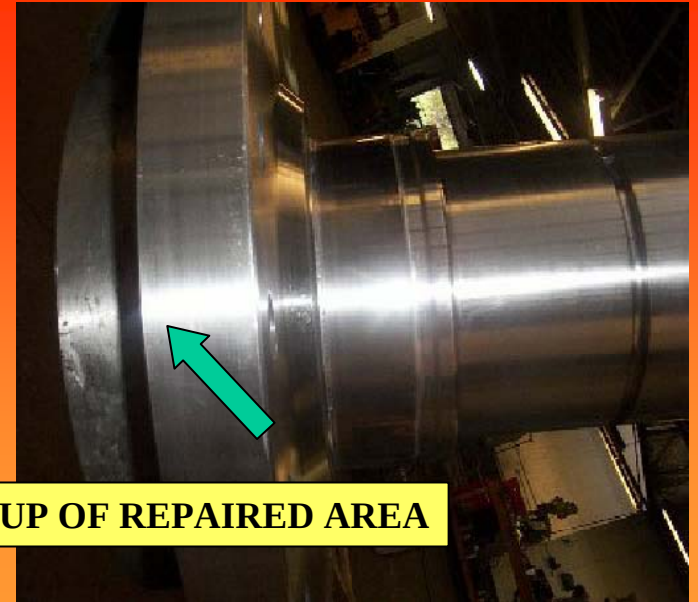
AFTER

SUBMARINE SHAFT FOR TOWED ARRAY HANDLING EQUIPMENT

**Bearing Area Restored With HVOF
Applied Tungsten Carbide for
Increased Wear Resistance for
Naval Undersea Warfare Center,
Newport Division**



CLOSE-UP OF REPAIRED AREA



**Restored bearing
area completed 400
hour wear test by
NUWC, Newport with
no measurable wear.
NUWC plans to
restore all worn
TAHE with HVOF
applied tungsten
carbide**

U.S. NAVY - PATROL COASTAL CRAFT

MAIN PROPULSION SHAFTS

Bearing Journals Repaired With HVOF Applied Tungsten Carbide

U.S. Navy – Patrol Coastal Craft



PC-1 Class - Length 170 Feet



Main Propulsion Shafts Installed In Strut Bearings After Repair

Z – DRIVE SEAL LINER

**Military Sealift Command – Cable Laying Ship
Repaired With HVOF Applied Tungsten Carbide**



AFTER REPAIR – 26" Diameter Ring

GATE VALVE – 12”

Seat Surface Repaired With HVOF Applied Tungsten Carbide

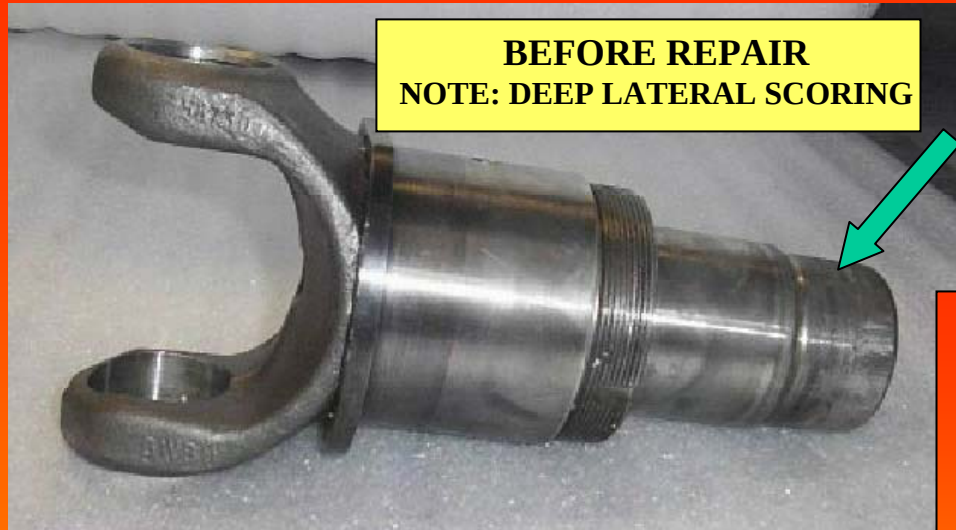


COMMERCIAL HIGH VELOCITY OXY-FUEL (HVOF) APPLICATIONS

INNOVATION ! EXPERIENCE ! QUALITY !

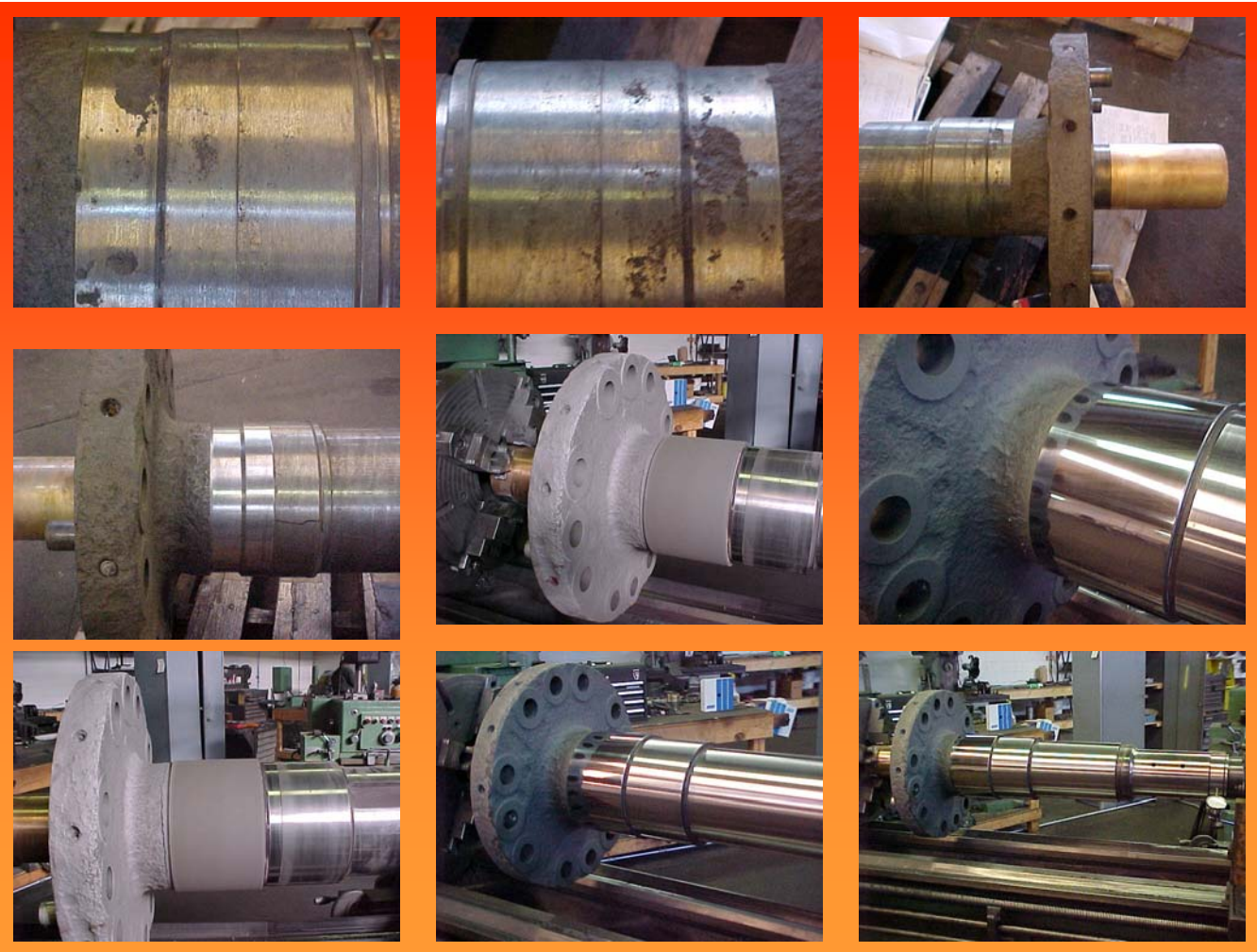
BOW THRUSTER YOKE

Alignment Fit Repaired With HVOF Applied Tungsten Carbide



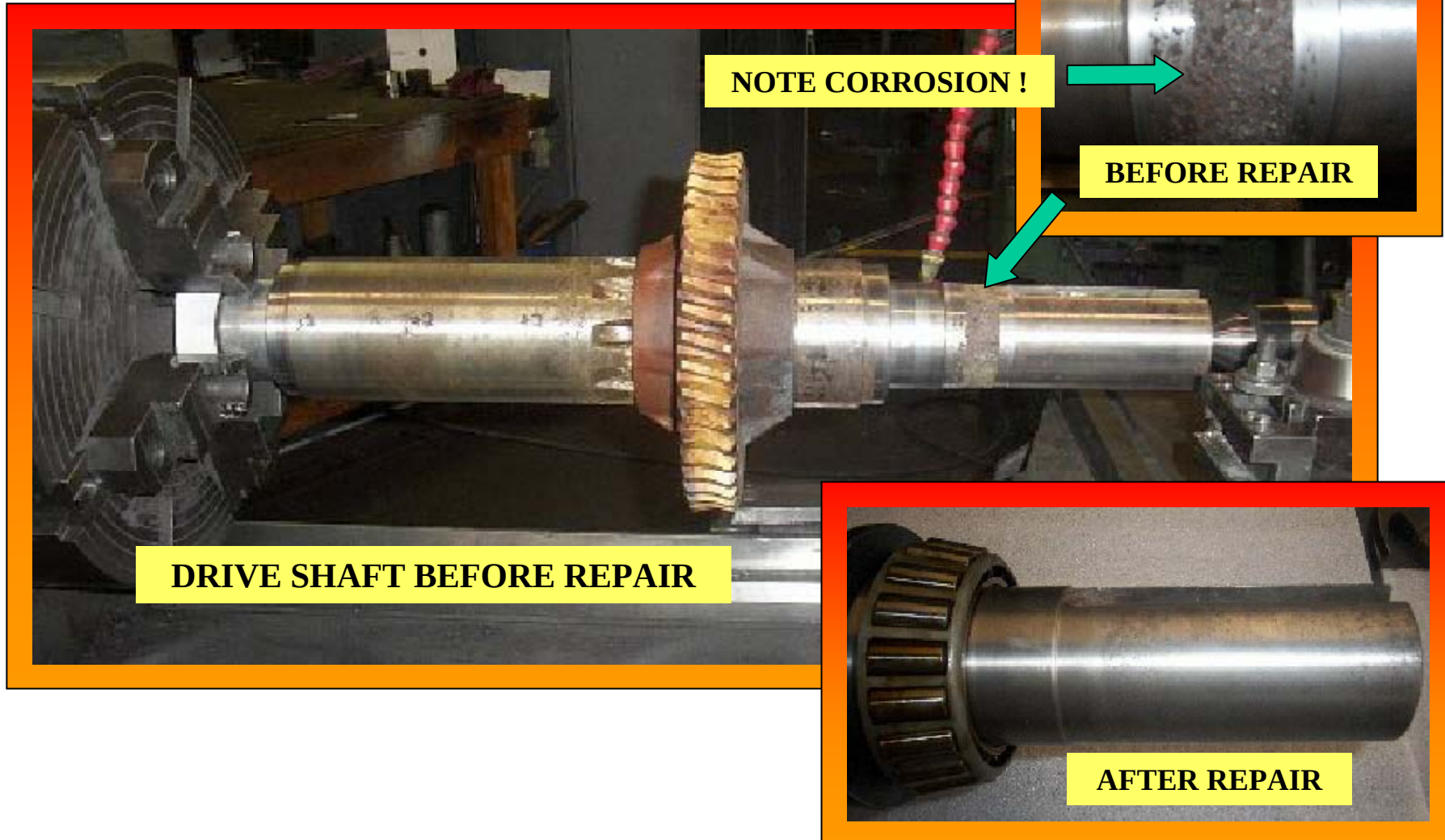
CSX Lines - Bow Thruster Shaft

**Bearing Journal and Seal Repaired with HVOF Applied WCCo/NI
Adjacent Flange Coated for Corrosion Prevention**



LINE WINCH DRIVE SHAFT

Seal Area Repaired With HVOF
Applied Tungsten Carbide



DIESEL ENGINE TURBO BLOWER

Bearing Areas Repaired With HVOF Applied Tungsten Carbide



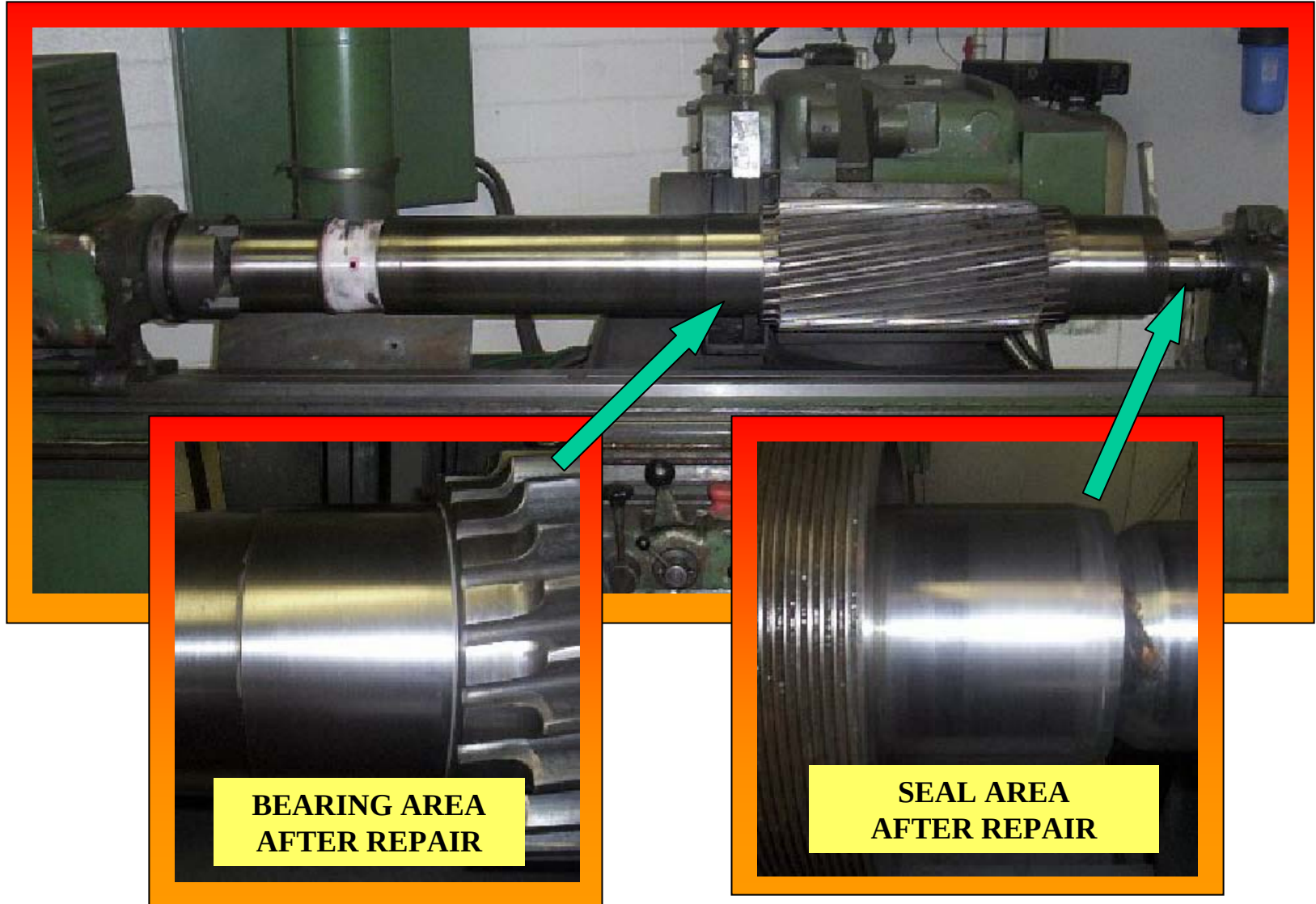
**CLOSE-UP OF BEARING
AREA AFTER REPAIR**



**CLOSE-UP OF BEARING
AREA AFTER REPAIR**

PINION GEAR – TUGBOAT GEARBOX DRIVE

Bearing And Seal Area Repaired With HVOF Applied Tungsten Carbide



Z-DRIVE SEAL LINERS

**Both Seal Liners Put Into Operation at the Same Time.
After One Year of Operation.....**

The Un-Coated Liner Has (2) 1/8" Grooves Worn by the Seal !

The Coated Liner Showed NO Signs of Wear !!
(only a slight discoloring of the coating in the seal area)



TUGBOAT Z-DRIVE SEAL LINER

Seal Area Coated With HVOF Applied Tungsten Carbide



STEERING DRIVE SEAL RINGS

Wear Areas Coated With HVOF Applied Tungsten Carbide



Increased Wear Resistance Provides Longer Service Life !

OIL DISTRIBUTION BOX SHAFT FOR CHANGEABLE PITCH PROPELLER

Bearing And Seal Areas Repaired With HVOF Applied Tungsten Carbide



BEFORE



AFTER

BUTTERFLY VALVE STEM

New Shaft Coated With HVOF Applied Tungsten Carbide To Prevent Wear



NEW VALVE STEM WITH COATING



OLD VALVE STEM

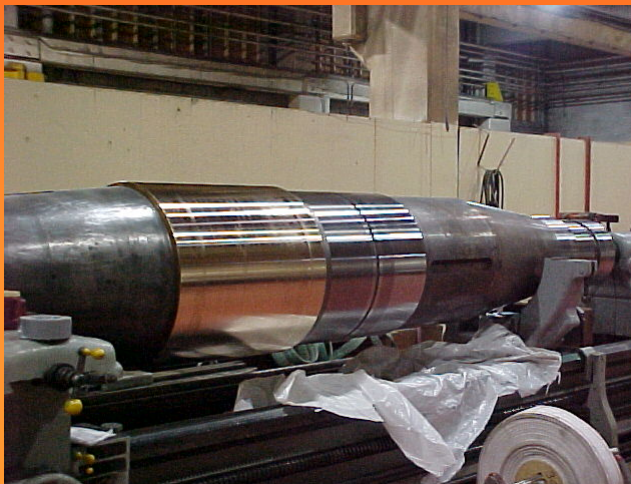
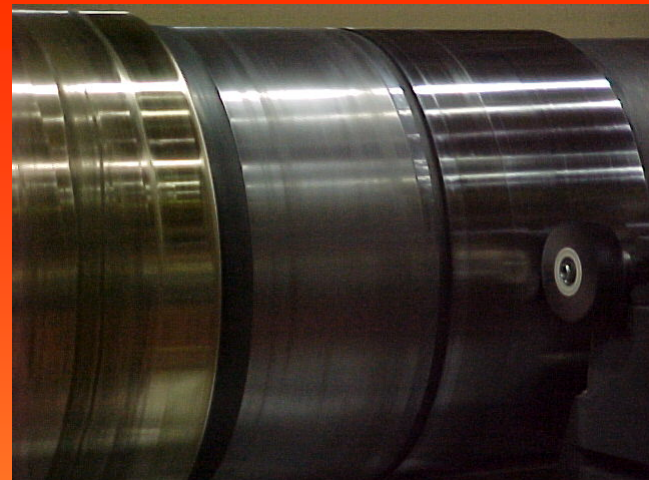
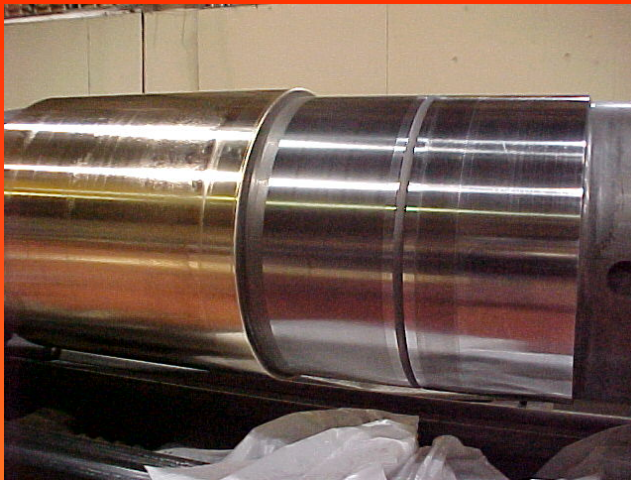
NAVY and COAST GUARD ELECTRIC ARC APPLICATIONS

INNOVATION ! EXPERIENCE ! QUALITY !

USS Halyburton – Rudder Post

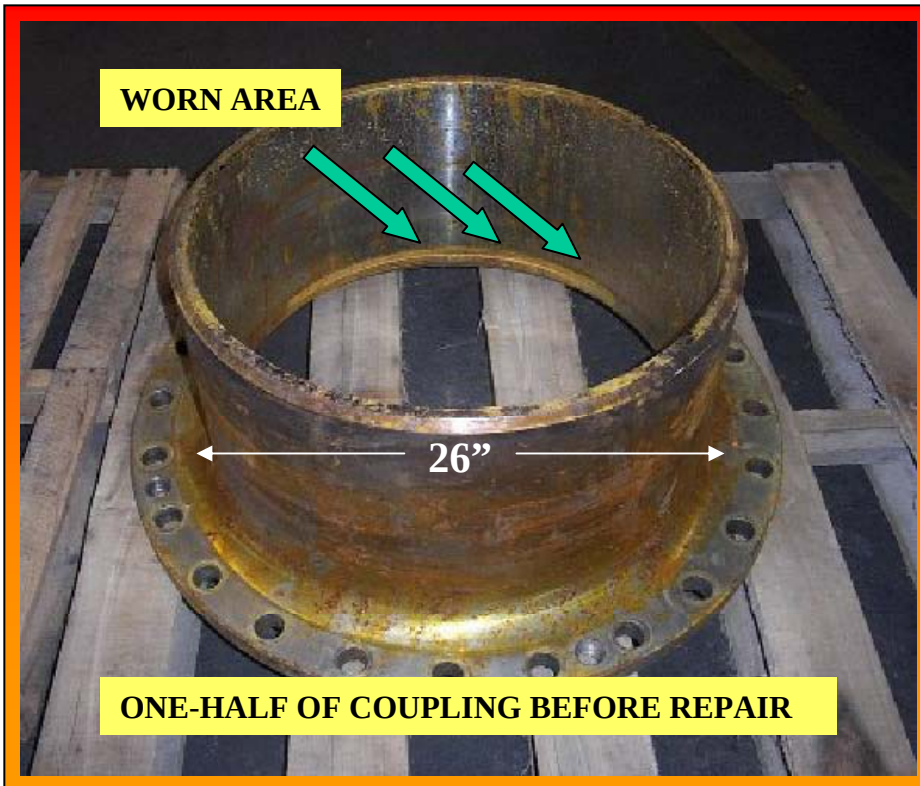
Seal Area Repaired with Arc Wire Al/Br

Bearing Area Repaired with Arc Wire SS



DIESEL ENGINE COUPLING – MILITARY SEALIFT COMMAND

Wear Groove Repaired With Arc-Wire Applied Inconel 625



AIRCRAFT CARRIER HANGAR BAY DOOR ROLLERS

Roller Surface Area Coated With Arc-Wire Applied

Pseudo-alloy AlBr-Mo



Submarine Bow Plane Housing Mating Flanges Repaired with Arc Wire Molybdenum



PLUG FOR DUPLEX STRAINER

Repaired Plug With Arc-Wire Applied AlBr And Machined to Fit



U.S. Coast Guard - CHANGEABLE PITCH PROPELLER HUB

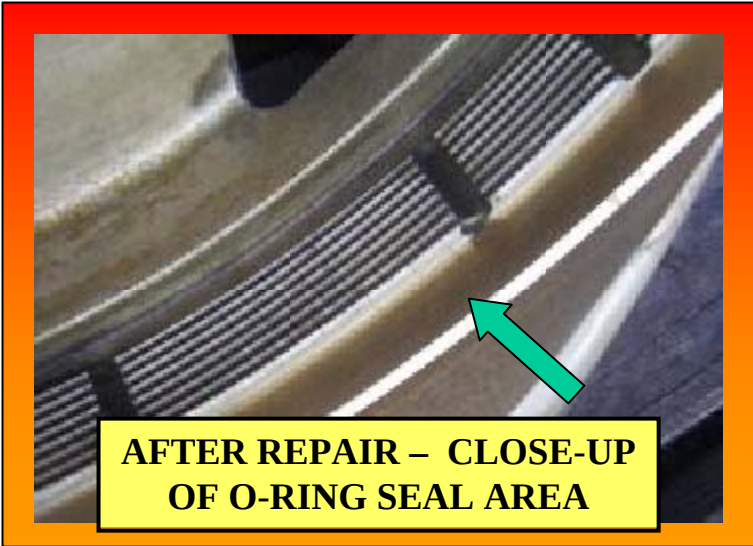
Damaged O-Ring Seal Areas Repaired With Arc-Wire Applied Bronze



U.S. COAST GUARD – 210 CLASS
CHANGEABLE PITCH PROPELLER HUB



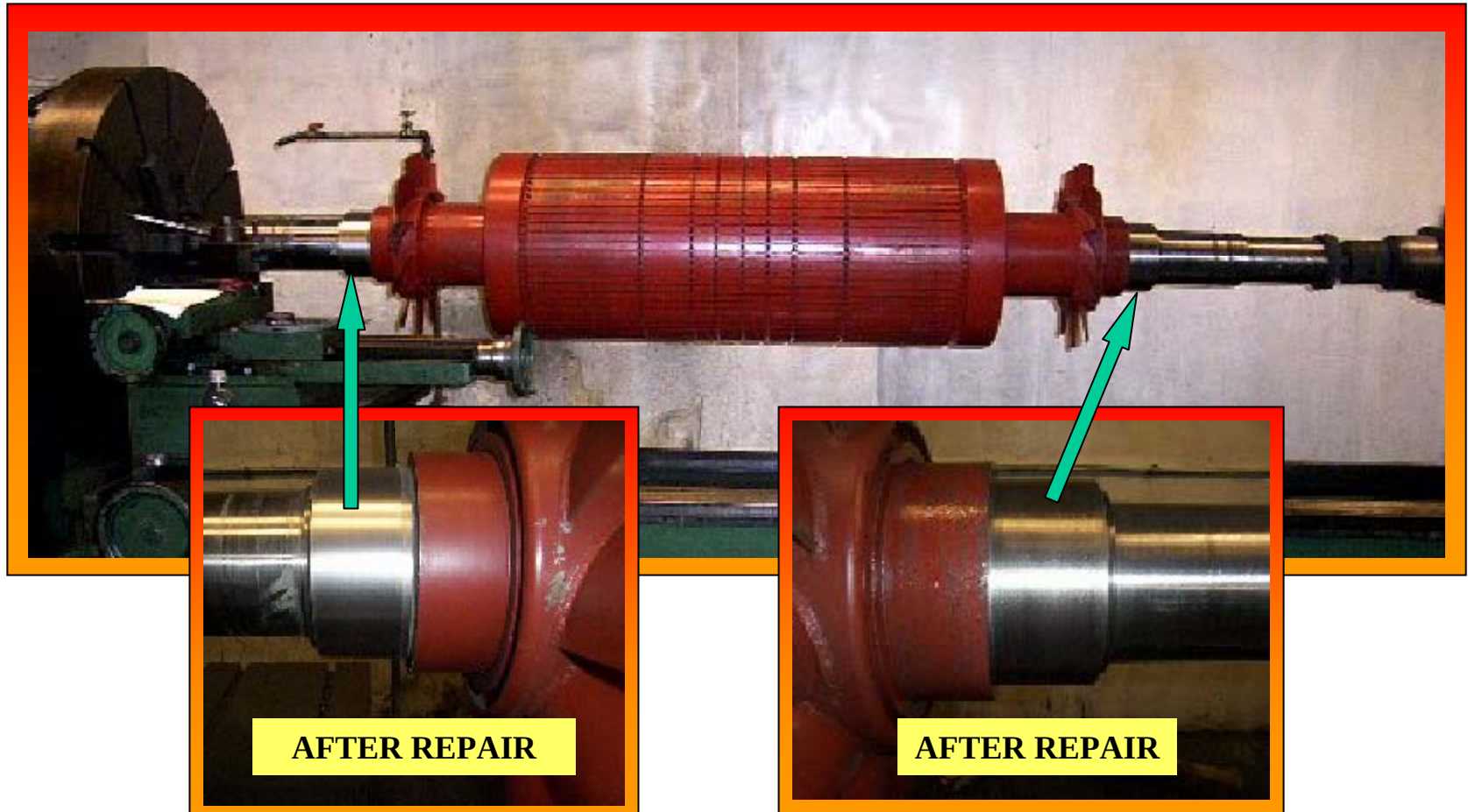
PORT – AFTER REPAIR



AFTER REPAIR – CLOSE-UP
OF O-RING SEAL AREA

ELECTRIC MOTOR GENERATOR ROTOR

Thrust Bearing Areas Repaired With Arc-Wire Applied Inconel 625





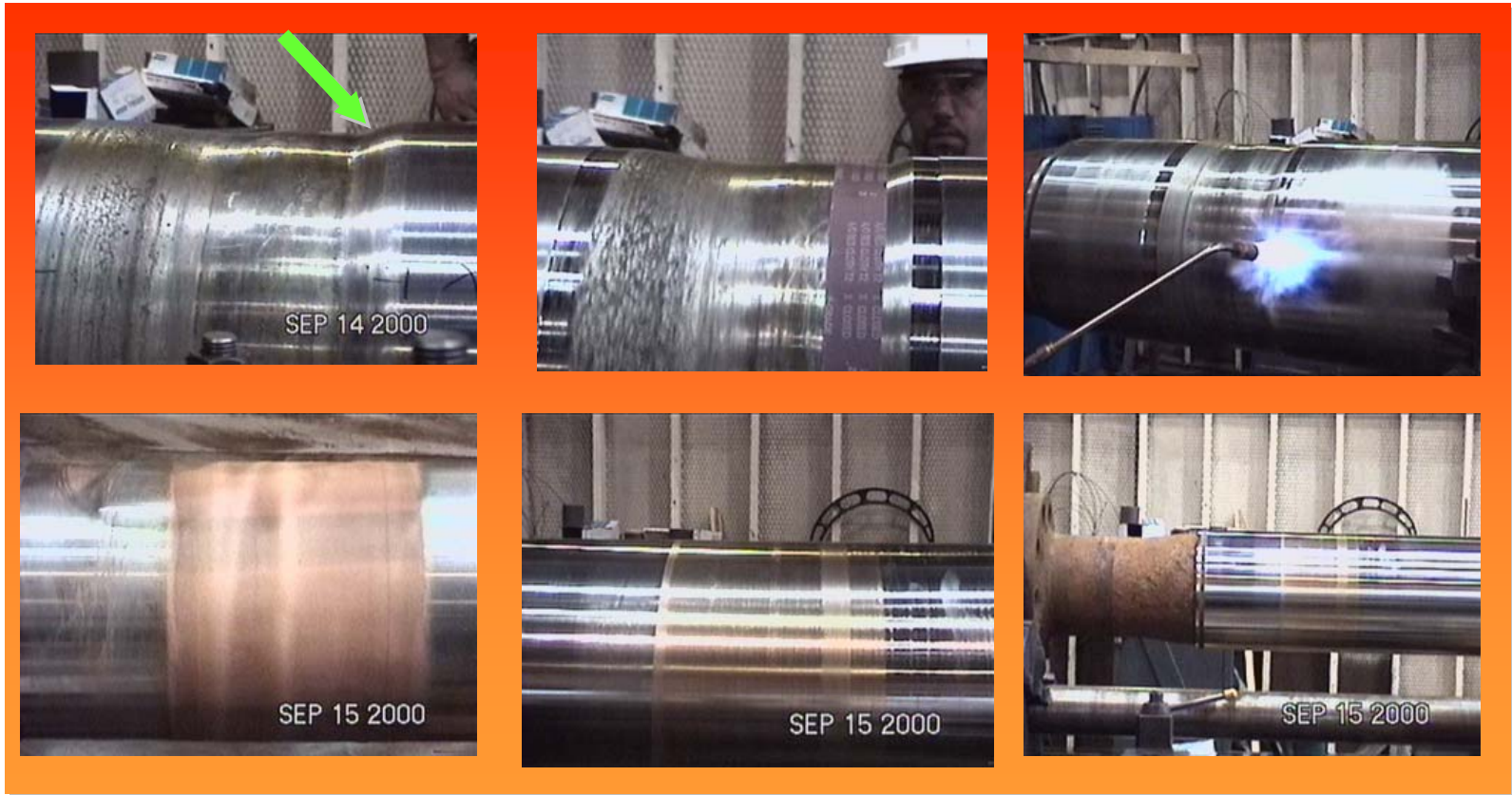
Thermal Spray & Machine Inc.

COMMERCIAL ELECTRIC ARC SPRAYED APPLICATIONS

INNOVATION ! EXPERIENCE ! QUALITY !

MV OCEAN BREEZE - Main Propulsion Shaft Repaired with Arc Wire Al/Br and Finished with WCCo/Ni

Shaft Worn 1 ¼" on Diameter ! – Repaired in Less Than 24 Hours!



TSM saved this Customer over \$200,000 and more than 2 weeks downtime ! !

MAIN ENGINE COUPLING HUB - TUGBOAT



**I.D. Of Hub
Repaired With
Arc-Wire Applied
Carbon Steel**



AFTER REPAIR

LOW PRESSURE CHAMBER FOR OIL DISTRIBUTION SYSTEM FOR CHANGEABLE PITCH PROPELLER

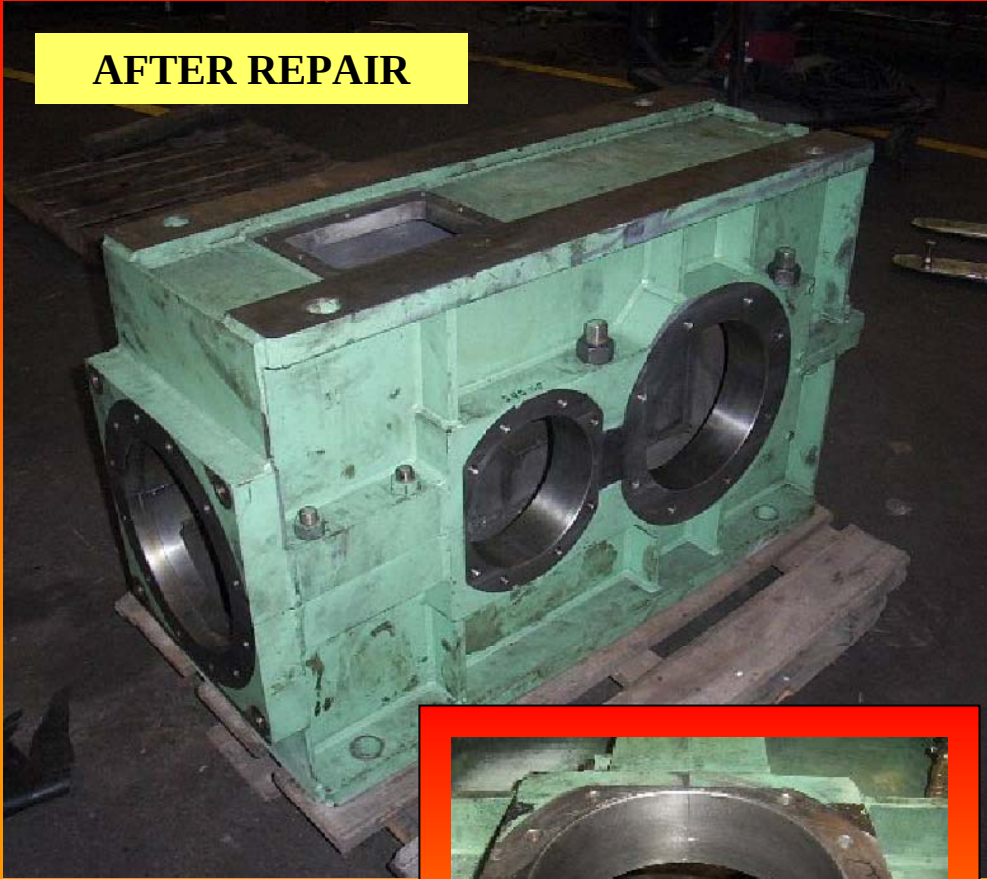
I.D. Areas (Corrosion) Repaired With Arc Wire Applied High Carbon Steel



GEARBOX CASING

Bearing Area Repaired With Arc-Wire Applied Inconel 625 And Line Bored

AFTER REPAIR



**CLOSE-UP AFTER
BEING REPAIRED
AND LINE BORED**



**AS-SPRAYED
BEFORE LINE
BORING**



ELECTRIC MOTOR SHAFT



**Impeller Fit Area Repaired With
Arc-Wire Applied CrSS**



**PLASMA APPLIED
NON-CONDUCTIVE COATING**

INNOVATION ! EXPERIENCE ! QUALITY !

SUBMARINE CABLE CONNECTORS

Connector Bodies Coated With Plasma Applied NCC Ceramic Coating To Prevent Corrosion Caused By Surface Electrical Currents On The Connectors. This Corrosion Would Cause The Polyurethane Coating To Separate Resulting In Failure.



**TSM HAS
COATED MORE
THAN 25,000
CONNECTORS !**

SUCCESS STORY

**SINCE TSM HAS STARTED
APPLYING NCC COATING TO
SUBMARINE CABLE
CONNECTORS, THERE HAS
NOT BEEN ONE DOCUMENTED
FAILURE !**



**COMPLETED CONNECTOR WITH
POLYURETHANE COATING**

SSN SPECIAL PURPOSE MOTOR LEAD CONNECTOR

Connector Body Coated With Plasma Applied Non-Conductive Ceramic Coating To Prevent Corrosion By Galvanic Action



UNCOATED



COATED

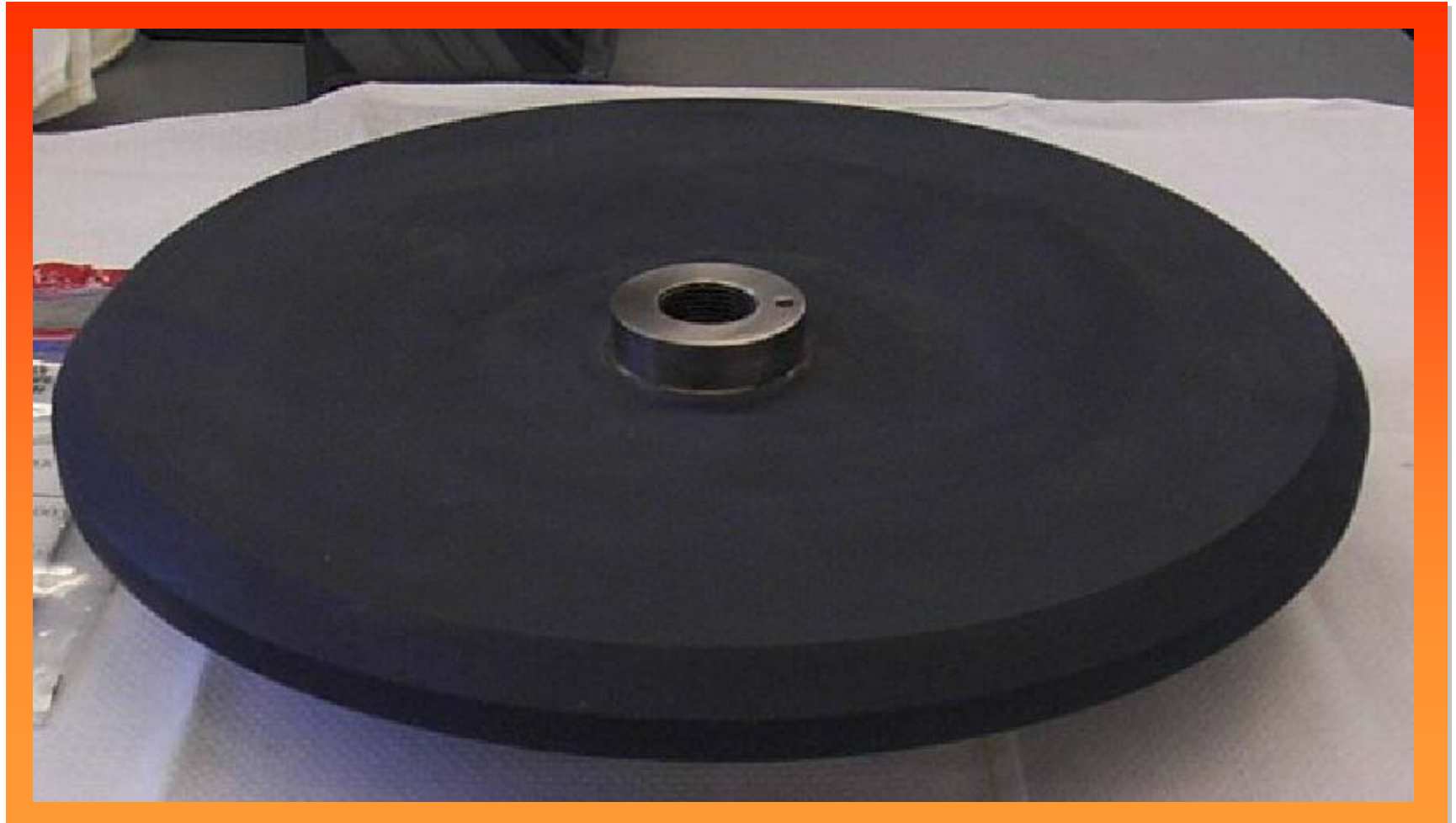
SUBMARINE ELECTRONICS ENCLOSURE

Interior Of Enclosure NCC Coated



SUBMARINE AIR INTAKE FLAPPER VALVE

Valve Flapper Coated With Plasma Applied Non-Conductive Ceramic Coating To Prevent Corrosion By Galvanic Action



SUBMARINE AIR INTAKE VALVE FLAPPER ARM

Valve Arm Coated With Plasma Applied Non-Conductive Ceramic Coating To Prevent Corrosion By Galvanic Action



AFTER COATING



**VALVE ARM
"AS RECEIVED"**

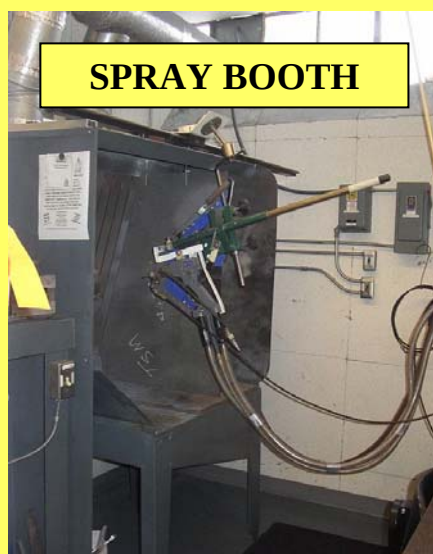
SUBMARINE SONAR TRANSDUCER PLATE

Surface Coated With Plasma Applied Non-Conductive Ceramic Coating (NCC) To Resist Corrosion From Galvanic Action



NON-CONDUCTIVE COATING DIVISION

SPRAY BOOTH



CLEANING & SEALING



RECEIVING & PREP



Thermal Spray & Machine Inc.

NCC DIVISION

**A Segregated,
Independent
Production Cell**

Q.A. & SHIPPING



U.S. ARMY HELLFIRE MISSILE EXHAUST DIFFUSER

**Protected By Plasma Applied Thermal Barrier Coating Of
Yttria Stabilized Zirconium Oxide To Deflect Intense Heat
Of Missile Exhaust Away From Helicopter**



**Diffusers Used On U.S. Army
Blackhawk Helicopters**

**Success Story ! 629
Diffusers Coated By
TSM For U.S. Army !**