Abradable Piston Coatings
Better Fit For More Power & Durability

Abradable Powder Coating ™ (APC ™) Attributes

- **Self-fitting**
- **Seats in quickly, lasts life of device**
- **Thin or thick: 20µ to *250µ and beyond (.00078” - .010” +)***
- **Temps: - 40° C to 300° C (- 40° F to 572° F)**
- **Excellent chemical resistance**
- **Blend of plastics and solid lubricants**
- **Hardness/Texture/Thickness tailored for applications**

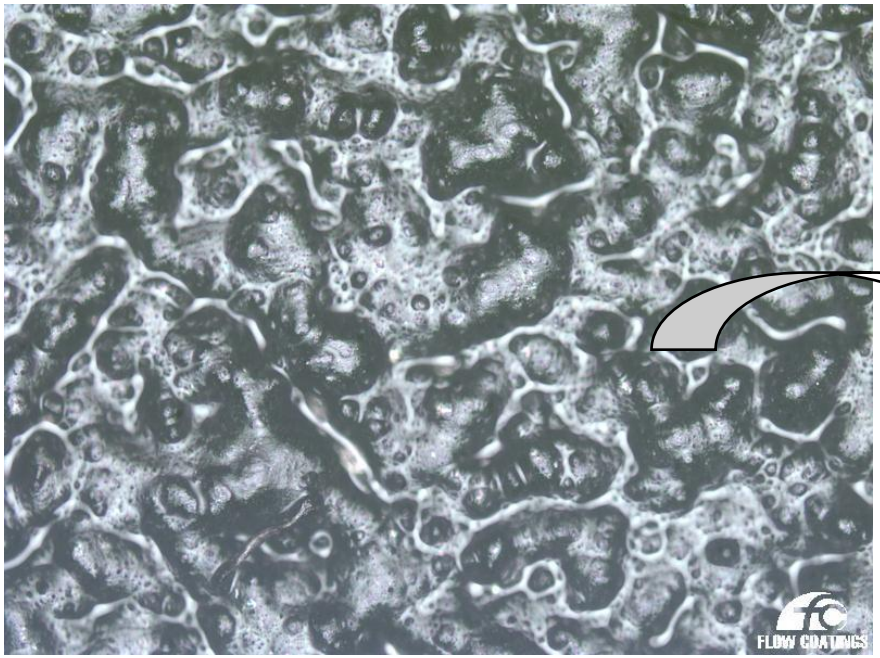
Enhances performance repeatability in power cylinder function and life

APC is ‘rough / fuzzy’ as applied

Prior to Break-In

Magnifications
~150X

After Break-In



Surface texture at assembly provides quick wear-in via controlled abrasion

**Polished plateaus (Low RpK)
Random pockets (High RvK) retain oil**

Stribeck Fitting™ - In an operating engine APC will find and preserve the lowest friction piston geometry for each bore

1. Build tight across entire skirt. At start-up, rapid, friendly wear-in

2. Self fitting - Oil film forms and wear rate asymptotically declines

3. Locked-in geometry - When there is just enough room for a stable oil film, the wear stops

4. APC Piston has: a) minimized secondary motion
b) minimum oil film thickness for lowest friction
c) no boundary lubrication

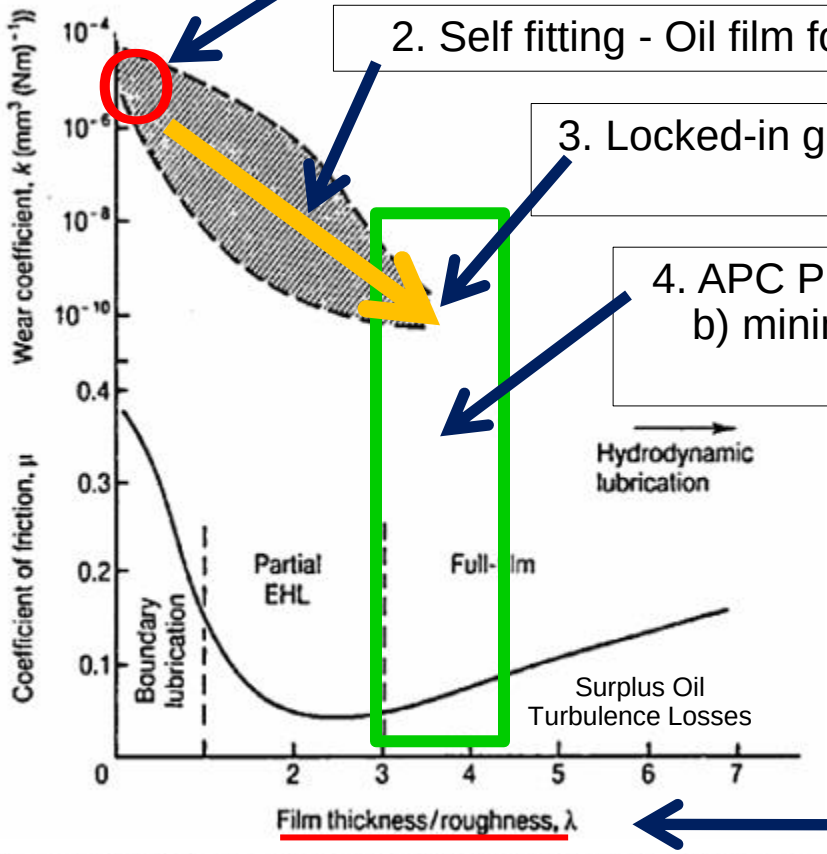
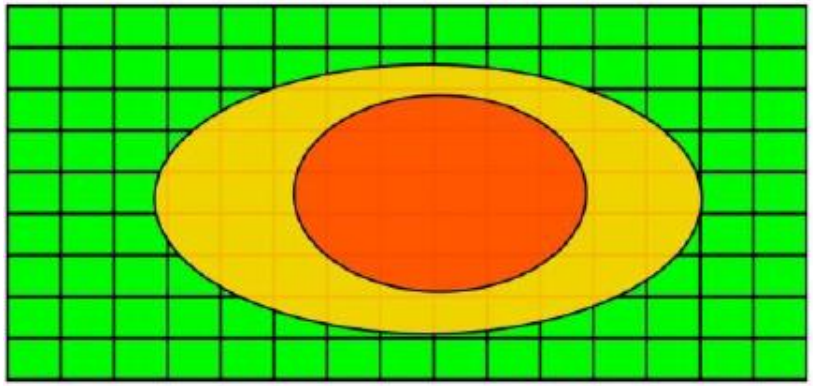


Figure 2. Lubrication regimes and wear coefficient in sliding of metals, as a function of λ (reproduced from Hutchings, 1992).
source: www.scielo.br/img/revistas/jbsmse/v29n1/a09fig02.gif

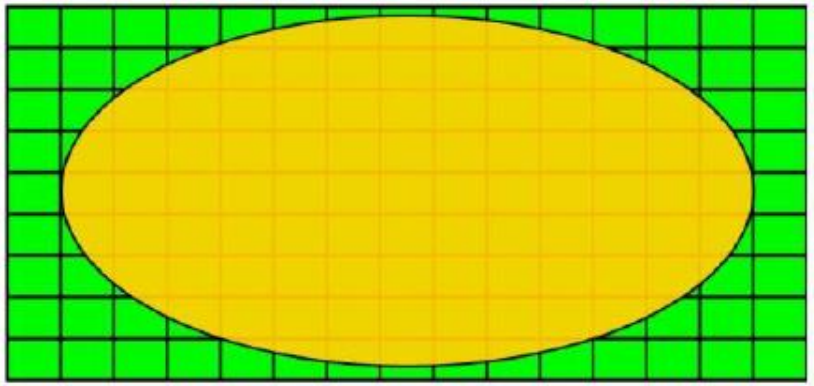
Final shape is determined at temperature, under load. Friction, wear, and secondary motions of the rotating assembly are minimized. *Engine efficiency and durability are enhanced.*

APC plateaus are polished, so a VERY THIN oil film can prevent asperity contact.

Load distribution on normal coating vs. operationally-fitted abradable coating piston skirts



Thin, hard coatings concentrate load



Thick, abradable coatings dissipate load

High load concentration

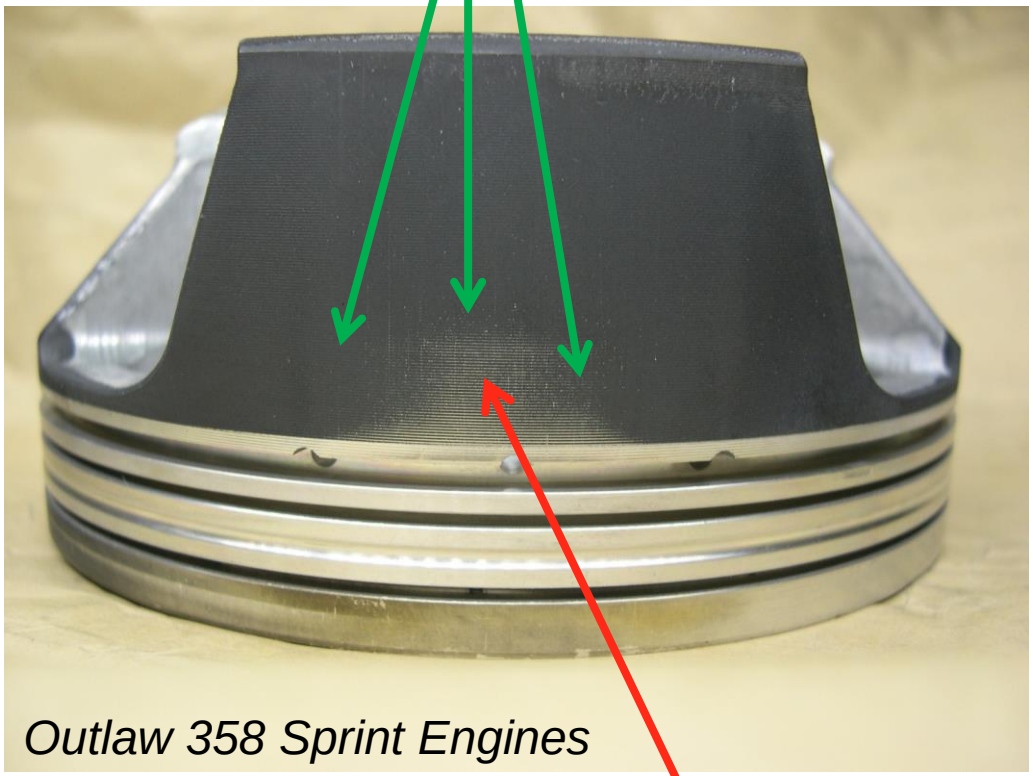
Uniform distributed load

Carries no load

Reduces Peak Loads and Prevents Scuffing

- Enables stiff architecture to achieve the perfect fit
- Redistributes load uniformly

Scuffing Epidemic Cured



How It Works On Pistons

Improved Fit

- Build it too tight
- APC hones piston to the ideal fit *for EACH bore*
- Reduces secondary motions in rotating group (less I.S.C.)
- Improves ring flutter, seal & life
- Reduces slap, noise
- Permanent geometric refinement

Improved Friction

- Creates optimum, stable oil film across entire skirt
- Break-in event seeks minimum friction per Stribeck diagram
- Enlarges contact area to spread load & lengthen oil leak path
- Tolerates foreign debris
- Lasts - long term scuff resistance

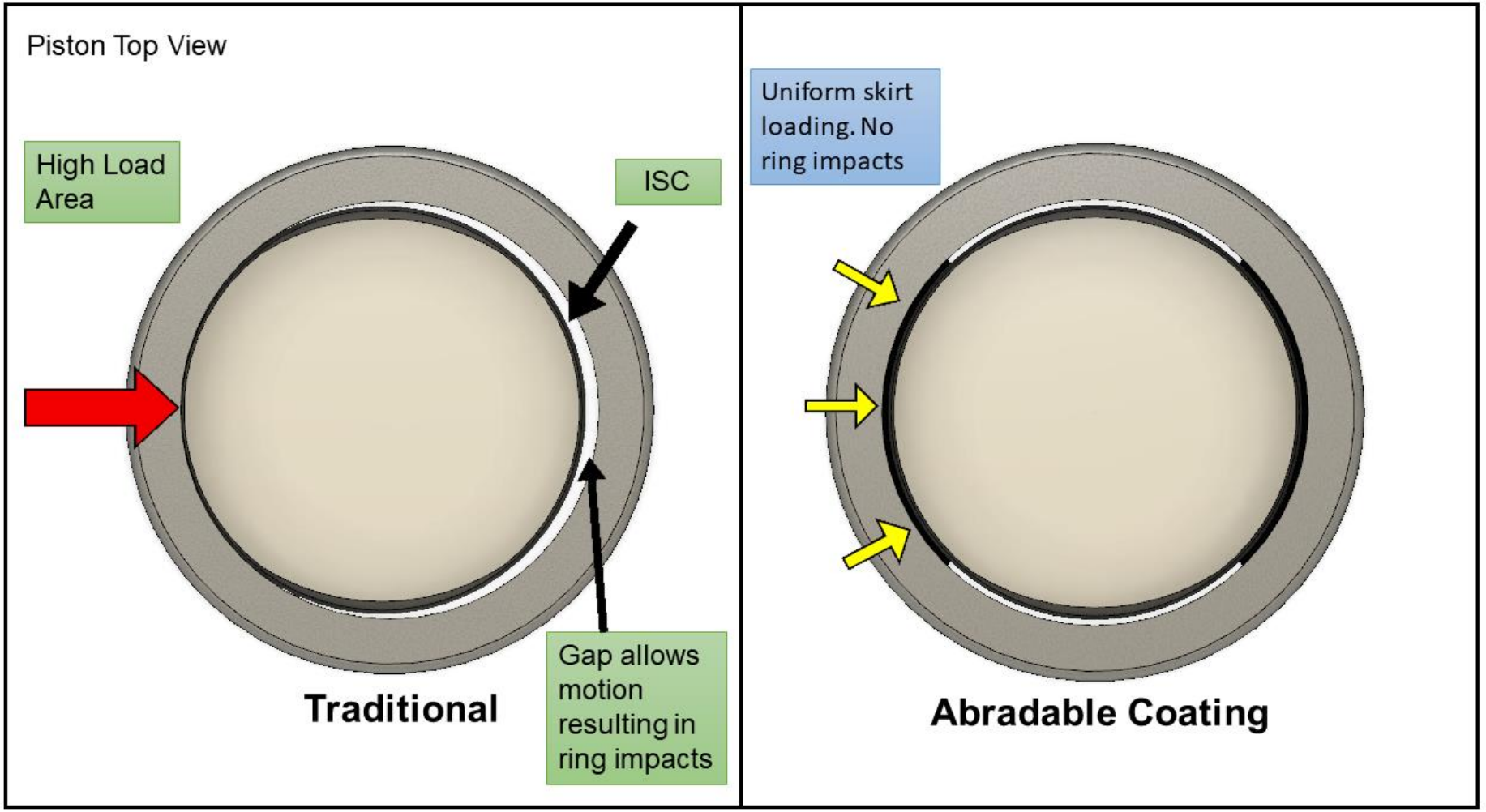
Secondary Piston Motion Effects On Rings

- Rock causes rings to work harder, flutter more, seal less.
- Rock requires larger crevice volume
- Rock can pump oil around the rings
- APC stabilizes piston, keeps rings square to bore
- APC enables reduced ring tension for lower piston assembly friction
- APC reduces volume of oil that rings must handle

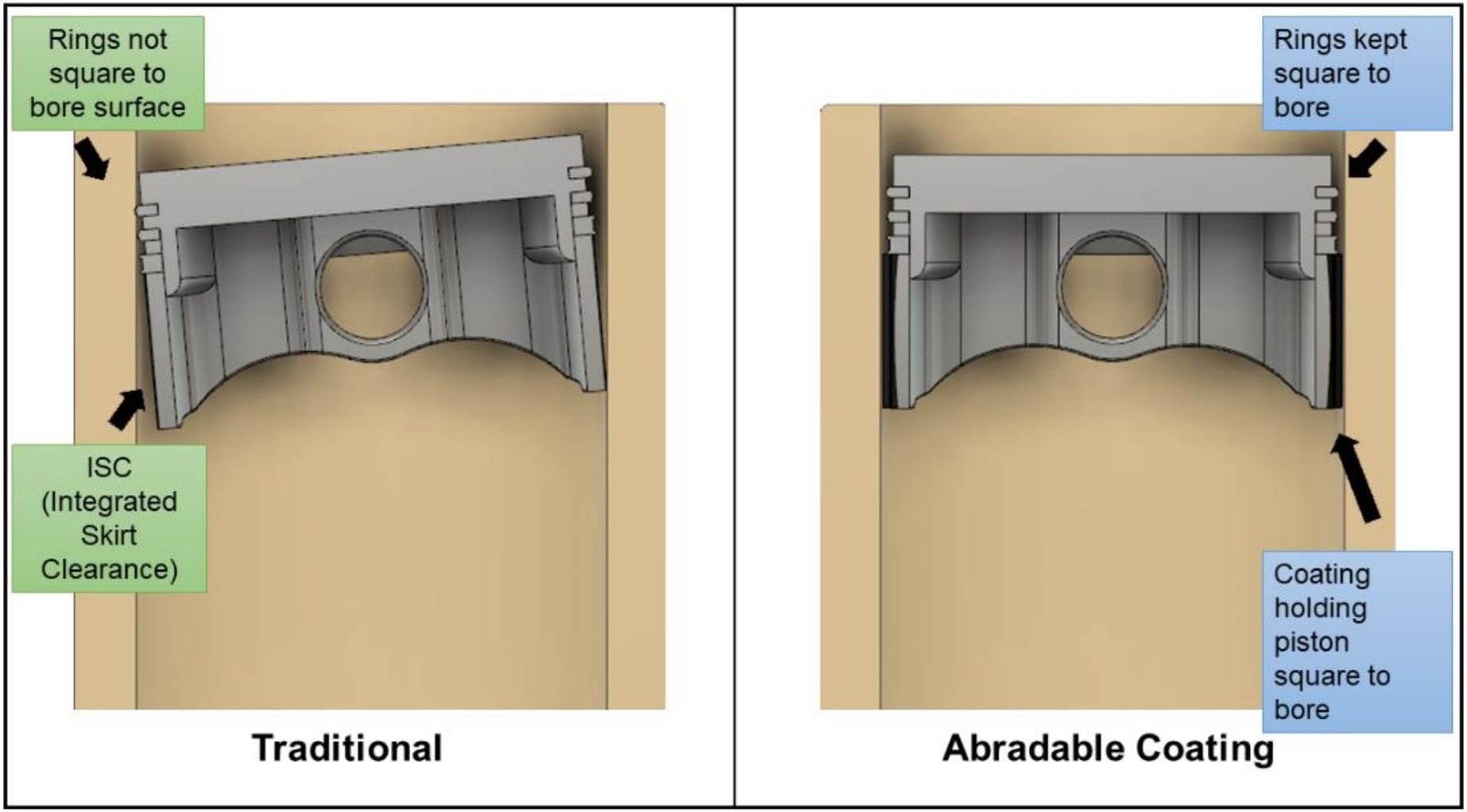
Component Impacts Pierce Oil Films

Causing WEAR

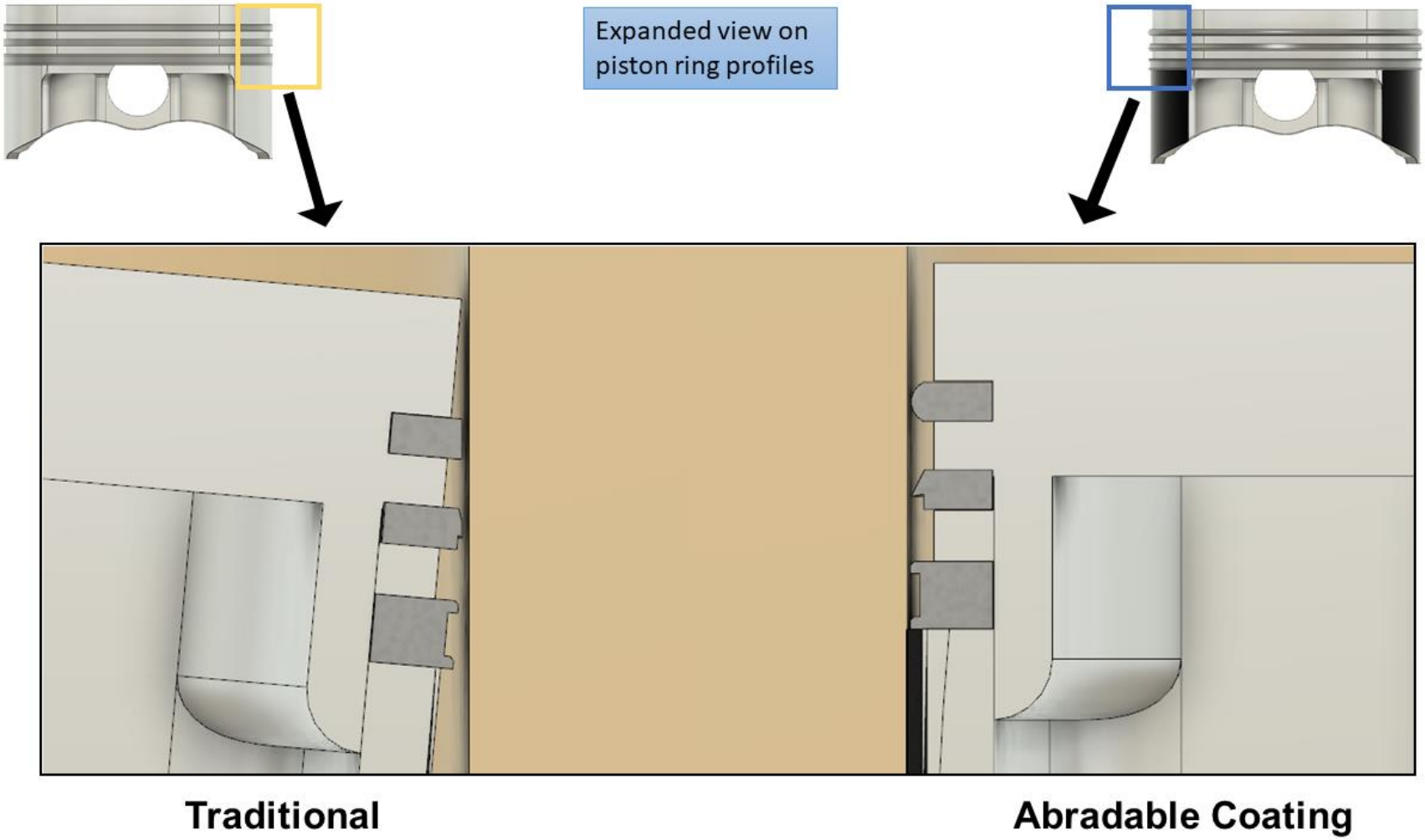
Piston Top View



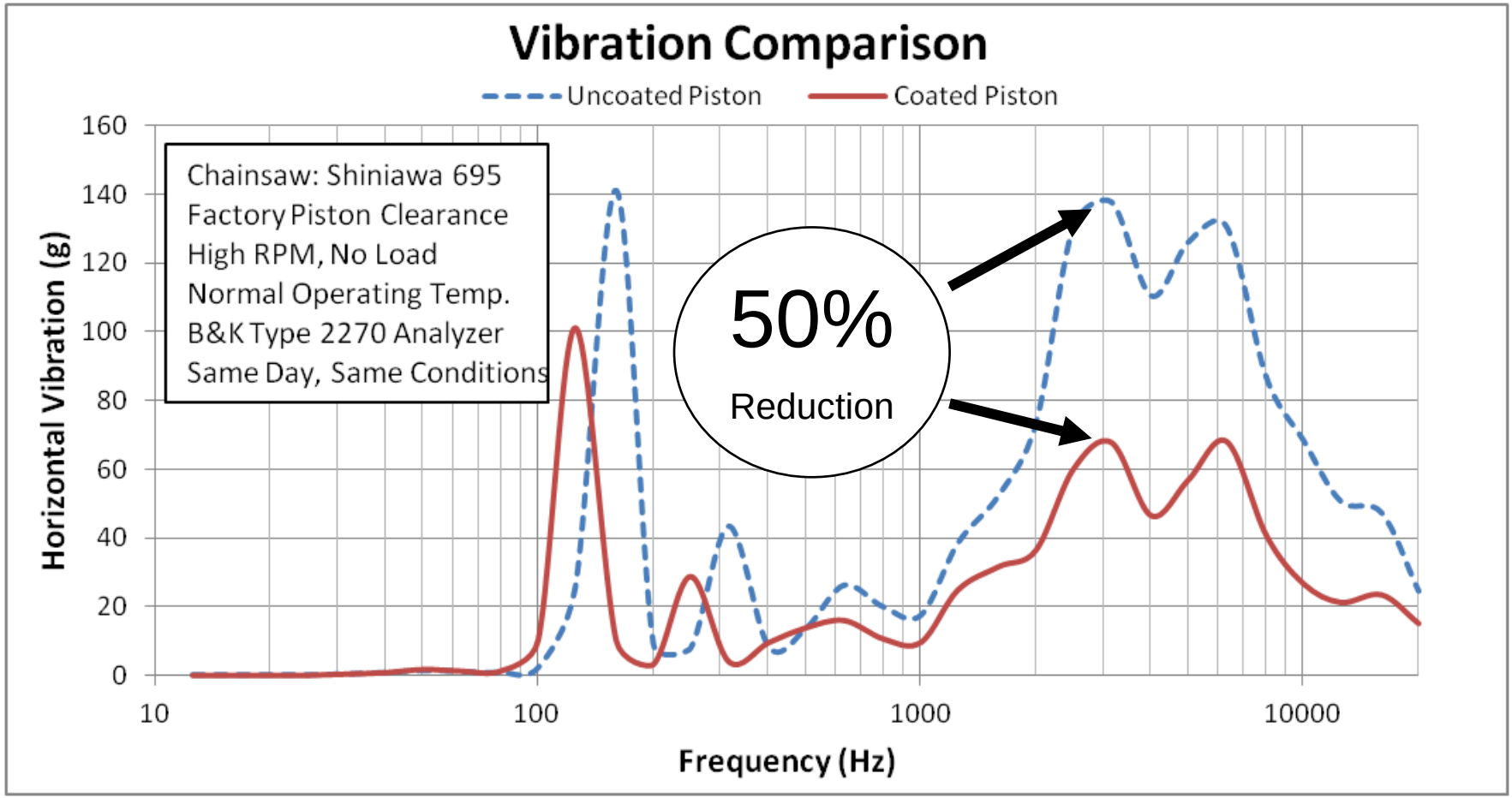
Piston Side View



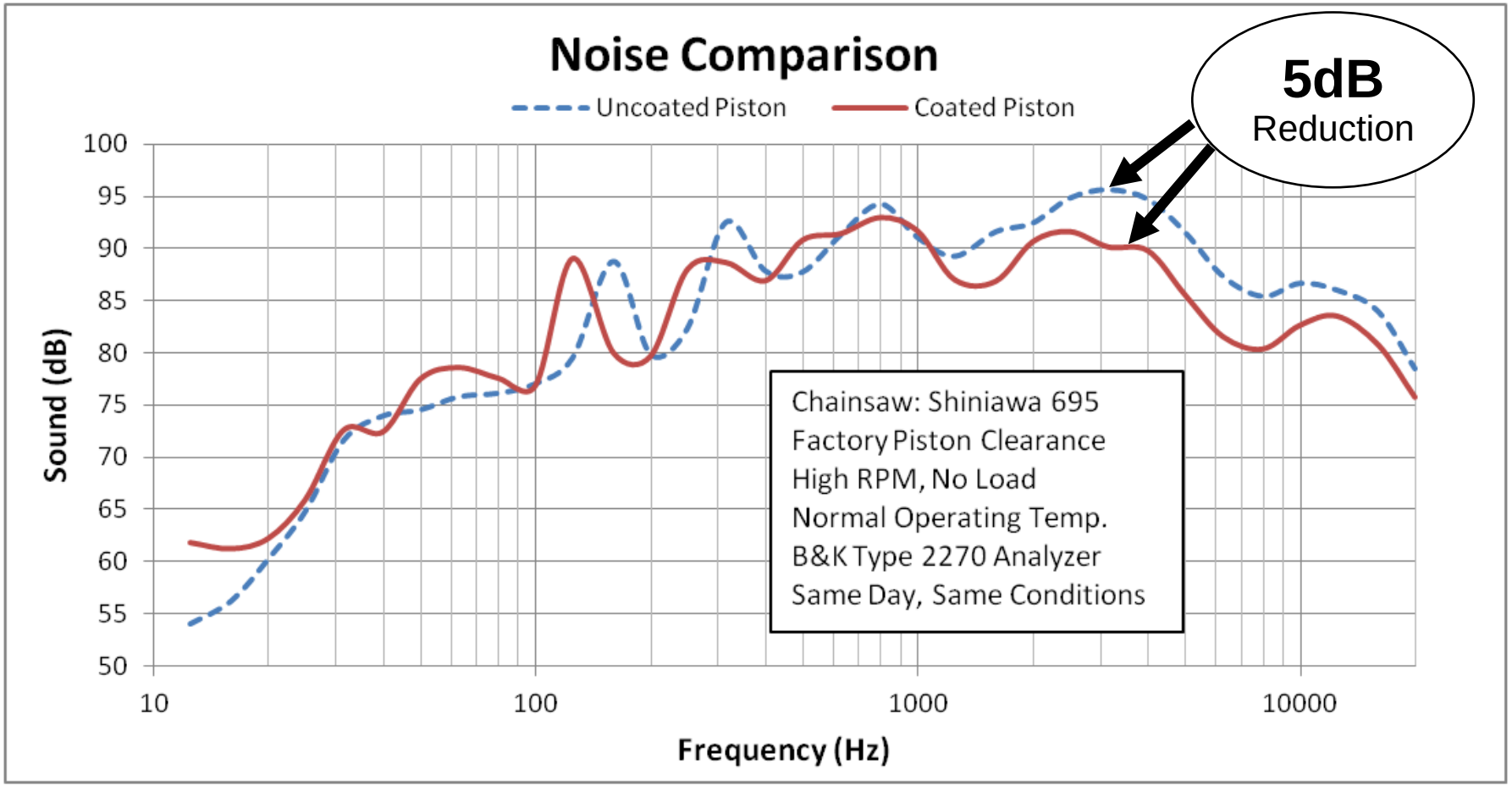
Expanded View Piston Ring Profiles



APC In A Chain Saw Engine - Vibration



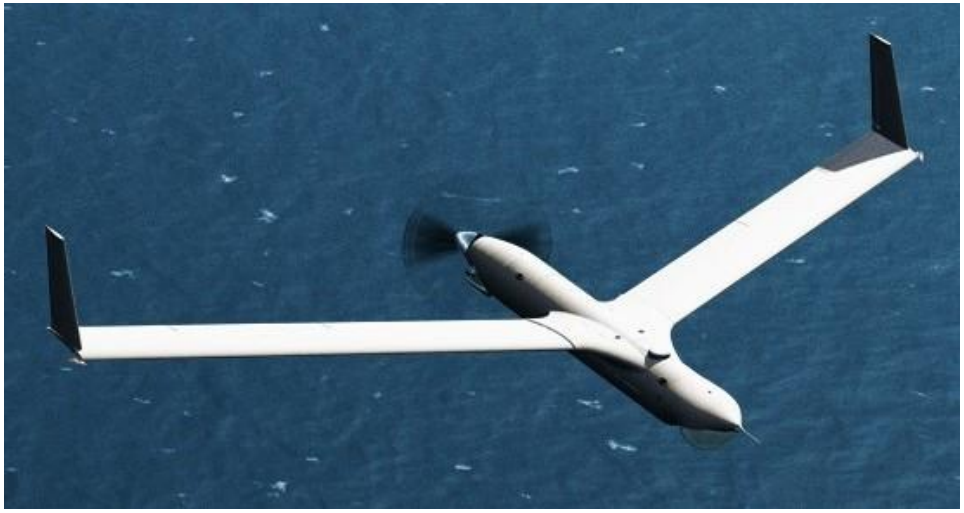
APC In A Chain Saw Engine - Noise



APC In:

Racing

Prototyping



Restoration

Production/Aftermarket

UNITED ENGINE & MACHINE
UEM
PISTONS

iCON FORGED PISTONS WITH LINE2LINE COATINGS

KB HYPEREUTECTIC PISTONS

SILV-O-LITE
Better Pistons Since 1922

DUALOY
DIESEL PISTONS

APC Pistons Cylinder Kit Field Results

Performance:

- More power
- Better leak-down
- Less variability in sealing among cylinders
- Cleaner combustion (cleaner spark plug)
- Less blow-by
- Higher oil pan vacuum
- Clean crankcase vacuum tank
- Opportunity to reduce ring tension
- Consistent combustion and predictable timing

Life:

- Longer lasting leak-down
- Scuff protection
- Less combustion contaminants in oil
- Cooler running pistons/rings
- Less ring and groove wear
- Reduced oil consumption
- Less bore wear
- Foreign particle tolerance
- Less hard carbon – burned oil particles

U.S. Army CCDC SBIR Phase II Program
High Temperature Wear Coatings for Improving High Output Military Diesel Engine Performance and Durability

OBJECTIVES:

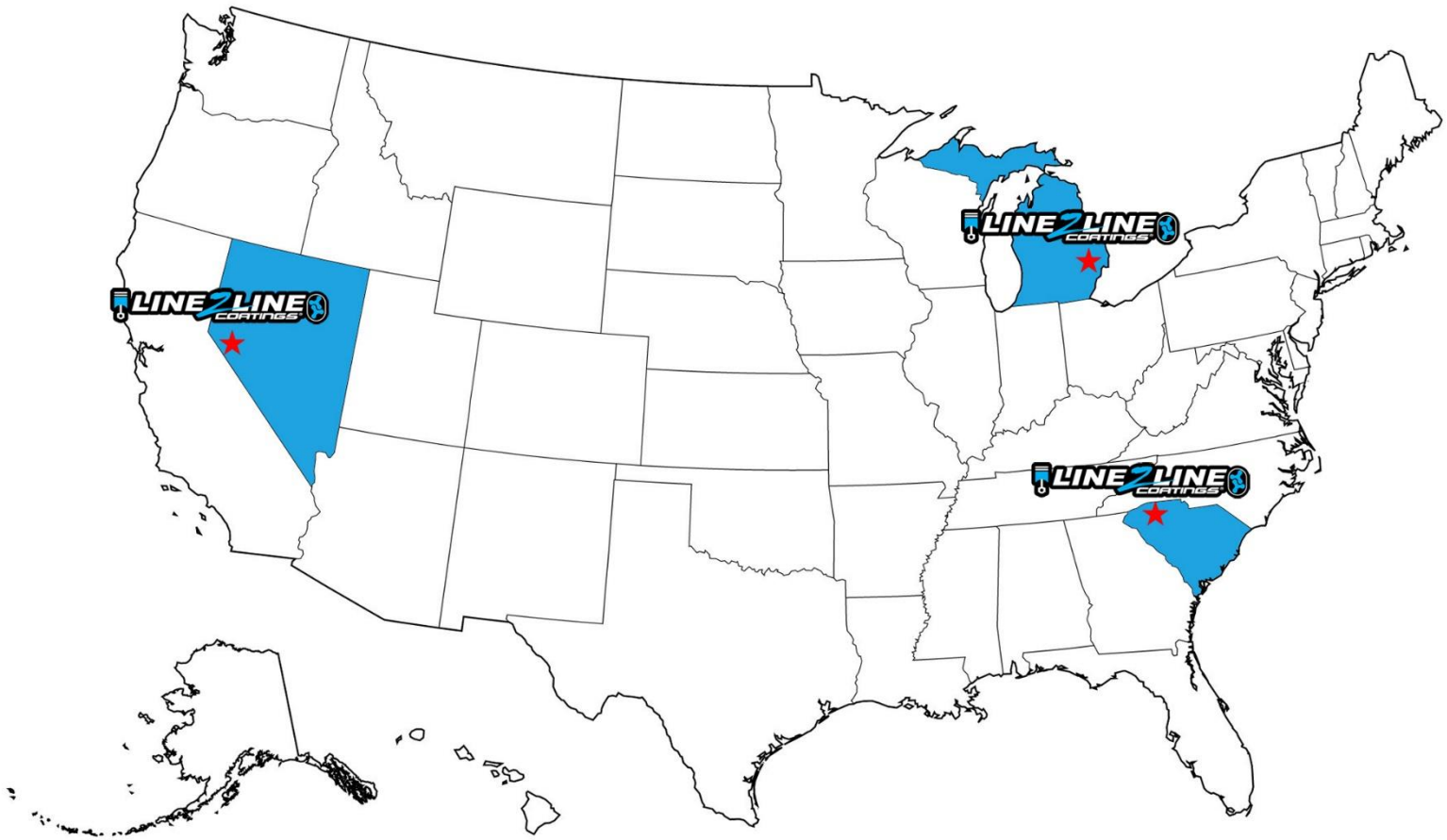
- Demonstrate and quantify cylinder kit efficiency and durability in Cummins R2.8 Turbo-Diesel with and without Abradable Powder Coatings on piston skirts
- Analytical modeling of Cylinder Kit using CASE to study effect of reduced Integrated Skirt Clearance on ring performance and life.

Phase II Team Members

Line2Line Coatings
CCDC Ground Vehicle Systems Center
McLaren Engineering
Michigan State University
C-K Engineering, Inc.
DRC Engineering Inc.
Napier Engineering, LLC
PMD Garage

APC - “A Perfect Fit Every Time”

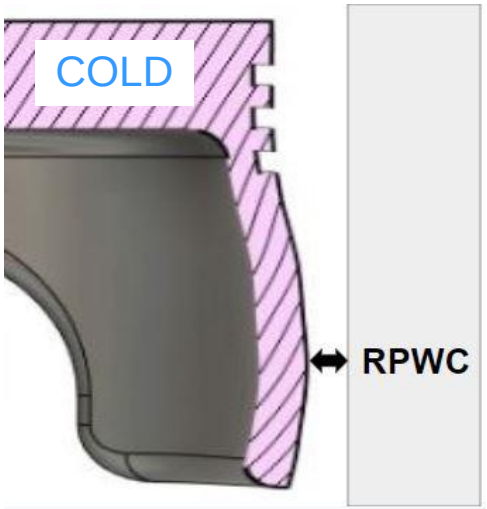
APPLICATOR LOCATIONS



WWW.LINE2LINECOATINGS.COM

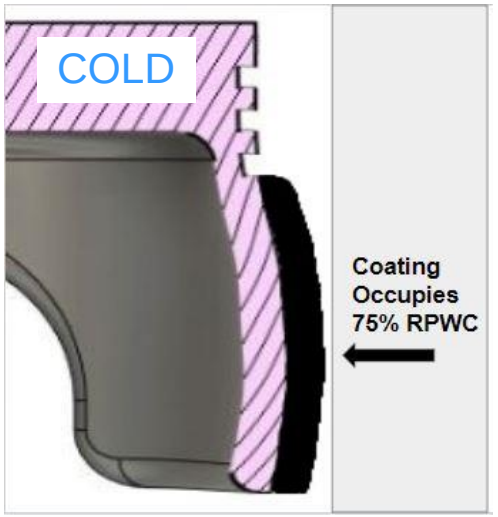
How To Order APC - Clearance / Thickness Sequence

At or Above RPWC

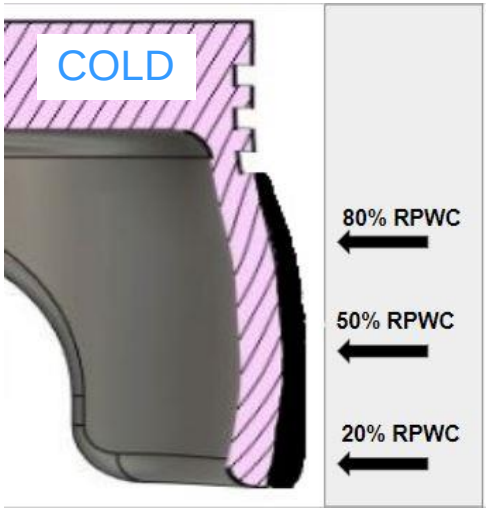


APC Coating

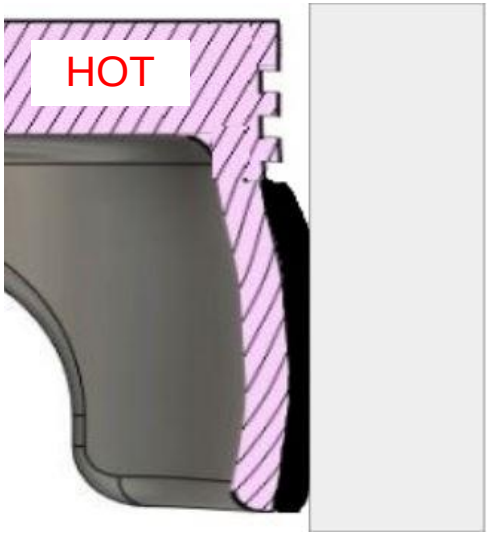
At Assembly



Full Duty Cycle



Stribeck Fitted



At Operating Temperature

MEMBER AERA ENGINE BUILDERS ASSOCIATION

Thank you

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