PO Box 1 Seymour, TN 37865
USA Phone/Fax: 865-773-0599
www.techlinecoatings.com

MANIFOLD COATING:

CERMAKROME BASE COAT; AND **BLACK SATIN TOP COAT:** APPLIED TO EXHAUST MANIFOLDS AND TURBO EXHAUST HOUSINGS BOTH INSIDE AND OUT. THE GOAL WAS TO REDUCE THE SURFACE TEMPERATURE BELOW THE FLASH POINT OF HYDRAULIC FLUID.

***TEST MACHINE**: HITACHI EX3500-2 HYDRAULIC EXCAVATOR

***TEST ENGINES**: CUMMINS K-T38 C 900, 900HP @ 1,800 R.P.M.
*ENGINE LOAD FACTOR: 85%+

***TEST INSTRUMENT:** TESTO 177-T4 TEMPERATURE DATA LOGGER. (GERMAN)
TEST INSTRUMENT WAS PROGRAMMED TO TAKE A TEMPERATURE READING EVERY 1 MINUTE FOR THE TEST PERIOD.

***TEST PROBES:** STAINLESS SHROUDED 4 METRE THERMOCOUPLES.

OPERATING HOURS OF EXCAVATOR DURING UNCOATED TEST: 23 HOURS.

OPERATING HOURS OF EXCAVATOR DURING COATED TEST: 23.5 HOURS

TEST RESULTS:
UNCOATED ENGINE:
NUMBER OF READINGS: 1,388
MAX TEMPERATURE RECORDED: 346.2 C
MIN TEMPERATURE RECORDED: 68.5 C
AVERAGE TEMPERATURE RECORDED: 263.1 C
NUMBER OF READINGS ABOVE 207 C (IGNITION POINT OF HYDRAULIC OIL): 1,193
AVERAGE PERCENTAGE OF READINGS ABOVE 207 C: (IGNITION POINT OF HYDRAULIC OIL): 85%
AVERAGE PERCENTAGE OF READINGS BELOW 207 C: (IGNITION POINT OF HYDRAULIC OIL): 15%

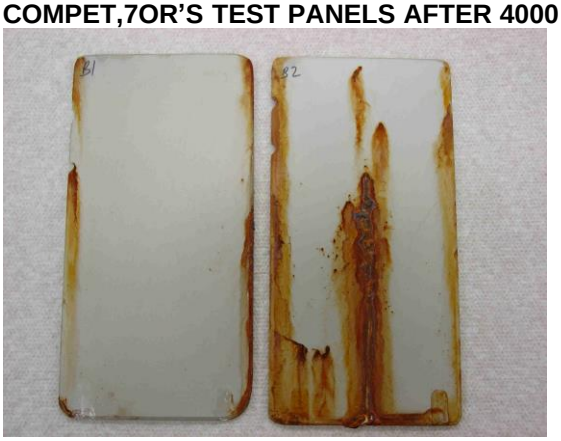
CERAMIC COATED ENGINE:
NUMBER OF READINGS: 1,388
MAX TEMPERATURE RECORDED: 211.7 C
MIN TEMPERATURE RECORDED: 47.4 C
AVERAGE TEMPERATURE RECORDED: 94.0 C
NUMBER OF READINGS ABOVE 207 C (IGNITION POINT OF HYDRAULIC OIL): 2
AVERAGE PERCENTAGE OF READINGS ABOVE 207 C (IGNITION POINT OF HYDRAULIC OIL): .001%
(NOTE 2 READINGS OUT OF 1388 WERE ABOVE 207C. ONE WAS 207.1C)

AVERAGE PERCENTAGE OF READINGS BELOW 207 C: (IGNITION POINT OF HYDRAULIC OIL): 99.99%
PERCENTAGE OF TEMPERATURE REDUCTION CERAMIC COATED MANIFOLDS VERSUS UNCOATED MANIFOLDS: MAX TEMP DROP: 39%
PERCENTAGE OF TEMPERATURE REDUCTION CERAMIC COATED MANIFOLDS VERSUS UNCOATED MANIFOLDS: MIN TEMP DROP: 31%
PERCENTAGE OF TEMPERATURE REDUCTION CERAMIC COATED MANIFOLDS VERSUS UNCOATED MANIFOLDS: AVG.TEMP DROP: 64%

SUPERIOR SALT/CORROSION PROTETCION
(INDEPENDENT TESTING)

TEST PANELS AFTER 6524 HRS OF SALT SPRAY:

COMPET,7OR'S TEST PANELS AFTER 4000 HOURS:



Thermal Shock Testing:

Test objective:

PO Box 668, 10840 Chapman Hwy Unit A♦ Seymour, TN 37865 ♦ USA
Phone/Fax: 865-773-0599
www.techlinecoatings.com

Coatings to be tested for extreme thermal shock and ability to protect and survive in the harshest environment. Ranging from - 200ºc to +1300ºc.

Application:
Oil refinery, liquid oxygen and liquid hydrogen tanks.

Test:
50mm by 100mm mild steel plates coated to manufactures specifications with above mentioned coatings.

Cryogenic and heat test:

1. Plates fully immersed in liquid nitrogen (- 273ºc) for one hour.
2. Plates immediately heated by blow torch to (+1300ºc).
3. Plates re immersed in liquid nitrogen.
4. Continues cycle of test for 8 hours.

Adhesion (ASTM D4541) Flexibility (ASTM D522) Impact (SABS 16)

4.0 Very Good 180º Full load 14 Joules

Adhesion testing: ASTM 4541: The adhesion of a protective coating system to the substrate is considered a good indicator of the coating's ability to resists corrosion and therefore represents the longevity of the coating.

An alcometer adhesion tester was used to evaluate the adhesive properties of the coatings. To quantify bonding strength between the coating and the substrate, ASTM standard D4541 was employed. Aluminum dolly's were glued onto the paint surface (as-received condition), allowed to cure for 24 hours, after which the "pull-off" strength of the coating was appraised.

Coating system	Adhesivity results (MPa), average
MCX/CermaKrome	3.5

Dry Film evaluation - (DFT): ASTM D1186-87: The DFT of the coatings was determined according to ASTM D1186-87. Test procedure: The test method covers the measurement of DFT of coating applied to a ferrous-based metal. An average of 10 reading were taken using the Quanix 1500. Readings were taken approximately 25mm from the edge of the sample and the results are given in Table 4.

Coating System	Average DFT, ìm	Std. Deviation
MCX/Cerma Krome	11.6	2.06

Comment: The DFT on the as-received test plates are on the lower envelope specified, and should be applied to the optimum DFT required**.**

ACCELERATED WEATHERING TEST PROTOCOL
Thermal Shock: Cyclic Test Protocol

An experiment involving continuous thermal cycling was chosen for accelerated testing because it provides a severe environment that accelerates degradation of a coating system. The test method employed exhaustive temperature shock cycling [0°C to 250° C] as presented below:

Thermal shock test protocol.

Cycling Protocol	Temperature,° C	Duration, hours	Cycles per day
Heating	200 to 250	~1.5	7
Cooling	0 to 5	~1.5	7
Weathering	25 to 40	~15	1

Total test duration: 2.5 weeks
Heating and cooling rate were immediate.

Weathering test protocol
Condensation water test protocol: DIN 50'017
Materials are subjected to a natural climate change cycle. The test simulates condition in a hot-humid atmosphere with the formation of condense water which can occur with the impact of humidity, condensing humidity or water. It is suitable for testing protective coating systems. Condense water can form because of temperature change, for instance when a cold sample is transferred into a warm environment. For the test, a test plate is subjected to a wet/humid cycle, which results in a compression of the test duration without deviating from natural loading mechanisms. An illustration of this protocol is shown below.

Weathering test duration 15 hour continuous cycle per day

Evaluation methodology and tested systems

Visual evaluation methodology of test plates:
Coating System Blistering Disbondment
From Scribe: No
Other-surface: No
Anomalies: None

CermaKrome MCX shows the highest Salt Spray and Corrosion resistance of any metallic Ceramic Coating and maintains excellent Adhesion.