

1. Abstract

DuraBlack is CO₂ laser markable aluminum that is engineered for on-demand marking in outdoor, marine, abrasive, chemical/fluid and high-temperature operating environments. DuraBlack is composed of a multi-level coating upon an aluminum base layer. Its integrated abrasion resistant coating reduces the need to apply a secondary protective topcoat.

While regular anodized aluminum (standard industrial product, does not refer to Trotec engraving aluminum) can show fading outdoors as well as reaction to chemical influences, DuraBlack® does withstand harsh environments, fulfilling requirements of industrial and military operating environments for resistance to abrasion, high-temperature, weather, salt-spray and fluid exposure (performance requirements of MIL-STD-130, A-A- 50271 and MIL-DTL-15024F).

The tests, which compare DuraBlack® to black anodized aluminum, laser-markable acrylics and photosensitive anodized aluminum (Metalphoto®), simulate outdoor, marine, abrasive, fluid/chemical and high-temperature operating environments. DuraBlack® exhibits environmental performance that surpasses other substrates including black anodized aluminum and laser markable acrylics.

DuraBlack® can be attached to either curved or flat surfaces with adhesive, rivets or screws.

DuraBlack® can be used with any CO₂ marking laser to produce a durable, high-resolution barcode or human-readable image.

2. Experimental Design

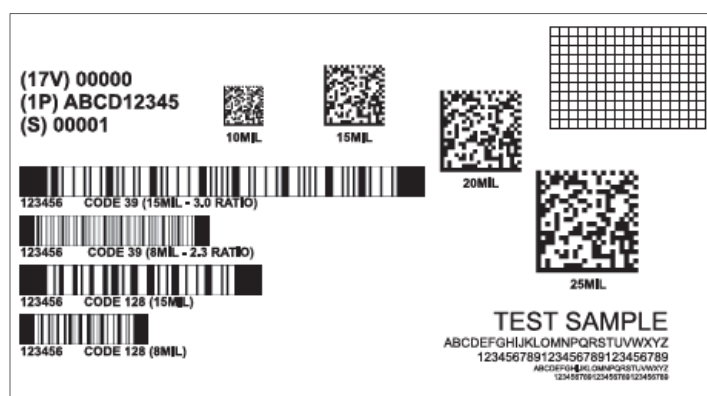
The performance testing was designed to compare several common label materials across a standardized battery of test conditions. Tests were modeled after those established by the U.S. Department of Defense under MIL-STD-810G (material performance) and MIL-STD-130 (identification of high value and/or mission critical assets through the UID program2).

Five operating environments were simulated in the laboratory:

Operating Environment	Test Conditions	Success Criteria
Weather Exposure	Q-Sun XE-3/HS UV chamber as per ASTM G155	2,500 hrs
Abrasion	Taber Abraser, CS17 with 1 kg wheel load as per ASTM G195	4,000 cycles

High-Temperature	Air Oven as per ASTM D573	370°C (700°F) for one hour
Marine/Saltwater Spray	Salt Spray Chamber as per ASTM 8117	30 days
Chemical / Fluid Exposure	Submersion in fluids as per MIL-STD-810G	96 hrs

The test image below was imprinted on all materials evaluated. The laser markable acrylics were mounted on 0.5mm aluminum.



1 Society of Photo-Optical Instrumentation Engineers (SPIE); SPIE Professional January 2010, CO₂ Laser By DeMaria, Anthony J. and Hennessey, Jr., Thomas V. (<http://spie.org/x38563.xml>).

2 Item Unique Identification (IUID) is a part of the compliance process mandated by the United States Department of Defense. IUID requires that all DoD assets that have an acquisition cost of over \$5,000, are mission essential, are controlled inventory, are serially-controlled or are consumable have a unique identifier permanently marked that survives the life of the asset. See <http://www.acq.osd.mil/dpap/pdi/uid/index.html> for more information.

Success is defined as a passing grade (“C” or better) on the 15mil data matrix barcode using a Siemens/Microscan verifier after exposure. This measure of success was used because it is both objective (quantitative, measured by a machine) and is the established military standard for an acceptable barcode mark under MIL-STD-130N and AIM DPM-1-2006.

3. MATERIALS EVALUATION

	DuraBlack®	Black Anodized Aluminum	Laser Markable Acrylic Tape	Metalphoto® photosensitive anodized aluminum
Marking Method	CO ₂ Laser	CO ₂ Laser	CO ₂ Laser	Photo Processor or Photographic Process
Base Material	Anodized Aluminum	Anodized Aluminum	Acrylic	Anodized Aluminum
Attachment Options	Adhesive or Mechanical	Adhesive or Mechanical	Adhesive	Adhesive or Mechanical





4. Results

Among the four materials evaluated, Metalphoto® photosensitive anodized aluminum offers the best resistance to weather, abrasion, high-temperature, salt-spray and fluid exposure. Among the CO₂ laser markable products, DuraBlack® outperformed both black anodized aluminum and laser-markable acrylic tape in selected applications.

5.1. Outdoor Exposure

DuraBlack maintained a readable, passing verification grade for 2,500 hours in the Q-Sun weather chamber. Standard black anodized aluminum faded below readability after only 1,500 hours. Laser markable acrylic tape and DuraBlack both verified after 2,500 hours in the Q-Sun weather chamber; however the acrylic label shows signs of physical deterioration (cracking/expanding).


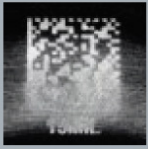
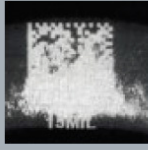

It is difficult to forecast actual outdoor life because each application environment is different, although it is anticipated that DuraBlack will outperform laser markable acrylic tapes when attached to metal substrates.

DuraBlack®	Black Anodized Aluminum
	
PASS @ 2,500 hrs	FAIL @ 1,500 hrs
Laser Markable Acrylic Tape	Metalphoto®
	
PASS @ 2,500 hrs	PASS @ 2,500 hrs*

5.2. Abrasive environments

The results of the abrasion testing were in line with expectations; top surface marked labels (DuraBlack, standard black anodized aluminum and laser markable acrylic tape) exhibited greater wear than labels where the image was embedded within the metal (i.e. Metalphoto®).





Among the top surface marked labels, DuraBlack offered significantly greater abrasion resistance than the others.

DuraBlack®	Black Anodized Aluminum
	
PASS @ 4,000 cycles	FAIL @ <500 cycles
Laser Markable Acrylic Tape	Metalphoto®
	
FAIL @ <500 cycles	PASS @ 8,000 cycles

5.3. High-Temperature Environments:

Materials were exposed to sequentially higher temperatures in 10°C increments, starting at 150°C, for one hour at each temperature.



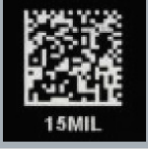

The 2D code marked on DuraBlack remained readable through 370°C, while black anodized aluminum and laser markable acrylics failed above 200°C. The DuraBlack label did turn darker, but still passes verification.

DuraBlack®	Black Anodized Aluminum
	
PASS @ 370°C (700°F)	FAIL @ 204°C (400°F)
Laser Markable Acrylic Tape	Metalphoto®
	
FAIL @ 288°C (550°F)	PASS @ 370°C (700°F)

5.4. Marine Environments:

The salt spray test is designed to simulate usage in a marine environment, as is encountered on commercial or military ships or intermodal shipping containers.

All materials passed verification after 30 days in the salt spray corrosion chamber.


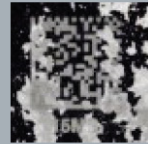





DuraBlack®	Black Anodized Aluminum
	
PASS @ 30 days	PASS @ 30 days
Laser Markable Acrylic Tape	Metalphoto®
	
PASS @ 30 days	PASS @ 30 days

5.5. Industrial Fluids/Chemical Environments:

A complete list of tested fluids, including all of those under MIL-STD-810G, is noted below. Most chemicals did not have an effect after a 96 hour (4 day) submersion.

However, black anodized aluminum did succumb to ammonia and alkaline cleaner after fewer than 24 hours. Similarly, laser markable acrylics did not withstand 48 hours in contact with gasoline and fewer than 24 hours with MEK and ethyl acetate. Materials were checked (verified) every 24 hours.

- Fuels: Jet, Diesel, Automobile
 - Hydraulic Oils: Mineral Oil, Phosphate Ester (Skydrol®), Silicone
 - Lubricating Oils: Motor Oil, Ester (synthetic), Preservative
 - Cleaning Fluids: Isopropanol, Ethanol (denatured), d-Limonene, Stoddard
 - Solvent, Aircraft Cleaner
 - Automotive Fluids: Deicing Fluid, Brake Fluid, Automatic Transmission Fluid, Deionized Water, 5% Salt Solution, Auto Anti-freeze
 - Lab Chemicals & Solvents*: Methyl Ethyl Ketone, Ethyl Acetate, Glycol Ether PM, Xylene, 10% Ammonium Hydroxide, 10% Sulfuric Acid, Greased Lightning®
- *Non-MIL-STD-810G fluids tested

DuraBlack®	Black Anodized Aluminum	
		
PASS all @ 96 hours	FAIL @ Ammonia (<24hrs)	FAIL @ Alk Cleaner (<24hrs)
Laser Markable Acrylic Tape		
		
FAIL @ Gasoline (48hrs)	FAIL @ MEK (<24hrs)	FAIL @ Ethyl Acetate (<24hrs)
Metalphoto®		
		
PASS all @ 96 hours		

5. Summary Grid

	DuraBlack®	Black Anodized Aluminum	Laser Markable Acrylic Tape	Metalphoto®
Weather/UV Resistance (2,500 hours)	PASS	FAIL @ 1,500 hrs	PASS	PASS
Abrasion Resistance (4,000 cycles, 1Kg)	PASS	FAIL @ <500 cycles	FAIL @ <500 cycles	PASS
Temperature Resistance 370°C (700°F) for 1 hour	PASS	FAIL @ 204°C (400°F)	FAIL @ 288°C (550°F)	PASS
Salt Spray (30 day exposure)	PASS	PASS	PASS	PASS
Fluid Resistance (96 hour submersion)	PASS	FAIL @ Ammonia & Alkaline Cleaner	FAIL @ Gasoline (48 hrs), MEK & Ethyl Acetate	PASS

→ DuraBlack® - Technical Data

→ Beyond durability

Beyond performance in harsh operating environments, DuraBlack has several advantages over other lasermarkable materials.

1. The abrasion resistant coating reduces the need to apply a protective topcoat; a standard practice for black anodized aluminum and laser markable acrylic tape.
2. DuraBlack can be attached to either curved or flat surfaces with adhesive or rivets or screws.
3. The aluminum base layer reduces potential damage from over marking.
4. The matte black finish reduces reflection for combat situations. All of the above, plus consistent, high-quality manufacturing control, the trusted leader in printable aluminum technologies, makes DuraBlack a reliable solution for marking and long-term tracking of assets.

→ Independent Laboratory Certifications

Because of its ability to perform across a range of challenging environments, DuraBlack meets an array of government, industrial and military specifications.

- A-A-50271 (~MIL-P-514D) Detroit Testing Laboratory
- MIL-STD-15024F, Type L (laser generated plate) According to Type L, testing shall “be determined by the acquiring activity and the supplier”. Horizons ISG recommends the standards of A-A-50271 be adopted for MIL-STD-15024F, Type L.

→ Conclusion

The tests identify DuraBlack as a preferred replacement for standard black anodized aluminum in high demanding environments; including, outdoor, abrasive, high-temperature and fluid environments. DuraBlack performs similarly to laser markable acrylic tape in tests of outdoor weather exposure and salt-spray corrosion, and it surpasses the acrylic material in abrasion and fluid resistance. Existing and future specifications should be changed to reflect this finding.

DuraBlack is unique because of its combination of durability, flexible attachment options, thicknesses and a non-reflective finish. These characteristics make it an excellent option for on demand marking used in harsh industrial and military environments.