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Control #: 7

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Environmentally Clean Coating: Ion Vapor Deposited Aluminum

Ion Vapor Deposited Aluminum, or IVD as it is commonly known, was developed by Mc Donnell Douglas in St. Louis. The first major program with IVD was the F-18A aircraft. Mc Donnell developed what they called the ivadizer which they sold in two sizes: 4' x 6' and 6' x 10'.

These ivadizers have been on the market for approximately twenty years. They are currently being sold by Abar Ipsen who bought the rights from Mc Donnell a few years ago. We have been coating with IVD for over ten years and have been in the forefront of the new use technology.

There are about 70 ivadizers throughout the world in approximately 45 locations. Our company has five, the Navy has seven at Naval Air Stations, the Air Force has seven at Air Force Bases, and Mc Donnell and other major manufacturers have their own. There are a number of job shops with ivadizers in the United States.

Ion Vapor Deposited Aluminum was developed to solve a number of different problems. Corrosion was the major problem. IVD also relieved hydrogen embrittlement, galvanic corrosion, dissimilar metal problems, solid metal embrittlement (Cadmium in contact with titanium), fatigue reduction vs. weight (on aluminum), and works in space applications.

The process is the same no matter what size the chamber. The standard procedures are: degrease the parts, aluminum oxide clean / grit blast, ivadize, glass bead, chromate seal.

The ivadize process begins once the parts are clean and put into the ivadizer. It is pumped down to a very low vacuum (8×10^{-4}), at which time a power supply is turned on and the chamber is back filled with argon. This is called glow discharge cleaning. Then the chamber is pumped down again and resistance heated elements called boats are heated. Next, ninety-nine percent pure aluminum wire is fed into them and vaporized.

The IVD process is versatile and adaptable to a wide variety of parts, shapes, and sizes. It is not confined to line of sight.

The coating is dense, adherent, pure, metallic aluminum. It has excellent adhesion to the substrate, no matter what the base material is. The coating does not tend to build up on the part edges as it does in electroplating. A thickness variation of 10% can generally be maintained from run to run.

Testing the adhesion is done by bend and break of coupons. Also, if you can glass bead at 40 psi, which is part of the process, and it does not come off, that is a very good adhesion test.

The IVD coating process is covered by military, industrial, and company specifications. For this presentation, I will talk about the Military Specification C-83488 Revision C. In this specification, there are three classes and two types. The coating thickness is controlled by the class call out:

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MIL-C-83488C (2)

TABLE I. Salt Spray Test.

| | Type I | Type II |
|--------------------------|--------|---------|
| Class 1 is .001 minimum | 504 | 672 |
| Class 2 is .0005 minimum | 336 | 504 |
| Class 3 is .0003 minimum | 168 | 336 |

Class 1 is used for most rack-coated parts or wherever good corrosion protection is needed. Class 2 is used where there might be some close tolerances that need to be held, although the blue print can call out other thicknesses, but this should be done with an experienced coater's knowledge. Class 3 is basically used for fasteners where the threads cannot stand a large build-up.

The type I call out is for as coated or as coated and glass beaded. The type II call out is glass beaded and a chromate conversion coating. The replacements for chromate conversion coating should work for IVD the same as they do for other aluminum.

The use of IVD aluminum has many known advantages and many yet to be discovered. Some of the advantages are:

- It outperforms cadmium in actual service tests as well as acidic salt fog.
- It has a 925^o F. (500^o C.) continuous service temperature.
- It does not induce hydrogen embrittlement or solid particle embrittlement.
- It helps to relieve dissimilar metal problems and galvanic corrosion.
- There is no fatigue reduction factor for aluminum parts caused by anodize.
- It is conductive.
- It has good wraparound coating and is not held to line sight.
- There is no sublimation of the coating in a space environment.
- There are no cleanup costs.

IVD aluminum is the U. S. government's choice as a cadmium replacement for all branches of service: Army, Navy, Marines and Air Force. Military Standard 1568 identifies IVD aluminum as an acceptable alternative to cadmium, citing its corrosion protection and non-toxic properties. As mentioned, IVD aluminum also is the primary replacement for cadmium in both aerospace and commercial industry.

There have been outdoor tests run over a 12 year period where IVD is still protecting and cadmium was depleted after just a few years.

A wide variety of parts of various sizes and shapes are coated in production. All of the primary

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metals; steel, aluminum, and titanium used in the fabrication of aircraft are coated. Composite material used in aerospace can be coated as well as matrix materials, glass, and some plastics.

IVD has been and is currently being used on many different programs and many different types of parts. Let it suffice to say that basically all current military and commercial aircraft use IVD aluminum on some parts whether they are airplanes, helicopters, or missiles. The parts vary from fasteners on stainless steel to protect from dissimilar metal problems, to wing skins and bulkheads that use IVD aluminum to replace anodize for fatigue reduction, to landing gear for protection from hydrogen embrittlement, and engine mounts where the coating has to protect at high temperatures. There are many other uses such as; neodymium magnets which require extreme corrosion protection, and the steam turbine blades which need protection against stress corrosion cracking. IVD aluminum was used with a topcoat on fasteners for a projected one hundred year performance in the Arizona desert. And, of course, IVD aluminum is used on normal parts requiring corrosion protection that are environmentally clean.

IVD aluminum is conductive and can be used to advantage where electrical conductivity is required. When used on hydraulic fittings, no jumpers are required for grounding.

IVD aluminum is an excellent coating for all types of fasteners. Fasteners have been mentioned in general being coated with IVD aluminum and are coated in the millions each year for all aerospace programs. Fasteners coated with IVD aluminum need to be coated a little thicker than when they were coated with cadmium and need to be lubricated. Care needs to be given to the size of the thread to the shank. The shank is measured for the coating thickness and the threads have a somewhat thinner coating. The coating has good uniformity and does not build up on sharp edges or thin out in recesses normally associated with electroplating. IVD aluminum has excellent adhesion to the substrate. IVD aluminum will not only protect the fastener but will also protect the countersink of any aluminum structure they are installed in. Many titanium fasteners are coated for this reason.

IVD aluminum has been coated with a ceramic topcoat for use in a permanent installation and was tested at over 28,000 hours in S. O₂ salt fog. Where the need has been to assemble and remove and replace and reassemble a topcoat over the IVD aluminum of a fluoropolymer has been used for the last five years on a program by the U. S. Navy. The IVD aluminum gives corrosion protection, the fluoropolymer gives added corrosion protection plus a lubricity for installation and removal. Many thousands of that type of fasteners are in use today.

Most of the fasteners coated with IVD aluminum are processed in a barrel coater by the batch process which reduces the price per part. The size of the parts that can be barrel coated is limited to not damaging themselves by their own weight. Of course, many other parts are barrel coated too: springs, fittings, connectors, and others.

Top coats over IVD aluminum have been used on other parts as well as fasteners. Most parts, if

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not top coated, will, at some point, get a coat of primer and then a top coat of paint. IVD aluminum is an excellent base for all primes and paints.

This presentation does not discuss the chromate conversion coating except to recommend it or a replacement of it. The 99.9% pure aluminum IVD is much enhanced with the addition of the chromate conversion coating and is environmentally clean by itself and only minorly effected by the chromate.

In summary, IVD aluminum, has been tested in the laboratory and in the field and found to be a high-performance corrosion protection finish, offering many advantages over many commonly used finishes and it is environmentally clean.

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