



AEROSPACE INFORMATION REPORT

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Hot Stamp Wire Marking Concerns for Aerospace Vehicle Applications

RATIONALE

Hotstamp marking is no longer authorized for aircraft applications (see AS50881). The continuing use of hot stamp marking on modern aircraft cable constructions may result in a safety issue and should not be used. Marking with hot stamp machines should only be used on separate identification sleeves.

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FOREWORD

Hot stamp ink marking of aircraft electrical wiring for circuit identification was initially introduced in the 1940s. At that time the process was well matched to the physical characteristics of the wire insulation, which was thick enough to withstand the indentation of the marking process. However, as wire insulation has become markedly thinner over the intervening years, problems have arisen with damage to wiring as a result of excessive penetration by hot stamp marking. The frequent need for adjustments in temperature, pressure and dwell time inherent to achieving legible hot stamp wire marking provides numerous opportunities for error. The controls, methods, and guidance necessary to achieve satisfactory performance with hot stamp marking are often not made available to operators in smaller wire shops.

In recent years, non-impact marking processes have been developed that can mark virtually all of the common wire types used in aerospace interconnect applications. Given the availability and cost effectiveness of these processes and the associated equipment, the time has come for military services and civil regulatory agencies to accelerate the phase-out of hot stamping in aircraft applications. Full conversion to non-impact marking processes is needed in order to enhance the safety and reliability of today's air vehicles.

Modern aircraft electrical and avionics systems depend heavily on their interconnecting wiring to function properly. To carry signals and power between components, thousands of feet of airframe wiring are routed through nearly every cubic foot of an aircraft's volume. Although some of this wiring is carefully installed and located in the pristine environment of pressurized interior sections, much of it is subjected to operational stresses. These stresses are created by operation in compartments that experience repeated cycles at extreme temperatures, vibration, fluids of various types, and potential damage induced during maintenance activities in adjacent areas. The ability of such wiring to resist failure under these circumstances is not only dependent on its materials and construction, it is largely dependent upon the application of the best available fabrication, assembly and installation practices during the manufacturing cycle.

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1. SCOPE:

This SAE Aerospace Information Report (AIR) discusses the often overlooked relationship between hot stamp marking and the environmental conditions that contribute aircraft wiring problems and discusses current beliefs of military service experts, regulatory agencies and industry standard writing bodies about the potential hazards imposed by the hot stamping process.

1.1 Purpose:

Although prominent members of the aerospace community are taking aggressive measures to phase out the hot stamping of interconnecting wire, the process lingers on, particularly within the operations of smaller manufacturers, modification shops, and operator maintenance facilities. In recent years, non-impact marking processes have been developed that can mark virtually all of the common wire types used in aerospace interconnect applications. The purpose of this document is to encourage full conversion to non-impact marking processes in order to reduce the probability of causing damage to the wire insulation.

1.2 Field of Application:

Today's civil aircraft are relied upon by airlines to perform safely for at least 50,000 flight hours and 20 or more years of operation. Military aircraft are typically in service for a comparable period under more severe conditions, but do not experience as many flight hours. Extending the life of the current fleet to meet these requirements depends heavily on the processes used for original manufacture, system upgrade modifications and life extension refurbishment programs. Improvement in the manufacturing techniques supporting these activities is essential to guaranteeing acceptable levels of performance throughout the life of the vehicle.

2. REFERENCES:

2.1 Applicable Documents:

2.1.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AS50881	Wiring Aerospace Vehicles
ARP5369	Guidelines for Wire Identification Using the Hot Stamp Process
ARP5607	Legibility of Print on Aerospace Wires and Cables

2.1.2 U.S. Government Publications: Available from DOSDSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-W-5088L	Wiring, Aerospace Vehicles
AC43.13-1B	Advisory Circular, Acceptable Methods, Techniques, and Practices - Aircraft Inspection and Repair, U.S. Department of Transportation, Federal Aviation Administration
WL-TR-95-4004	Aircraft Mishap Investigation Handbook for Electronic Hardware, Materials Directorate, Wright Laboratory, U.S. Air Force Material Command

2.1.3 ASTM Publications: Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 3032 Hookup Wire Insulation, Standard Methods of Testing

2.1.4 Other Publications:

UK Civil Aviation Authority Note 11-22 Appendix 24-3, Electrical Cable Failure, June 22 1998

prEN3838 AECMA Standard, Aerospace Series, Requirements And Tests On User-Applied Markings On Aircraft Electrical Cables, September 1995

G244 British Standard Aerospace Series Code of Practice For: Installation/Repair of Electrical Interconnection Systems, 1989

Handbook Slenski G. and Galler D., Electronic Failure Analysis Handbook, McGraw-Hill, 1999

2.1.5 Technical Papers:

John W. DeHart, DuPont Company, Carbon Arc Tracking Tests, May 17, 1985

John Brooks, International Aero, Gary Scott, Square D Company, Arc-fault Circuit Interrupters for Aerospace Applications, 1999

Dr. Armin M. Bruning, Lectromechanical Design Company, Aging Measurements of Operating Aircraft: Implications for Specification Writing and A/C Reliability, 1997

3. DISCUSSION:

3.1 Failure Investigation:

It is very difficult to determine the initial cause of some types of failures that may involve an aircraft's wiring system. Given the usual condition of affected aircraft sections, it is normally very difficult to determine exactly where the failure occurred and whether wiring was the victim or the cause of the damage.

3.2 Determining the Cause of Wiring Failures:

Wire arcing failures are sometimes followed by insulation destruction, in which the subject wire(s) and much of the surrounding materials are destroyed. It is usually very difficult under such circumstances to determine the exact cause of the event that resulted in such a failure. However numerous efforts have been made to replicate some of these incidents in a laboratory environment and occasional successes have been achieved.