MAGNETIC MEDIA CHARACTERIZATION AND TESTING

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ABSTRACT

The Department of Defense (DOD) is establishing a Navy operated magnetic media RDT&E facility at the Naval Air Development Center (NAVAIRDEVCEN) in Warminster, PA. The facility will support all present and future DOD data storage requirements by characterizing new media, generating technical specifications, developing modern test hardware and by conducting both qualification and acceptance testing for these media. The findings will support consolidated tri-service procurement activities, recently assigned to the Defense Electronics Supply Center (DESC) in Dayton, OH.

The technical specifications for analog instrumentation tape (W-T-001553) and tape reels and hubs (W-R-175) have been updated and revised. A computerized testing system to measure electrical performance parameters has been developed and includes a modular system for multi-channel drop-out testing. New techniques for measurement of critical physical parameters are being investigated. Several state-of-the-art techniques for media characterization have also been developed.

A characterization of both normal and high coercivity instrumentation tape for high density digital data applications has been conducted. Testing criteria and hardware are under development to support near term specification and consolidated procurement of this commodity.

INTRODUCTION

Prior to January 1982 high quality magneitc instrumentation tape was specified, procured and tested by the General Services Administration (GSA). The Department of Defense fought the Executive Order to close the test laboratory facility operated by GSA and to suspend the related Federal Specifications and consequent testing. These new conditions in conjunction with the existing single source market and no government stockpile of material forced DOD to seek alternative facilities.

In October 1984 the Naval Sea Systems Command was established as the Preparing Activity for both Federal Specifications and the Naval Air Development Center was assigned as the Technical Agent. Procurement and commodity management responsibilities were transferred from GSA to the Defense Electronic Supply Center in Dayton, Ohio.

MAGNETIC MEDIA

NAVAIRDEVCEN, as the Technical Agent, is responsible for all technical areas associated with supporting the federal specifications. Periodic update is necessary to stay current with quickly evolving and demanding requirements for increased areal data packing densities. New testing methods and state-of-the-art hardware must be developed in order to ensure that present and future recording media performance meets these specifications. Qualification and acceptance testing of magnetic instrumentation tape will be conducted to assure consistent quality for all media to be utilized in tri-service applications.

Both pertinent Federal Specifications have been rewritten and are presently being reissued by the Naval Sea Systems Command. The specification for magnetic instrumentation tape, last revised in 1974 , had become grossly outdated. The specification was deficient to the degree that nearly all present day instrumentation tape easily surpassed its requirements. However, many of todays applications require tape meeting more stringent specifications. The rewrite, presently being reissued, is a preliminary attempt at addressing this issue. Every test was evaluated for relevance to present day tape anamolies. Some tests were eliminated for this reason, while other tests in this category were retained so as to prevent outdated problems from reappearing as new competitors enter into this market.

In general, new parameter tolerances, sampling rates and test methods were not included in the current update of W-T-1553. These type of changes have been postponed until the new NAVAIRDEVCEN facility is operational for a sufficient lenght of time to establish an adequate empirical database that supports tighter but realistic tolerances. It is important to stress that changes of this nature are aimed to select the finest quality tape while remaining realistic and relevant to the required applications. In particular, overly restrictive specifications that would reject media with useful performance characteristics will be avoided.

The present tape specification pertains to standard and high resolution analog tape. The next revision of this document will include high density digital tape of both normal and high coercivity. Digital instrumentation tape will be tested using analog measurement techniques that describe digital performance characteristics. This approach is essential so as to avoid evaluating the technical discrepancies that may exist among the various tape

recorder manufacturer's proprietary encoding/decoding schemes and hardware implementation. For example, intrinsic bit error rate performance is highly dependent on error correction schemes and bit synchronizer design. Code dependency actually plays a secondary role. The DOD testing facility must avoid such desparities and yet perform tape testing of universal value to all user applications. Consequently, mapping digital parameters into the analog domain and specifying these parameters solves that problem.

The testing techniques employed for analog and digital tapes are similar, however, the acceptance values and tolerances of these parameters will vary. The types of tests used for evaluation of magnetic tape fall into four major categories; visual inspection, electrical performance, physical properties and magnetic characteristics. Tape testing, using the first of the three categories of tests, has been common for many years. Only recently have magnetic tests been implemented and utilized for this purpose. Tape characterization, using magnetic properties, has the benefit of defining intrinsic tape quality and expected performance. Other test methods, which use an instrumentation tape recorder/reproducer, tend to mask intrinsic tape performance due to the dependency of the unique tape-to-head interface characteristics of individual transports.

The new instrumentation tape specification specifies that the reference tape recorder for performance testing will be a Honeywell Model 96C/97 or equivalent as determined by the government. This selection was made in consideration of tape-to-head interface performance and to employ the computer controlled automated calibration features of the Model 97. The NAVAIRDEVCEN laboratory will consider any other transport which yields equivalent test results as an equivalent machine.

Prior to placing tape on a transport for electrical performance testing, visual inspections are conducted to assure good workmanship. Tape and reels are examined for general appearance, construction, and cleanliness. The wound pile envelope is examined for folds, buckling, cinching, spoking, gaps between tape layers, protruding edges and clearance to each reel flange. The radial distance from the outtermost tape layer to the flange edge (E-value) is also measured.

The electrical performance parameters to be measured are signal-to-noise ratio, wave-lenghth response, sensitivity, harmonic distortion, short-term output uniformity, long-term output uniformity, and instantaneous nonuniformity commonly called dropouts. These parameters are measured for production tapes and compared to the values previously established for the manufacturers centerline tape of that particular product type. NAVAIRDEVCEN personnel have designed and developed a computerized, three station, testing system which can simultaneously measure and evaluate all of these parameters. The automation of these tests makes it cost effective to test more tape samples and more data tracks per tape. This testing system has the capabilities for controlling the reference

tape recorder, monitoring and adjusting its calibration, storing the test results and performing statistical computations. The system is programmed to develop a comprehensive database for future updates of the specification parameter tolerances.

The automated system contains a NAVAIRDEVCEN developed drop-out measuring system. The unique drop-out system connects directly to the internal drop-out detectors in most high density digital recorders and has an external interface for use with any analog recorder. The system will simultaneously test as many as 28 data channels for individual drop-outs of five microseconds or longer. The system identifies the track number and footage location of all drop-outs. The footage location can be calculated using the systems' own internal clock or connected directly to the tape recorders capstan motor control circuitry. Threshold levels are adjustable on a per track basis. A desktop computer package contains specification pass/fail criteria and utilizes the footage measurements to determine overall dropout lengths. Dropout coincidence across the tape can also be calculated. The systems capabilities are being expanded to include dropout burst measurements.

The physical parameters to be measured are electrical resistance, frictional vibration, modulus of flexibility, longitudinal curvature, layer-to-layer adhesion, elongation, shook strength, yield strength, fungus resistance, toxicity, flammability, width and edge quality. The majority of these tests are only performed during qualification testing and need not be performed during acceptance testing. However, the government reserves the right to perform these or any other specified tests as part of quality assurance and acceptance testing. Development efforts are underway to automate the simultaneous and continuous measurement of tape width, edge quality and longitudinal curvature. A computerized laser micrometer system with ten microinch resolution is being adapted. These parameters are becoming increasingly more critical at higher bit packing densities and are of prime concern for the emerging rotary digital technology. Oxide coating anamolies and tape edge problems will be examined using an electron scanning microscope.

The tests for flammability and toxicity are physical tests which are necessary to ensure the safety of recorder operators and fleet personnel. Tape manufacturers are required to submit certification showing that their products meet these requirements. The government will contract private testing laboratories for quality assurance in these areas.

The use of magnetic characteristics for evaluating magnetic media is not a new concept but has only recently been applied to the instrumentation recording field. In general, the testing entails the use of a vibrating sample magneto-meter to develop a static hysteresis loop which describes the magnetization process in detail. Characteristics, such as saturation moment, squareness, coercivity and switching field distribution, can be extracted from the curve and provide a magnetic description of the recording media.

The research team at NAVAIRDEVCEN has developed a technique to “unfold” the static hysteresis loop by plotting the moment as a function of applied field over one complete field cycle and then to take the Fourier transform of the resulting waveform. The dependence of the harmonic content of this waveform on maximum field is used to differentiate among various oxide coated media. Additional applications of the Fourier transform method include characterization of the temperature dependence of hysteretic properties and analytic expressions for accurate loop reconstruction.

Another technique developed by the NAVAIRDEVCEN research team involves using the Magneto-optic Kerr Effect to derive a direct comparision between the hysteretic behavior of the surface and bulk of particulate oxide recording media. Several different types of particulate recording media were measured using this technique. The surface coercivity was found to be about ten percent higher than the bulk coercivity for some of the high energy tapes; however, it was virtually identical to the bulk coercivity in several other samples.

These new analytical techniques are essential to developing new testing methods for evaluating all data storage media including magnetic tape. Specifications which are being developed for normal and high coercivity digital tapes will reflect these phenomena. In addition, new drop-out criteria pertinent to actual performance are evolving. The new criteria will address dropout bursts. The coincidence of bursts, the coincidence of random drop-outs and bursts, and the coincidence of random dropouts across all digital channels will be specified and measured. These new criteria may define a burst as a 20 decibel minimum reduction in signal amplitude for the equivalent of 10 digital bits (2.5 microseconds) at bandedge. Studies are underway to determine the number of such occurences that will be allowable in a 100 foot section of tape. The specification will not permit either areal or lineal averaging of bursts. When these digital tape specifications are complete these commodities will be added to the list being procured and stocked by the Defense Electronic Supply Center.

Upon completion of the new NAVAIRDEVCEN test laboratory DESC will enter into full scale competitive procurement of instrumentation tape. In conjunction with qualification testing a Qualified Products List will be established along with a Multiple Award Schedule for equivalent performing analog tapes. About one year later longitudinal digital tape will be procured and stockpiled in a similar manner. It is anticipated that these procedures will eventually be followed for rotary digital media.

TAPE REELS AND HUBS

In rewritting the specification for tape reels and hubs the mechanical tolerances and measurement techniques have remained as they have been. Sections of the specifications which pertained to reel and hub types no longer is use were deleted. Measurement parameters and diagrams have been changed to comply with the lastest ANSI standards.

The types of measurements made for these materials involve highly accurate mechanical measurements; some of the measurements require accuracies of one ten thousandth of an inch. The NAVAIRDEVCEN laboratory is investigating new automated measurement techniques for converting from single point type measurements to continuous run-out testing. These techniques would give the desired go and no-go decisions while acquiring supportive data for diagnosis of discrepant material problems.

The glass reel, supplied only by Corning Glass Works, represents the finest quality tape reels available today in respect to precision, flatness and temperature and humidity stability. The solid flanges prevent dust and other foreign particles from being drawn into the tape pack during wind and rewind operations. The glass reel is intrinsically more expensive than its precision aluminum counterpart and for this reason many users have avoided them. NAVAIRDEVCEN is seeking an alternate and less expensive solution by investigating composite plastic type materials. If such a material can be used it would solve the majority of the metal flange problems in a most cost effective manner.

REFERENCES

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