Tamper Evident Tape Integrity Analyzer

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Abstract--

The Cargo Supply Chain Integrity Technology (CSIT) Research, Development, Test and Evaluation project, jointly managed by the Transportation Security Administration (TSA) and the Department of Homeland Security’s (DHS) Science and Technology (S&T) Directorate develops standards and certifies systems to mitigate threats posed by the potential introduction of improvised explosive devices into cargo carried by passenger aircraft. At the direction of Congress, Public Law 110-53, “Implementing the Recommendations of the 9/11 Commission Act of 2007”, mandates that all 100% of all cargo shipped via passenger aircraft be screened.

In 2013, National Strategy for Global Supply Chain Security Implementation was initiated by the White House that called for aligning technology needs and investments among Federal departments and agencies by developing a set of United States Government-wide cargo and supply chain research and development (R&D) priorities; and identifying opportunities to test, in operational environments, specific technologies that have the potential to improve the security and integrity of cargo.

In order to preclude insertion of a security / explosive threat into screened cargo prior to loading onto the aircraft the TSA has established its Certified Cargo Screening Program which required cargo to be locked down or sealed with anti-tampering technology. This technology may include the use of tamper evident tape (TET). After a series of industry surveys and laboratory tests on these tapes, recommended standards and practices documents were published by DHS to insure the quality and performance of these tapes.

This paper focuses on the TET analyzer software that has recently been issued a United States Patent, numbers 9, 305,246, entitled ‘Method of Analyzing Tamper evident Tape Residue” This patent was issued by the U.S. Patent and Trademark Office (USPTO) on April 5, 2016. This patent describes a method and software for measuring the effectiveness of tamper evident tape by optically analyzing the residual pattern left by the tape after it has been pulled off a substrate. The software has application for cargo and luggage screening and security alerting devices and allows for greater analysis and performance test standards of tamper-evident tapes and the residual material they leave behind. The testing method, plus an application of the software to authenticate tampering of the tape used to seal cargo/baggage units will be
TET integrity analyzer software will ensure air cargo supply chain integrity by streamlining the inspection procedures of the air cargo and assist in compliance with TSA regulations to track tampering at any point in the supply chain.

**Key words -- Cargo Supply Chain Security, Tamper Evident Tape**

I. INTRODUCTION

In the 9/11 bill, Congress mandated TSA to screen 100% of air cargo on passenger carrying aircraft by August 2010. TSA/DHS is enhancing the security of the supply chain while ensuring the flow of commerce using a combination of technology-based solutions using a multilayered approach that includes establishing a system to enable Certified Screening Facilities (CCSFs) to physically screen cargo using approved screening methods and technologies. Since the combination of process with information and technology-based solution entails screening of air cargo to be done well in advance of its being actually loaded into the aircraft in the CCSF, the supply chain integrity depends upon reliable and performance based cargo seals including Tamper Evident Tape. Currently, there is no industry standard that details the performance requirements of tamper evident tape that would help secure cargo. This paper focuses on the TET analyzer software that provides a method to determine the effectiveness of tamper evident adhesive tapes used to secure boxes, pallets and other types of cargo. The key application of the TET analyzer is to ensure integrity of the supply chain by verifying the checked baggage/cargo unit is not tampered with

II. BACKGROUND

The National Strategy for Global Supply Chain Security Strategy, released in 2012, called for developing technologies that have the potential to improve security and integrity of cargo. The TET analyzer uses a method to compare the effectiveness of a security alert image formed by breaking the adhesion of tamper evident tapes. Certain kinds of security tapes provide evidence that the cargo has been tampered with by leaving behind adhesive or other residue such as in the form of words VOID, OPENED, etc. Numerous such tapes are available to the public but there exist no standard method to compare the effectiveness of the tape-to-substrate adhesive transfer between different products. The analyzer provides a visual analysis approach that provides an independent evaluation of a given tape’s performance. Although several standards and devices exist that provide a way to measure adhesion, the resulting values have no obvious relationship to the extent of residue transferred to the substrate, which is the key feature of the tamper evident tapes. Existing standards and devices that measure adhesion rely on technical assessments of physical force such as force of resistance; the analyzer uses a novel approach in visually evaluating the amount of pigment transferred.
III. LABORATORY EVALUATION OF TAMPER EVIDENT TAPES

DHS/TSL conducted extensive market surveys of all TET manufacturers and existing specifications and standards that these TET vendors complied with. Most of the tape manufacturers conformed to some of the requirements of the specifications of TET industry association, the Pressure Sensitive Tape Council (PSTC) and testing standards for American Society for Testing and Materials (ASTM). Comprehensive evaluation of the majority of TET domestic vendors was conducted that entailed collection of TET samples, data gathering and information exchange meetings with TET manufacturers and vendors, laboratory testing and analysis of results. All of these efforts were accomplished at the DHS Transportation Security Laboratory, and special accredited private testing laboratories with capabilities to conduct performance tests as specified.

IV. DEVELOPMENT OF STANDARDS

A straw man draft standard for TET was developed after comprehensive review of TET test results by TET working group comprising of various internal (DHS) and external stakeholders such as independent testing laboratories. The draft standard was translated to a performance specification suited to TSA technical and regulatory requirements. The TET standard defined several general requirements, principal among these were: tape roll size, product manufacturer ID, and single size adhesive; physical requirements such as width( 2-3 inch), length (55-60 yard, color (red), pressure sensitive adhesive, bonding duration (3 minutes), temperature (40-95 °F) and polyester or polyethylene backing. Additional parameters included: a silicon release coat, adherence restrictions for wet or contaminated surfaces; Security requirements included parameters such as a tamper evident pattern - VOID, OPENED or equivalent, leaving 50% of ink as residue on the surface, alpha numeric and serial numbering. Testing requirements were also called out, such as an adhesion test (ASTM D3330), a tensile strength test (ASTM D3759), and an elongation test ((ASTM D3759).

V. DEVELOPMENT OF SPECIFICATIONS

The TET standards document was translated to performance specifications with the intent to be used for qualification testing by third party Independent Testing Labs for qualifying TET products used by the regulated air cargo industry. The performance specifications were derived from the earlier developed standards and tested tapes data. The performance specifications have translated the requirements of the standards into both critical performance parameters (Musts) and desired features (Wants). For example, TET products were classified depending upon the substrates they would be applied to such as corrugated cardboards, polyethylene panels or packaging tape.

VI METHODOLOGY FOR ANALYZING TAMPER EVIDENT TAPE RESIDUE

The methodology called “METHOD” involves an algorithm to visually measure
the amount of pigment or residue transferred by the tamper evident tape to the substrate (such as cargo box, pallet wrapping, or other container) once the tape has been removed. The METHOD involves establishing a defined test area on a substrate material on which residual image has been formed by pulling of tape, and then dividing the area into a predefined number of units. The number of units in which a residual amount of pigment, color, or other residue has been left behind is the counted and compared to the number of units with tape residual left by another type of tape. The percentage of units with color, pigment or residual is the criterion for evaluating the relative effectiveness of the tamper evident tapes and may be related to a specified performance standard set by DHS/TSA as regulator.

VII. DESCRIPTION OF THE INVENTION

The METHOD can be carried out in the following manner. A transparent grid is obtained or computer software that can count pixels may be used. A predetermined length of tamper evident tape is applied to a substrate for example, a cardboard shipping box). The grid is overlaid on the tape and the number of grid units occupied by the tape is counted. This is the value Tape Unit Count. Next, the same length of another piece of tape is applied to the substrate. The tape is then removed by pulling, as illustrated in Figure 2. Units with color, pigment, or any other visible tape residue are counted. This value is the Substrate Unit Count. The METHOD works by dividing the Substrate Unit/ Pixel Count by the Tape Unit to derive the Total Unit Count. The Total Unit Count yields the percentage of color, pigment or residue transferred by the tamper evident tape. The METHOD can also use as a control for an ideal deposition of residue: for example, the center panel in Figure 1. When a control is used, the total amount of residue is the ideal deposition is the Tape Unit Count.

VII. FIELD OF INVENTION

OBJECTIVE AND USES

The METHOD is meant to be used to compare the effectiveness of a security alert image formed by breaking the adhesion of tamper evident tapes used primarily to secure boxes, pallets and other types of shipping containers. METHOD provides a visual analysis approach that provides an independent evaluation of a given tape’s performance. This evidence allows security inspector, cargo processing staff and/or receivers to quickly understand that the package has been tampered with and arrange for additional screening or other mitigation activities. Due to the high volume of cargo items processed each day, tamper evident tapes provide relatively inexpensive means to secure cargo, and several products are available. This METHOD allows any tamper evident tape manufacturer to demonstrate the effectiveness of their product relative to any regulatory requirements, industry recommendations or procurement requirements. The METHOD fills a need for an objective measure of effectiveness of the pigment in tamper evident tapes. 9. TET ANALYZER USER GUIDANCE

The TET Analyzer User Guidance Manual has been developed as a tool to determine the compliance with DHS
developed recommended practice for tamper evident tape applications for securing air cargo units. Such as boxes, pallets or trays. The TET application runs on a Windows, Linux or Apple PC Workstation, Laptop or Tablet Computer connected to a scanning device such as a camera or flatbed scanner. It employs a Graphical User Interface (GUI) to enable the operator to analyze a scanned image of a TET adhesive pattern transferred to a substrate to determine the percentage of visible tape adhesively transferred to a substrate. The TET Analyzer manual provides guidance to TET software installation, analyzer operation covering sample preparation, program start-up covering program settings, tape parameters, transfer analysis sequence and printing of a report.

X. U.S PATENT SUMMARY AND APPLICATION

The TET Analyzer Software has been issued a U.S. Patent No. 9,305,246. Entitled “Method for Analyzing Tamper Evident Tape Residue”. This patent issued on April 5, 2016 describes a method and software for measuring the effectiveness of tamper evident tape by optically analyzing the residual pattern left by the tape after it has been pulled off a substrate. The software has application for cargo and luggage screening and security alerting devices and allows for greater analysis and performance test standards for tamper-evident tapes and the residual material they leave behind. The METHOD is meant to be used to compare the effectiveness of security alert image formed when breaking the adhesion of tamper evident tapes used to secure cargo against the placement of a threat object, such as an improvised explosive device, in boxes, pallets and other shipping containers.

XI. CONCLUSION

Currently DHS/TSA has no plans to qualify TET products due to potential cost and regulatory impact to the air cargo industry. TET will be used to ensure supply chain integrity and economy, by reducing the need to rescreen, and its associated costs for the regulated air cargo industry. Also, TSA can streamline its inspection procedures by using TET analyzer software to verify whether the cargo unit (box, pallet or container) has been tampered with. TET application has the potential to significantly enhance supply chain integrity by its capability to verify any tampering secured by tamper evident tape.

Note: The views and conclusions contained herein are the authors’ alone, and do not reflect the official views or policies of the United States Government, nor the Department of Homeland Security, and its component agencies, the Transportation Security Administration, and the Science and Technology Directorate.
Figure 1. Illustration of tamper evident tape performance variation.

Original tape on substrate
Ideal residue (control) left by tape after tampering
Less than ideal residue left by tape after tampering

Figure 2. Illustration of tamper evident tape pull adhesion testing