The Expected Lifetime for Printed Security Cards

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Abstract

Printed security cards [1] are among the most abused of all photographic prints. These cards are used as identification, shown to various officials, passed through multiple readers, and stored in a wallet without protection. Security cards are exposed either accidentally or intentionally to various chemicals. They are handled in cold climates and left in a hot car exposed to sunlight. Security cards must resist alterations, yet must remain readable throughout their expected lifetime. To meet these needs, the security industry has operated at the forefront of technology, adapting conventional and digital imaging technologies to specific industry requirements.

Introduction

Durability includes multiple requirements, with cards needing to resist alteration and to hold-up under relatively heavy usage. Expected lifetime ranges from gift cards at one year to credit cards at three to four years to IDs and driver's licenses which may be expected to last up to ten years. Materials for these applications range from PVC to polycarbonate and teslin multilayer constructions, with composite cards having the highest durability. [2]

The image used for ID cards typically contains a photo, text, and bar code. Each portion of the image must remain readable for the card to serve its intended purpose, leading to some very specific requirements. For example, bar codes are validated with an infrared reader since these devices are frequently used to read linear and 2-D bar codes. Specific applications may also require the presence of security features, such as UV fluorescent ink [3].

Laminates enhance card durability and prevent alteration. In general, laminates are permanently adhere to a card surface and are destroyed if they are removed.

ID cards may include embedded contact and contactless RFID chips and antenna adding an additional layer of complexity. These smart card components increase the chance of failure since they are vulnerable to physical damage and because the manufacturing process for smart cards requires laminating multiple layers, increasing the possibility of delamination. Finally, smart cards may not be perfectly flat, making them more vulnerable to abrasion and physical damage. To compound the problem, the higher cost of smart cards leads to a desire for longer card expiration times which further increases the requirements for card durability [4]. Potential mechanical abuse of the RFID system includes all possible bending and twisting motions, as well as the damage that can result from delamination and intentional alterations [5]. Tests are available to simulate the damage that may result from carrying an ID card in a back pocket, as well as for spherical bending, two-sided bending, one-sided bending, and delamination. In one study of card longevity at Xavier University, the primary failure modes were card cracking and delamination [4].

Test Methods for Plastic Cards

Test methods are available for most factors that may adversely affect plastic cards. These methods are standardized in various international and national standards. Requirements for durability are far more severe than typical photographic requirements.

ISO 10373-1:2006 Test Methods [6]

5.1 Card warpage
5.2 Dimensions of cards
5.3 Peel strength
5.4 Resistance to chemicals
5.5 Card dimensional stability and warpage with temperature and humidity
5.6 Adhesion or blocking
5.7 Bending stiffness
5.8 Dynamic bending stress
5.9 Dynamic torsional stress
5.10 Opacity
5.11 Ultraviolet light
5.12 X-rays
5.13 Static magnetic fields
5.14 Embossing relief height of characters
5.15 Resistance to heat
5.16 Surface distortions and raised areas

ISO 24789-2 Method of evaluation of card service life [7]

5.1 Xenon arc light exposure
5.2 Surface abrasion
5.3 Magnetic stripe abrasion
5.4 Integrated circuit module (ICM) adhesion
5.5 Plasticised vinyl storage
5.6 Wear and soil test
5.7 Temperature and humidity aging
5.8 Temperature shock
5.9 Temperature and humidity cycling
5.10 ID-1 card flexure
5.11 Temperature and humidity aging followed by peel strength testing
5.12 Cross-cut test

Test sequences, such as temperature and humidity aging followed by peel strength testing are particularly important as they establish card performance after a specific sequence of aging or durability tests.

ISO test methods do not cover all possible tests. Consequently, national organizations, such as ANSI [8], and trade associations, such as the American Association of Motor Vehicle Administrators [3], have developed specific tests to supplement ISO procedures.

Standardized test methods and the ability to predict whether plastic cards are suitable for a give application is critical to the security card industry. These predictions ensure that security cards meet specific requirements and will not fail over time.

Test methods are used in combination with ISO 24789-1 [9] to predict whether a particular card is suitable for its intended application [10,11]. ISO 24789-1 takes into account how a card will be used in determining its suitability for a specific application. It uses a probabilistic approach to determine the appropriate test conditions given the expected usage. Tests are also combined to identify any possible interactions between the factors.

Determining whether a particular card design will meet specific application requirements involves initially calculating an aging and usage class. The aging and usage classes are based on expected temperature, relative humidity, exposure to light, exposure to chemical and particulates, and physical stresses, along with expected lifetime and usage.

The aging and usage class determine test conditions. Age is used to represent time dependent factors while use represents physical stress.

Factors that determine the aging and usage class include:

- Temperature
- Temperature changes
- Relative humidity
- Daylight
- Chemicals and particulate exposure (e.g. sand and dust, oils and fats, corrosive gases, salt)
- Physical stress (bending, e.g. pressure by roller)
- Physical stress (friction)
- Physical stress (impact, e.g. pressing the card against a contactless reader
- Reader contamination (resulting in deposits inside the reader causing abrasion)

For each factor, age and usage points are determined by multiplying the probability that a specific condition occurs times the severity of the condition.

The aging factor is corrected by multiplying the sum of the aging factors by the expected lifetime (card service life) and the usage factor is corrected by multiplying the sum of the usage factors by the number of uses per day plus one.

The total of all age and usage points determines the aging (0-3) and usage class (A-D). These classes then determine the severity of the test and the number of repetitions, with the specific tests that are carried out depend on the card and its characteristics, since cards do not typically include all possible technologies. For example, access cards that are designed for contactless entry may not include a magnetic stripe. Characteristics of the card include personalization, embossing, magnetic stripe, IC with contacts, contactless IC, dual interface, and optical memory.

Predetermined application profiles are included in ISO24789-1 for health care, national ID, transportation, access, magnetic stripe based campus card, driving license and financial cards. The practice of using predetermined application profiles is discouraged as it may not reflect actual conditions [10]; however it does simplify the process for validating card lifetime.

Applicable tests and test conditions are based on the aging and usage class. For example, the number of bending cycle repetitions, abrasion cycles, depends on aging class. Tests include stand-alone methods and evaluation sequences. Available test methods are categorized into aging usage, and conformity tests:

- Aging simulation methods (8 tests)
- Usage simulation methods (5 tests)
- Tests for conformity (24 tests)

The required tests are used to assess card performance. These tests attempt to balance the various factors that influence card lifetime. They tests are predictive, and like any predictive tests, may not include all factors that affect card performance. The required tests do, however, include most major factors that affect card performance, and if the card passes it is likely to be suitable for the intended application.

Access Card

Access cards are plastic cards that contain embedded electronics for building and computer access. Retransfer printers [12], such as the HID Global HDP5000, HDP5600, or HDP8500, are frequently used to personalize these cards, since they may not be perfectly flat. Access cards have an expected lifetime of 5-10 years.

Access cards may be exposed to a variety of temperatures and are typically worn indoors (p=0.8) or outdoors (p=0.2). They may be exposed to low level of chemical in an office environment (p=0.4), medium level in a factory (p=0.5) or high levels of chemicals in a car repair or heavy factory environment (p=0.1). Access cards are subjected to a medium level of physical stress through bending, friction, and compression and a relatively low level of stress from the reader. Lifetime is 10 years and the cards are used 10 times per day. These factors combine to 6.6 age points and 4.86 usage points, with a corrected aging coefficient of 66 and a usage coefficient of 53.46. The corrected application profile is written as 3D.

The evaluation requires visual assessment as well as ensuring that the machine readable functions of the card are preserved. Accelerated aging prior to testing requires 3 cycles of 48 h at 50 ± 3°C and 93 ± 5% RH, each followed by 1800 bending cycles.

Testing for conformance includes visual assessment, and verification of machine readable functions, along with surface abrasion, adhesion (cross-cut test), light stability, and chemical resistance, with the exact tests dependent on specific customer requirements.

Alternative Approaches

ANSI INCITS 440-2015 [13] provides an alternative approach to determining test conditions for card durability and service life. This standard considers five factors when determining required test conditions:

- Redundancy
- Replacement
- Usage per Year
- Expected Card Life
- Allowable Annual Post-Issuance Functional Failures

These factors are then combined to produce a durability category ranging from D1 (not durable) to D10 (very durable). Each durability category corresponds to a set of test requirements.

Test requirements for these factors address the card body, laminate adhesion, image stability, and machine readable features:

- Card Flex
- Stress & Plasticizer Exposure
- Dimensional Change at Elevated Temperature
- Light Stability (Indoor and Outdoor Xenon Arc)
- 90° Peel
- Cross-hatch
- Surface Abrasion
- Bar Code Abrasion
- IC Card with Contacts Micromodule Adhesion

For the access card example given above, the card would receive 30.3 Usage Points, 10.0 Redundancy Points, 2.5

Replacement Points, 32.1 Expected Life Points, and 6.1 Allowable Annual Post-Issuance Functional Failure Points for a total of 81.0 points, placing the card in Category D9.

Tests and the durability requirement to ensure that the access card meets user requirements are based on this category. Performance requirements include 76,100 flexes for Card Flex A, 38,000 flexes for Card Flex B, 72 h plasticizer exposure, 1% maximum linear dimension change at elevated temperature, maximum xenon arc ΔE of 10.0 (indoor) and 7.5 (outdoor), 0.4 N/mm laminate strength, cross-hatch tape rating of 5, surface abrasion resistance of 2,500 Tabers.

As with the ISO 20489, these tests do not cover all possible failure modes. Instead, they provide general guidance indicating that a card is suitable for a specific application.

Potential Application of Card Service Life Approach to Photographic Prints

For applications outside the scope of ID cards and identity documents the methods that have been developed within the security industry provide a specific example of how to combine complex factors into an overall assessment as to whether a product will meet customer requirements. The resulting assessment does not guarantee a specific lifetime. Instead it provides general guidance as to whether or not a product is likely to meet customer expectations for a specific use case. It provides for more information than failing to determine life expectancy because the system is "too complex" or because "too many factors are involved." In addition, the probabilistic approach eliminates the need to define a single test condition that accurately reflects a specific use case.

For photographic prints, this approach would need to account for the four environmental factors that affect aging (temperature, humidity, ozone, and light), along with any usage factors. These factors would then be combined to calculate the aging and usage class for applications, such as print on display, print in shoe box, print in album, print in window, and photo book.

The aging and usage class would then determine the relevant aging test conditions, with the specific material determining evaluation criteria. If the photographic print passes the evaluation criteria it would then be likely to meet customer requirements for a given application.

Conclusion

The general approach that is taken to evaluating the performance of plastic cards within the security printing industry allows customers to assess whether a specific product is likely to meet usage requirements for a given application. For application such as access cards, the test methods account for usage along with the expected lifetime.

For applications outside of security printing, a similar approach is also possible. This approach would allow the photographic industry and their customers to determine the suitability of specific products for different applications with different requirements.

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