Durability of Smart Cards for Government eID

Part of a Series of Datacard Group White Papers for the Secure Document Issuer

DURABILITY OF SMART CARDS FOR GOVERNMENT EID

Overview

To be successful, a Government eID smart card program faces many trade-offs. The right combination of components for the complete use chain must be carefully selected and qualified to help ensure that the card will meet the extended life requirements of Government eID cards and does not have to be reissued before its expected life time.

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SECURE ID AND CARD PERSONALIZATION SOLUTIONS

DURABILITY OF SMART CARDS FOR GOVERNMENT EID

Contents:

1. Smart card types - comparative overview

- Contact
- Contactless
- Dual interface
- Hybrid

CONTACT

Contact smart cards have a metallic chip contact pad embedded on the surface of the card and must be inserted into a smart card reader to make a direct connection for the transfer of data. It is the wear and tear on the contact pad and card surface caused by insertion into readers which has the greatest affect on the life expectancy of contact cards. Another significant factor is the possible separation of the contact pad from the card body, which can be a result of persistent bending or flexing of the card. Five year life has been widely achieved for contact cards in the financial card market for many years. However, recent advances in card body materials and mechanical chip embedding technologies have now made a 10 year lifetime for contact cards realistic.

CONTACTLESS

Contactless smart cards have no contact pad and instead use radio waves to communicate with card readers. The connection is achieved through electromagnetic induction between an antenna in the reader and an antenna embedded between layers of the smart card body. Contactless smart card durability is greatly assisted by not requiring physical contact with readers. Another significant influence on contactless durability is the quality of the bond between the embedded antenna and chip. This connection can break if the bond is weak and the card is subjected to excessive bending and flexing. The quality of the bond between the card layers containing the chip and antenna is also important in preventing separation of

these layers. The level of industry experience of a life-span of 10 years or more with contactless cards is limited, since the technologies involved have been developed more

recently. However, contactless cards are currently ranked as the most durable of the various card types by a majority of the smart card industry, with a 10-year life considered feasible.

DUAL INTERFACE

Dual interface smart cards have both contact and contactless connections to a single chip in the same card. For this reason, dual interface smart cards exhibit the benefits and weaknesses of both technologies. Dual interface smart cards are a more recent development with few large-scale field studies available. A majority of smart card industry organizations believe that a 5-year life is certainly feasible; however, it may be too early to guarantee a 10 year life at present. These views are largely based on internal test results and knowledge of the manufacturing processes. One advantage is that dual interface cards may retain (limited) functionality even when one of the interfaces fails.

HYBRID

Hybrid smart cards have two chips, with one connected via a contact interface and another connected via a contactless interface. They are essentially two smart cards in a single card body, with no communication between the two chips. They are widely considered to be the least durable of the main card types, with suggestions that dual interface cards are the better option. A majority of the smart card industry supports the view that 5-year durability for hybrid cards may be feasible but that a 10-year life is unlikely.

2. Main drivers influencing smart card type selection

- Card durability
- Cost and availability of reader infrastructure
- Ease and speed of use
- Security (anti sniffing / PIN entry / high or low value)
- Transition from contact to contactless (dual interface)

CARD DURABILITY

Card replacement costs at population scale can represent one of the largest cost elements of a National ID project. Especially if renewal and re-issuance involves face-to-face interviews and data cross-referencing. To re-issue 50 million eID cards every 5 or 7 years, can be vastly more expensive than a 10-year renewal cycle. So careful evaluation of smart card durability factors to help ensure a minimum guaranteed card life can have significant financial benefits.

COST AND AVAILABILITY OF READER INFRASTRUCTURE

It is generally accepted that contact readers cost less than contactless readers. It is also often the case that a new project could make use of a previously installed reader infrastructure, which currently tends to be contact based because contactless is a more recent technology.

A good example of this might be the inclusion of a contact interface for a national eID project, which could make use of the existing installed base of EMV® contact readers (in

banks, shops and supermarkets) for ID verification using chip and PIN. In contrast the maintenance and service costs tends to be higher for contact readers than for contactless, because contactless readers have no moving parts.

EASE AND SPEED OF USE

Ease or speed of use of the smart card may prove to be the most significant factor influencing smart card type choice. If the card is intended to be used at a work-desk or counter, then speed of use is not as relevant and a contact smart card may be the best solution. However, if the card is to be used for transportation or access control, where speed of flow through a check-point is more important, then a contactless smart card would be the better choice.

SECURITY

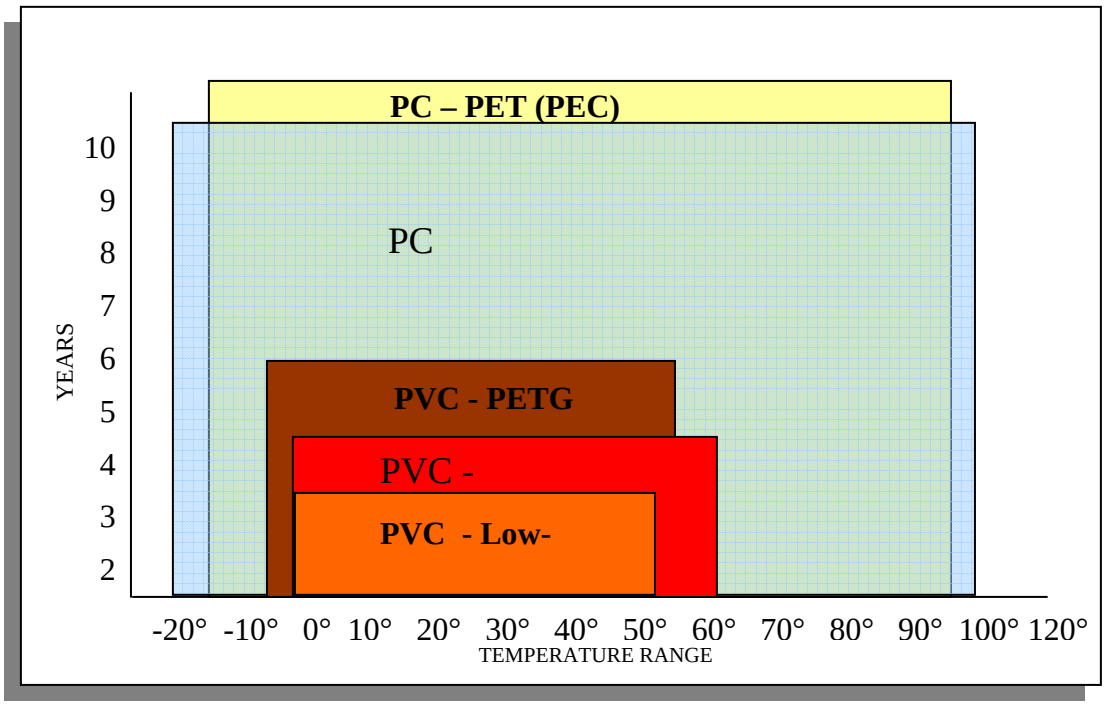
While it used to be true that a contact interface was generally accepted to be more secure than a contactless interface, recent cryptographic communications developments have gone a long way to establish new security standards for contactless smart cards. In order to counter concerns that information could be covertly read or "sniffed" from a contactless smart card without the owner's knowledge or consent, many contactless smart card solutions employ a secondary authentication to enable chip access (e.g. MRZ read for ICAO). Often it is the value of transactions or cost to the individual of a compromised card that will determine the choice of smart card type. For example, with transport cards the benefits of speed and ease-of-use outweighs the financial risk represented by the small transaction values involved.

TRANSITION FROM CONTACT TO CONTACTLESS

One of the primary drivers for using dual interface smart cards is to support the migration from a legacy contact smart card infrastructure to an updated contactless solution. Dual interface smart cards will allow a gradual transition from contact to contactless over a number of years.

3. Comparisons of main card body materials

- PVC
- PC (polycarbonate)
- PET
- Special Composites



PVC

PVC is the least expensive of the main card body materials. It is used for both contact and contactless cards, but generally has a shorter life expectancy than other card body materials, due to a lower resistance to heat, UV and bending stress, which can cause premature de-lamination and module separation. PVC is generally used for financial cards with a life expectancy of 3-5 years. The main durability issues of PVC include: surface wear (scratching and print erosion), de-lamination where finishing layers begin to separate, effects of physical stress (flexing and twisting) on the card body, chemical damage (from petrol, nail varnish, cooking oil, etc.), UV light causing print finish deterioration, and weaknesses caused by certain personalization features (embossing, laser engraving).

PC

PC (polycarbonate) is a more rigid card body material which has a much higher resistance to damage from heat, flexing and UV. However, PC can have a tendency of brittleness which can be adversely affected by frequent automated handling, causing shatter cracks and is less resistant to caustic solutions and certain solvents.

PET

PET (polyester), PETF and PETG are special materials that have been developed to enhance specific strengths or reduce certain weaknesses. These derivative materials are often combined with specialty card body substrates to significantly enhance the physical durability of cards for specific applications. In particular to reduce the incidence of antenna connection breaks and contact plate separation caused by flexing and bending of the card body. For example, PETF (polyester film) is a PET derivative that has very high thermal stability,

mechanical strength and chemical inertness. In fact, PETF has one-third the tensile strength of steel and can withstand temperatures of up to 200° C and has high resistance to solvent.

Other strong combinations include PET/PETG and PEC as well as combinations of hard materials (like PET and PC) with soft materials like TPE/TPU.

The choice of card body material can influence the available options for printing and finishing, which can affect the eventual durability of the finished cards.

Comparisons of card body materials

	PVC	PC	PET	Teslin®	Composite	ABS
Heat Stability (warpage)	3	1	1	2	2	3
Flex Resistance	3	1	1	1	1	3
UV Resistance	3	2	1	2	1	3
Cost	1	3	2	2	2	1
Compatible with Contact Chip	1	1	1	2	1	1
Compatible with Contactless Chip	1	2	2	3	1	3
Delamination	2	1	1	1	1	2
Laser Engravability	3	1	2	3	1	3

1	= BEST
2	= BETTER
3	= GOOD

4. Physical and mechanical factors affecting card durability

- Manufacturing processes – chip insertion and antenna connection
- Chemical Attack
- Heat (warping)
- Abrasions
- Moisture
- Ultraviolet Light
- De-lamination
- Customer usage patterns

Most smart card solutions feature personalization printing such as photos, text, logos, bar codes and other graphic elements. These personalized plastic cards are regularly exposed to a variety of potentially destructive elements that can degrade printed images. The smart card industry offers a full range of card protection alternatives that can provide effective protection against these threats.

MANUFACTURING PROCESS

Smart card durability can be strongly influenced by the smart card manufacturing process. In particular, the method used to bond contact chips into the card body recess and how the

contact plate is attached to the chip module is important. Poor quality of manufacture can cause these components to separate from the card body if the card is subjected to flexing by

the user or in mechanical reading equipment. In contactless cards, durability can be influenced by how the antenna is bonded into the card, the strength of the connection to the chip and the rigidity of the card body material where flexing can cause the chip/antenna connections to break.

CHEMICAL ATTACK

The plasticizers used to construct vinyl pouches found in most people's wallets can penetrate a smart card surface and extract the dyes used to print photos and other images. The same holds true for skin oils, certain cosmetics, petrol, and leather treatment chemicals. The application of a high quality durable laminate can provide strong protection against most forms of chemical damage.

HEAT

Heat (for example from sunlight when leaving a card in the window of a car) can cause significant damage by warping and distortion to most smart card body materials. PVC in particular can suffer heat damage at temperatures of around 60° C while Polycarbonate and PET can withstand temperatures over 120° C.

ABRASIONS

Repeated swipes through a card reader can remove features from a plastic card, especially if the card has no topcoat or overlay protecting the printed image. Smart cards with applied relief features like embossing, indenting and tactile printing are also more sensitive to abrasion and wear.

MOISTURE

Humidity, perspiration, and other moisture can attack or weaken adhesion of poor quality topcoats and laminates and cause premature failures. The use of high durability laminates matched to the card body properties will help protect a card against moisture damage.

ULTRAVIOLET LIGHT

Prolonged exposure to sunlight and other UV sources can fade printed images on plastic cards, causing color washout, pixelated images and partial characters. UV exposure can also degrade some protective layers and laminates more than others. Careful selection of printing and finishing technologies can reduce the effects of UV exposure.

DE-LAMINATION

The different card body materials have better adhesion qualities with certain laminates and topcoats than others. The selection of the most suited laminate for the card body material being used is crucial in avoiding premature separation of laminates from the card body.

USAGE PATTERNS

Recent surveys indicate that customer usage patterns can have a significant impact on card life. The majority of banking cards currently use a contact interface, are made from PVC,

are normally held in a protective wallet or purse and are typically used an average of 2-3 times per week. These cards tend to have a life expectancy of 3-5 years.

By comparison; transport cards tend to use a contactless interface, are often kept with other items in a pocket or handbag and are typically used an average of 10-12 times per week. Although these cards are generally used far more frequently, they tend to have a greater life expectancy of 5-7 years due mainly to the absence of reader contact.

Identity cards tend to be used far less frequently than either banking or transport cards and are generally better protected by the user. Such cards have been widely predicted to deliver life expectancy in excess of 10 years, if they are made using high quality card body materials, durable printing processes and protective coatings.

5. Applied personalization and finishing issues affecting card durability

- Card printing technologies - *dye-sublimation, resin, inkjet, laser*
- Card finishes - *top-coats, varnish and polyester*
- Added security - *embossing, laser etching, micoprinting, etc.*
- Chip limitations - *read/write cycle limits, durability of electronic certificates*

Card durability can be heavily impacted by what is added to the card body. For instance, a blank card body could have flex life from 10,000 to 100,000 flexes depending on materials used. When printing is added, the flex life may decrease. The flex life may be further reduced with the addition of embossing, magnetic stripe, embedded IC module and laminated IC/Antenna modules. Therefore, the effects of personalisation, printing and finishing on the durability of the finished card needs to be carefully considered. Wise selection of printing, personalisation and finishing technologies, properly matched to the choice of card body materials, chip insertion and connection methods can extend card life significantly.

Comparison of Card Printing

	Dye Direct	Dye Re-transfer	Resin Direct	Resin Re-transfer	Inkjet	Laser Engraving	Electrophotography
Print resolution	3	3	2	1	3	1	2
Comatible with Pre-printing	1	1	1	1	3	1	3
Consumables cost	2	3	1	3	1	1	2
Laminate adhesion	1	1	1	1	3	1	1
Printing speed	2	2	2	2	1	3	1
Complexity of technology	1	1	1	1	3	3	3
Security	2	3	2	3	3	1	2

1	= BEST
2	= BETTER
3	= GOOD

The smart card industry offers a broad range of card protection alternatives, including topcoats, clear laminates and secure polyester laminates which can include high resolution

(or holographic) security images and advanced security optical devices. These offer unique levels of protection that can be used individually or in combination to preserve printed images and extend the life of personalized cards from the destructive elements they are exposed to daily.

Polyester laminates were developed specifically for national ID and driver's license programs requiring extended card life. They provide the best chemical and abrasion protection offered and when applied to composite cards, meet or exceed most specifications for abrasion and chemical durability. The most durable laminate is a thick polyester laminate that incorporates a heat-activated bonding layer and is designed to be applied with uniform heat and pressure to force a strong bond. These laminates can be applied over cards that have been personalized with graphics, dye diffusion and thermal transfer imaged photos and pictures.

Typical Applications: Government ID, Driver's License, Healthcare, Corporate ID, Student ID

A clear topcoat is a 3 – 4 microns thick protective layer applied over the face of the card. The topcoat resin bonds to the surface of the card and protects bar codes, signatures, variable text, logos, and images from abrasions and chemical attack.

Typical Applications: Voter ID, Loyalty Cards, Transport Cards

Comparison of Card Coverings

	Top-coat edge-to-edge	Roll-on Varnish	Polyester Patch
Abrasion Resistance	3	2	1
Chemical Resistance	3	2	1
Ease of Delamination	1	1	3
Permeability (resistance to cracking)	3	2	1
Appearance	2	2	3
Complexity of technology	2	3	1
Ability to incorporate security features	2	1	3

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ADDED SECURITY, PERSONALIZATION FEATURES

It is important to keep intended usage considerations in mind when making decisions about added security and personalisation features of card design. For example, the smart card industry recommends applying a protective coating or laminates to virtually every smart card containing color photos and also suggests that all forms of personalisation should be kept away from card edges and other wear-prone areas. Other personalization and security

processes can influence card durability. In particular those processes which physically alter the card body, including embossing and laser engraving, which may cause stress weakness points. The application of high quality protective topcoats and laminates can go a long way to mitigating these effects.

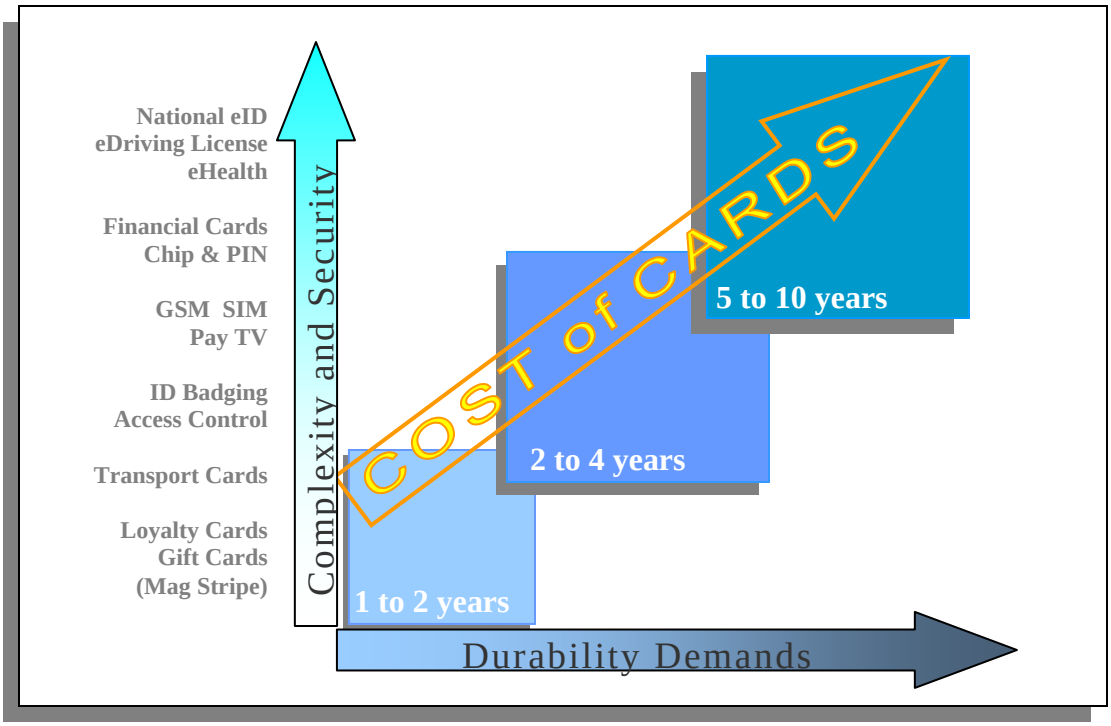
CHIP LIMITATIONS

In the past, the number of times that data could be written to a smart card chip was a limiting factor. New technology developments have now extended the read/write cycle limits to over 500,000 cycles. Similarly, the length of time that data could be securely stored in the chip memory has been extended by advances in technology; to where these limits are now well beyond the 10 year life expectancy of national ID cards. The only significant limitation now comes from the logical data stored in the chip. In particular digital signatures and certificates can have a limited validity. Changing the PKI certificate may require a re-issue of the card.

6. Comparative cost of main smart card types

Given the use of similar chip and card body materials, the following is an approximate guide to the relative cost of the different smart card types:

Contact	= N
Contactless	= N + 15-30%
Dual	= N + 50–100%
Hybrid	= N + 80–120%



7. Durability testing standards

Card durability is becoming a significant consideration as government ID applications for smart cards begin to expand and as such cards are being carried long-term in wallets, pockets and purses. The card industry has a plethora of materials and processes available to meet nearly any card requirement. The selection of materials and processes will usually involve trade-offs. It is important that users have the necessary tools to evaluate the trade-offs in a

consistent manner, in order to make an informed choice of materials and processes. This calls for a reliable and comprehensive set of criteria and test methods.

ANSI (American National Standards Institute) has been working on card durability for 12 years and has developed and published the ANSI NCITS 322-2002 - Card Durability Test Methods.

At the international level, ISO/IEC JTC1 SC17 WG1 have been working on sequence testing and ISO/IEC JTC1 SC17 WG4 have developed additional test methods, to meet the extended life requirements of Government ID cards.

The following is a typical set of practical tests selected from existing international standards to provide an indication of the durability of the physical body of a card and the related components. The tests are designed to stress the components of a card, namely, antenna durability, antenna-chip connection durability, layer sturdiness and bonding, chip stability, temperature resistance, etc.

PEEL STRENGTH - Measure the peel strength between card layers.
Standards referenced:
ISO 7810 § 8.8 / ISO 10373-1 § 5.3 / ANSI NCITS 322-2002 (5.1) / ISO 10373-1 § 5.3.2
Performed at 90° F and 180° F (32.2° C and 82.2° C).
Any layer shall possess a minimum peel strength of 0.35 N/mm (2 lb/in). If the overlay tears during the test, this signifies that the bond is stronger than the overlay, which is automatically deemed acceptable.

RESISTANCE TO CHEMICALS - Verify card remains within the dimensions and warpage requirements after exposure to chemical contaminants.
Standards referenced:
ISO 7810 § 8.4 / ISO 10373-1 §§ 3.2, 5.4 / ISO 14443-4 § 5.2 / ISO 10373-1 § 5.4.1-2
The structural reliability shall remain in compliance for dimensions and warpage.

CARD DIMENSIONAL STABILITY AND WARPAGE WITH TEMPERATURE AND HUMIDITY - Verify card remains within the dimensions and warpage requirements after exposure to specified environmental temperature and humidity.
Standards referenced: ISO 7810 §§ 8.5 / ISO 10373-1 §§ 3.2, 5.5 / ISO 14443-4 § 5.2
Temperature ranges from –31° F to 122° F (± 37.4° F) or –35° C to +50° C (± 3° C)
Relative humidity ranging from 5% to 95% (± 5%)
Minimal exposure time: 1 hour
Rest time in default test environment: 24 hours

DYNAMIC BENDING STRESS - Verify card's structural stability and endurance to bending stress.
Standards referenced: ISO 7816-1, Annex A.1 / ISO 10373-1 §§ 3.2, 5.8 / ISO 14443-4 § 5.2
Bend card vertically and horizontally - Minimum of 1000 bending cycles.

DYNAMIC TORSIONAL STRESS - Verify card's structural stability and endurance to torsion stress.

Standards referenced: ISO 7816-1, Annex A.2 / ISO 10373-1 §§ 3.2, 5.9 / ISO 14443-4 § 5.2
Apply torsion at 0.5 Hz and 15° ± 1° Minimum of 1000 torsion cycles.

ULTRAVIOLET LIGHT - Verify card remains within conformity after exposure to ultraviolet light.
Standards referenced: ISO 7816-1 § 4.2.1 / ISO 10373-1 §§ 3.2, 5.12 / ISO 14443-4 § 5.2
Wavelength is 254 nm. Exposure time: 10 minutes to 30 minutes.

X-RAYS - Verify card remains within conformity after exposure to X-rays.
Standards referenced: ISO 7816-1 § 4.2.2 / ISO 10373-1 § 5.13 / ISO 14443-4 § 5.2
Expose both sides of card to X-rays.

3 WHEEL TEST - Verify card remains mechanically reliable after subjecting the card to the stresses applied by the three steel wheels test equipment.
Standards referenced: ISO 10373-3, A.1+2 / ISO 14443-4 § 5.2

Note: After performance of each of the previous tests, the card shall be testably functional (Defined in ISO 10373-1:1998(E) § 3.2) and the card is considered operationally functional (i.e., card shall return a compliant ATS) and all laminations should remain firmly bonded together.

Durability tests are generally performed by vendors at the prototype stage to ensure that the product being built will meet the expectations of the customer and, above all, will match the warranty provided to the customer. While durability testing of prototypes has some value, the most crucial stage in which to perform these tests is when actual production samples are available. This is important because the production samples are representative of what the end customer will receive. As part of an ongoing quality assurance program, many vendors will repeat durability testing at this stage and continuously take random samples from their production runs to ensure reliable and consistent products.

Application profile and Test sequences for a National ID card using the DIN/AFNOR cycles for use within WD 24789-1
DIN proposes to use the systematic approach developed for the European Citizen Card. This model was verified and compared to the ANSI approach (1N1373).

Test sequence:

A. PRECONDITIONING TO T = 73.4° F (23° C) AND RH = 50 % FOR 24 H

B. PRE-EXPOSURE TESTS (MINIMUM REQUIREMENTS):
Dynamic bending stress acc. to ISO/IEC 10373-1
Delamination acc. to ISO/IEC 10373-1

Adhesion of chip module acc. to ISO/IEC CD 24789-2
Functional tests (chip, MRZ, barcode)

C. DURABILITY CYCLES: (the number of cycles will depend on the AGE global rating value)

One durability cycle consists of:

a) Storage in acid solution acc. ISO/IEC 10373-1 for 24 h
b) Storage in alkaline solution acc. ISO/IEC 10373-1 for 24 h
c) Storage in Fuel B acc. ISO/IEC 10373-1 for 1 min
d) Softener storage acc. to ISO/IEC CD 24789-2
e) UV Light ageing acc. to ISO/IEC CD 24789-2
f) Thermal cycling acc. to ISO/IEC CD 24789-2
g) Wear and Soil Test acc. to ISO/IEC CD 24789-2
h) Dynamic bending stress acc. to ISO/IEC 10373-1

D. POST-EXPOSURE TESTS (MINIMUM REQUIREMENTS):

- Dynamic bending stress acc. to ISO/IEC 10373-1
- Depending on the evaluated durability class the following number of bending cycles has to be applied: A x 1000, B x 2000, C x 4000, D x 6000
- Delamination acc. to ISO/IEC 10373-1
- Adhesion of chip module acc. to ISO/IEC CD 24789-2
- Functional tests (chip, MRZ, barcode)

8. Summary and Recommendations

A. Select the card type (contact, contactless, dual, hybrid)
B. Select the most suitable card substrate
C. Add printing and security technologies that are compatible with the card substrate
D. Add protective laminates or finishes to prolong card life
E. Ensure that your finished smart card passes standard durability tests

A. SELECT THE CARD TYPE (CONTACT, CONTACTLESS, DUAL, HYBRID)

Evaluate the comparative drivers influencing card type selection including; legacy reader infrastructure, required ease of use, data security requirements, relative costs, preferred chip hardware and operating system, to determine the most suitable card type for the intended use.

B. SELECT THE MOST SUITABLE CARD SUBSTRATE

The choice of card body material has a very significant impact on the serviceable life of a smart card. PVC cards are generally accepted to be unsuitable for national ID projects and would not be recommended for any project with a card reissue cycle of more than 5 years. While Polycarbonate has a much higher resistance to damage from heat, flexing and UV and is therefore much better suited to such projects, it can have a tendency of brittleness. The ideal choice would be a composite card body constructed from bonded layers of different

materials. We would recommend that you discuss this with your smart card manufacturer to determine the most suitable card body construction for your application.

C. ADD PRINTING AND SECURITY TECHNOLOGIES THAT ARE COMPATIBLE WITH THE CARD SUBSTRATE

The choice of card body material can influence the available options for printing and finishing. For example, certain printing processes require that the inks or dyes used are absorbed by the card substrate. The absorption properties of different card substrate can make some print finishes unsuitable. The same holds true for security features, in particular those processes which physically alter the card body, including laser engraving, embossing, microprinting, optically variable devices and electro-photography, which may cause stress weakness points. The application of high quality protective topcoats and laminates can go a long way to mitigating these effects. The smart card industry recommends applying a protective coating or laminates to any smart card containing color photos and also suggests that all forms of personalisation should be kept away from card edges and other wear-prone areas. We would recommend that you discuss this with your smart card manufacturer to determine which personalisation and security features can be applied to your chosen card body material without adversely affecting the durability of the cards.

D. ADD PROTECTIVE LAMINATES OR FINISHES TO PROLONG CARD LIFE

The smart card industry offers a broad range of card finishing options which offer unique levels of protection, including topcoats, clear laminates and secure polyester laminates. Many laminates can be supplied with embedded customized high resolution UV or holographic security images and advanced security optical devices. These protective finishes can be used individually or in combination to preserve printed images and extend the life of personalized cards from the destructive elements they are exposed to daily. The most durable laminate is a thick polyester laminate that has been developed specifically for national ID and driver's license programs. We would recommend that you discuss available card laminates and finishes with your smart card manufacturer to determine which of these will give the maximum protection for the card body material, printing and security features you have chosen.

E. ENSURE THAT YOUR FINISHED SMART CARD PASSES STANDARD DURABILITY TESTS

Whilst durability testing during the prototype phase has some value, the most crucial stage in which to perform these tests is when actual production samples are available. This is important because the production samples are representative of what the end customer will receive. For large-scale high volume deployments, or projects where card issuing happens over a number of years, it is important to maintain an ongoing quality assurance program, by continuously testing random samples from production runs, to ensure that cards continue to meet established durability testing standards.

To be successful, a smart card program faces many trade-offs and the right components for the complete use chain must be carefully selected and qualified to ensure that the card meets the expected performance levels. We would recommend that you discuss all aspects of smart card design with your smart card manufacturer, as early in the project planning phase as possible, to ensure that it will meet the extended life requirements of government ID cards and does not have to be reissued before its expected life time.