CHAPTER III
EXPERIMENTAL

3.1 Card Material

All of smart cards (PC-STD, PVC, PETG, PC-Teslin and PC-DDI) were supported by Smartrac Technology LTD.

3.2 Equipments

3.2.1 Salt Spray Tester (model: ST-ISO-3)

The cards were tested with salt mist by salt spray tester. Cards were placed in the instrument according to ASTM B117. The concentration of NaCl was 50 g/l with pH of 6.5. Salt mist of 1.6 ml was sprayed on the area of 80 cm^2 per hour. Temperature of vessel at 35 °C and pressure of 100 kPa were controlled during the test.

3.2.2 QUV Weathering Tester (QUV / SE Accelerrated Weathering Tester)

The cards were placed in QUV chamber which was set the conditions as below

- Wavelength = 313 nm
- Irradiance = 0.68 W/m^2
- Time = 79.19 min/side of card
- Temperature = 35 °C

3.2.3 Dynamic Bending Tester (Ref. ISO/IEC 10373/6) (@Smartrac Technology)

- Set the machine and card to allow the bending along axis A

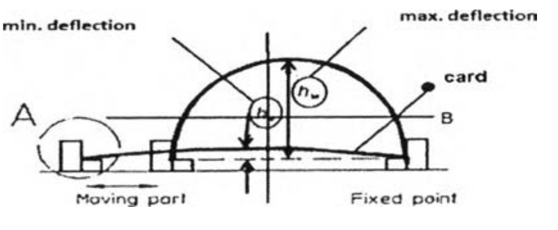

Figure 3.1 Card to allow the bending along the machine.

3.2.4 US Postal Tester

The cards were tested with mechanical stress by US postal tool in Figure 3.2

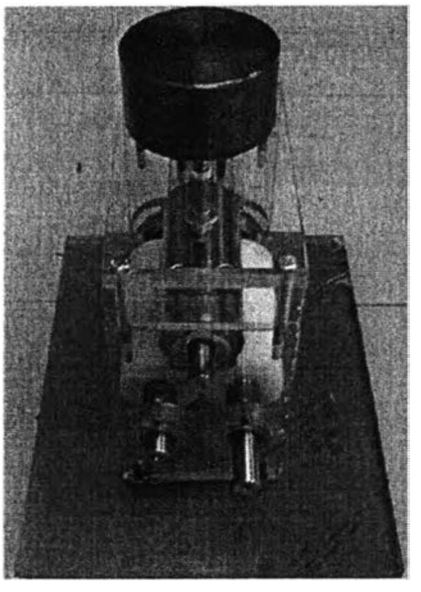

Figure 3.2 US postal tool.

3.2.5 Oven at 50±2°C

3.2.6 Freezer at -35±2°C

3.2.7 Climatic Chamber at 50±3°C, 93±3%RH

3.2.8 Contactless Reader for Functionality Testing (brand: Baltech, model: AG ANT1 reader)

The cards were tested for functionality before and after each test. The cards were placed on the reader and move up to the highest distance at which the reader can read the data. This height is the maximum distance for each card.

3.2.9 Differential Scanning Calorimeter (DSC)

The crystallization and melting behaviors (T_m, and T_c) of plastic cards were measured with Mettler DSC1. Nitrogen was consisting purged into the equipment, maintaining at 50ml/min, during the scan to prevent specimens from thermal degradation.

The thermal scans consisted of three steps. Firstly, the temperature of samples was heated from 25°C to 300°C at a rate of 10°C/min. This temperature was held for three minutes before being cooled to 25°C at 10°C/min. Then, the sample was subsequently heated at 10°C/min for corresponding the melting behavior investigations.

3.2.9 Thermogravimetric Analysis (TGA)

The samples were analyzed by TGA using a Perkin-Elmer Pyris Diamond TG/DTA instrument under N_2 flow of 200 ml/min. The heating process was conducted from 50-700 °C at a rate of 10°C/min.

3.2.10 Instron Universal Testing Machine

It is use to indicate how the material will react to force being applied in tension. The tensile test are used to determine the modulus of elasticity, elastic limit, elongation, proportional limit, tensile strength, yield point, yield strength and other tensile properties. The tensile test was performed using Instron/4206 Universal Testing Machine. The tensile specimens were prepared according to the ASTM D882 standard. The grips move a part at a constant speed of 50mm/min, then the tensile stress, modulus and strain were test at least five sample of each condition.

3.2.11 Scanning Electron Microscope (SEM)

The measurement was carried out at 2 kV with 100x. Before the measurement, the surfaces of the plastic card after finished cycles were coated by platinum.

3.2.12 Haze-Gloss Measurement

After finished each cycles, the samples were analyzed by gloss measurement at 60°.

3.2.13 Colorimetric Spectrophotometer

After finished each cycles, the samples were analyzed by colorimetric spectrophotometer. Color changes were calculated using the following formula;

$$\Delta E = [(L^*)^2 + (a^*)^2 + (b^*)^2]^{1/2} \qquad \textit{(equation 3.1)}$$

where L^* represents brightness, from 0 (black) to 100 (perfect white), a^* represents the red (positive value) or green chroma (negative value), while b^* represents yellow (positive value) and blue chroma (negative value).

3.3 Methodology

3.3.1 Identify the Environment, Storage, Reader Profile, and Frequency in which the Cards is Used Follow to ISO/IEC 24789-1

3.3.1.1 *Select the Possible Condition*

Select the possible environment, storage, reader profile and frequency with the lifetime 10 years in order to find the data of Usage (U), Age (A) and Coefficient (c) for 10 years testing.

3.3.1.1.1 *Determination Of Testing Procedure For Cards Service Lifetime*

3.3.1.1.1.1 *Service Life Description*

It is stated that 3 main parameters must be taken into account to define raw card mission profile.

- Environment
- Storage
- Reader Profile

Environment : The environment in which the card is used

Table 3.1 The environment conditions in which the card is used

ENVIRONMENT	Usage	"Age"
Controlled clean room	0	0
Residential/office	0	2
Light factory	0	3
day to day temperate country	1	3
Chemical exposure	0	4
Extensive UV exposure	0	5
Extreme cold	0	5
Extreme T/H	0	5
Extreme T/H change	0	5
Heavy factory	2	4
Vehicle environment	2	4

Storage : It defines how the end user will store the card when not used.

Table 3.2 The storage conditions in which the end user is stored

STORAGE	Usage	"Age"
Hard plastic holder	0	1
Hard plastic holder in pocket, purse...	0	1
Tyvek sleeve	3	0
Wallet in purse	1	0
Soft plastic holder	3	0
Soft plastic holder in side pocket	5	1
Soft plastic holder in pant pocket	10	1
Wallet in pant pocket	9	2
Loose in purse	9	4
Loose in pocket	10	4
Attached to key ring	10	6
Loose in schoolbag	9	7
loose in car or glove box	8	8

Reader Profile : It determines how the reader damages the card

Table 3.3 The reader profile conditions in which damages the card

READER PROFILE	Usage	"Age"
Long range vicinity	0	0
Medium proximity	0	0
Barcode scanner	0	1
Short range C-less	1	0
IC contact	4	1
Card imprinter	2	4
Mag. stripe insertion	4	2
Barcode swipe	2	5
Mag. stripe swipe	2	8

The usage frequency and the card lifetime have a strong impact of the various stresses the card will have to withstand. Two weighting coefficients have been introduced to correct the raw mission profile:

Frequency coefficient: it has influence on the “Usage” factor.

Table 3.4 The frequency coefficient conditions

FREQUENCY	Coefficient
Monthly(10-100/yr)	1
Weekly(100-500/yr)	2
Daily(501-2000/yr)	5
Hourly(>2000/yr)	10

Lifetime coefficient: it applies to “Age” factor.

Table 3.5 The expected lifetime coefficient conditions

EXPECTED LIFETIME	Coefficient
Up to 2 years	1
Up to 3 years	2
Up to 5 years	5
Up to 10 years	10

3.3.1.2 *Determine Uc and Ac*

Determine Uc and Ac to find the durability class and test sequence cycle. After get the summation of U and summation of A in each condition. Uc and Ac are checked against the table to determine the age class and durability class.

3.3.1.2.1 *Card Service Life Testing Parameters Determination Procedure*

To determine card raw mission profile ;

- **A** = Sum the 3 grades obtained from the “Age” columns.
- **U** = Sum the 3 grades obtained from the “Usage” columns.

To determine card corrected mission profile ;

- Multiply **A** value by the lifetime weighing coefficient chosen accordingly to card application. The result is noted as **Ac**.
- Multiply **U** value by the frequency weighing coefficient chosen accordingly

to card application. The result is noted as **Uc**.

- Check **Ac** value against the table below to determine the age class of the application.

Table 3.6 The Ac value to determine the age class of the application

Ac value	---->	Age class
0-10		0
11-20		1
21-50		2
>50		3

- Check **Uc** value against the table below to determine the durability class of the application:

From the meeting, the selected data of environment, storage, reader profile, and frequency are shown as below;

Table 3.7 The Uc value to determine the durability class of the application

Usage global rating value	--->	Durability class
Up to 10		A
Up to 20		B
Up to 50		C
>50		D

- Test requirements will be located in the tables that follow for specific card applications.

From the meeting and discussions, the selected environment, storage, reader profile, and frequency are shown as below.

Step 1: Possible environment, storage, and reader profile

Condition 1

Environment:	Day to day temperate country	U=1	A=3
Storage:	Soft plastic holder in side pocket	U=5	A=1
Reader profile:	Short range C-less	U=1	A=0
Sum		**U=7**	**A=4**

Condition 2

Environment:	Vehicle Environment	U=2	A=4
Storage:	Loose in car or glove box	U=9	A=8
Reader profile:	Mag.stripe swipe	U=2	A=8
Sum		**U=13**	**A= 20**

Step 2 : Determine UC&AC to find durability class and test sequence cycles

Condition 1

Frequency Monthly (1-100/yr) Coefficient 1: Uc = 7 x 1 = 7 Durability class A

Daily (501-2000/yr) Coefficient 5: Uc = 7 x 5 = 35 Durability class C

Expected life time Up to 10 years Coefficient 10: Ac = 4 x 10 = 40 Age class 2

Condition 2

Frequency Monthly (1-100/yr) Coefficient 1: Uc = 13 x 1 = 13 Durability class B

Daily (501-2000/yr) Coefficient 5: Uc = 13 x 5 = 65 Durability class D

Expected life time Up to 10 years Coefficient 10: Ac = 20 x 10 = 200 Age class 3

From all information, we got 4 mission profiles which are C1, C2, D1, and D2 for testing

3.3.2 <u>Test Cycles: One Cycle Consists of</u>

a) Storage in short term contamination: follow ISO/IEC 10373-1
b) Storage in long term contamination:
   - Salt spray test: follow ISO 9227
   - Storage in acid solution: follow ISO/IEC 10373-1
   - Storage in alkaline solution: follow ISO/IEC 10373-1
c) Softener storage: follow to ISO/IEC 24789-2
d) UV light exposing: follow to ISO/IEC 24789-2
e) Thermal storage: follow to ISO/IEC 24789-2
f) Thermal and Humidity ageing: follow to ISO/IEC 24789-2
g) Dynamic bending stress: follow to ISO/IEC 10373-1
h) US Postal test: follow to ISO/IEC 10373-3

3.3.3 <u>Define the Test Method From Durability Class and Test Sequence Cycle: for Example, the Test Method for A3.</u>

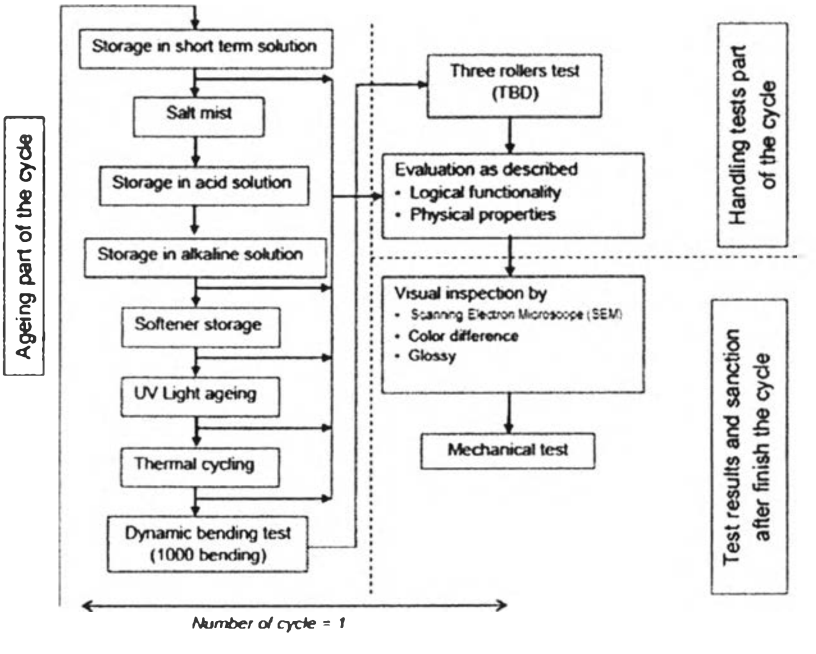

Figure 3.3 Test cycle for determining card service lifetime.

a) Number of cycles for C2, and D2 is 2 and for C3, and D3 is 3.

b) For dynamic bending test, a number of bending depends on durability class as shown in Table 3.8.

Table 3.8 Number of bendings for each durability class

Durability class	No. of bending
A	1000
B	2000
C	3000
D	4000

3.3.4 Characterzations and Testing of Plastic Smart Card

a) Thermal Stability Analysis

TGA was used to investigate the degradation temperature (T_d). The sample were analyzed at temperature of 50-700 °C with the heating rate of 10°C/min under the nitrogen gas atmosphere.

b) Logical Functionality

Functionality of data storage devices, memories and microprocessors must be checked after each test and checked Max. distance after finish each cycle.

c) Visual Inspection

The glossy, ΔE (Color difference) and surface of plastic card were observed by haze-gloss measurement, colorimetric spectrophotometer and scanning electron microscope (SEM), respectively.

d) Mechanical Properties Testing

First, tenisle strength and % strain at break were test following ASTM D882 . They were measured by Instron Universal Testing Machine.