

## Evaluation of the Mechanical Durability of the Egyptian Machine Readable Booklet Passport

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### Abstract:

In 2008 the first Egyptian booklet Machine Readable Passport/ MRP has been issued and its security and informative standard quality levels were proved in a research published in 2011.

Here the durability profiles of the Egyptian MRP have been evaluated. Seven mechanical durability tests were applied on the Egyptian MRP. Such tests are specified in the International Civil Aviation Organization / ICAO standard requirements documents. These seven very severe durability tests resulted in that the Egyptian MRP has achieved better & higher results than the values detected in ICAO-Doc N0232: Durability of Machine Readable Passports - Version: 3.2.

Hence, this research had proved the complete conformance between the Egyptian MRP mechanical durability profiles to the international requirements. The Egyptian booklet MRP doesn't need any obligatory modification concerning its mechanical durability profiles.

### Keywords:

Security Printing, Secured Prints, Machine Readable Passport/Mrp, Booklet Passport Durability, Passport Standard Requirements, Security.

## 1. Introduction

For decades, the Egyptian travel documents & passports were analogue and personalized with handwriting. In 2008 the first Egyptian digital personalized booklet MRP was issued. The inner side of the right (face) cover of the Egyptian MRP is digitally personalized as the holder's page (datapage). There are two Optical Character Recognition /OCR lines and a 2D barcode lines are digitally printed on the Machine Readable Zone / MRZ of the Egyptian MRP datapage. The Egyptian MRP is not an ePassport. Also the Egyptian MRP is not recordable for any of its holder digital biometric data. There are few published standard tackle with the booklet MRP's durability scope. The International Civil Aviation Organization / ICAO had issued the majority of these standards. This year, the International Organization for Standardization/ ISO is about to issue a standard titled "ISO/IEC DIS 18745-1: Test methods for machine readable travel documents (MRTD) - Part 1: Physical Test Methods for Passport Books (durability)".

In June 2006 the European Union\EU has issued its working document titled: EU – Passport Specification, but the MRP's durability profiles and testing were out of the scope of that document. In 2011 the Egyptian booklet MRP physical, security& informative conformance ratios to the standard international requirements have been evaluated. The analysis of the results has proved that the Egyptian booklet MRP has a compliance ratio of 96.7% to ICAO obligatory requirements, as demonstrated (Yosri, A.M., 2012).

This research is trying to evaluate the conformance of the Egyptian MRP mechanical durability profiles to the ICAO standard requirements. Like any other permanent identification document, the MRP's are exposed during their circulation lives to multi mechanical deterioration factors. Those effective factors differentiate according to the nature and the inner components of the usage (circulation) environments of the documents. That's why the MRP's must have excellent mechanical durability profiles.

## 2. Problem

The Egyptian booklet MRP has been issued five years ago, but till now, there is not yet any scientific research evaluates the conformance of its mechanical durability profiles to the standard international requirements. That's means that the Egyptian booklet MRP impact stress resistance, back pocket stress resistance, dynamic bend stress resistance, sheet turning stress resistance, sheet pull stress resistance & abrasion stress resistance profiles haven't been evaluated before.

## 3. Targets

1. Evaluation the conformance of the Egyptian booklet MRP- mechanical durability profiles (impact stress resistance, back pocket stress resistance, dynamic bend stress resistance, sheet turning stress resistance, sheet pull stress resistance & abrasion stress resistance ) to the requirements specified in the ICAO-Doc No232: Durability of Machine Readable Passports - Version: 3.2 - Author: ISO/IEC/JTC1/SC17/WG3/TF4 for ICAO-NTWG / 30-08-2006.
2. Standardizing the necessary adaptation - if needed - of the current Egyptian booklet MRP mechanical durability profiles making them reaching a full conformance with the ICAO -Doc No232 standard requirements.

## 4. Methodology

The Egyptian booklet MRP mechanical durability profiles have been tested according to a standardized laboratory methodology. In an analytical methodology, the tests' results were compared to the standard targeted values detected in the ICAO-Doc No.232: Durability of Machine Readable Passports - Version: 3.2.

Hence, the Egyptian booklet MRP mechanical durability profiles were evaluated.

## 5. Definitions

### 5.1. MACHINE READABLE PASSPORT/ MRP

The MRP is a member of the Machine Readable Travel Document / MRTD<sub>s</sub> family. The MRP can be a booklet one or just a polymer card.

The booklet MRP<sub>s</sub> can be uploaded only with static (unchangeable) encoded informative components (ex. OCR lines or barcodes) alone. As an option, the booklet MRP<sub>s</sub> can be equipped with Contactless Integrated Circuits/ CIC<sub>s</sub> which work via radio waves. The CIC<sub>s</sub> are recordable for numberless times with variable data. Contrary, putting the CIC<sub>s</sub> inside the card MRP<sub>s</sub> bodies is a must. Logically, card passports which are not booklets can only carry digital visas & digital airports' seals. The (booklet or card) MRP<sub>s</sub> with CIC<sub>s</sub> are classified as smart or electronic passports (ePassports). So all the card passports are smart ePassports but not all the booklet MRP<sub>s</sub> are the same. Sometimes a CIC together with a contact Integrated Circuit (a micro chip with a contact copper interface) are merged inside the layers of one card passport. Such passport is called «dual smart ePassport».

### 5.2. HOLDER'S PAGE (DATAPAGE)

The datapage may be the inner side of the booklet MRP face cover or being its first visa page. The datapage could be made from cellulose fibers (paper) materials or be made from polymer plastic layers. The datapages are digitally personalized (printed) with the MRP<sub>s</sub> holders' personal (unrepeatable) information. If the datapages are of laser burnable plastic materials, they usually personalized by the various laser burning technologies.

### 5.3. VISUAL CHARACTER ZONES/ VIZ

According to the ICAO DOC 9303, there are five zones locate in the top & the middle of the MRP datapage. They are digitally personalized with the MRP holder's and the MRP itself readable information (name, birth date and place, photo, residence address, position, MRP number, MRP issued and expired dates).

### 5.4. OPTICAL CHARACTER RECOGNITION/ OCR TECHNOLOGY

imaging the encoded figures (characters + numbers + symbols.... &etc) via scanning, then decoding (interpreting) the captured digital data using special computer software(s).

### 5.5. OCR TWO LINES

Every OCR line must consist of forty four digits. The two lines both fill the MRZ area on the bottom of the MRP datapage. The OCR lines are digitally personalized with all MRP holder's personal encoded data (except his photo) which is pre-produced readably in the VIZs. The two OCR lines have check digits which can be, if needed, implemented in analogue verification equations.

### 5.6. MACHINE READABLE ZONE/ MRZ

Locates in the bottom of the MRP datapage, underneath the MRP holder's photo. The MRZ is digitally personalized to create the encoded OCR two lines.

### 5.7. OPTICAL CHARACTER VERIFICATION/ OCV

When the OCR data decoding mechanism is followed by a comparison between the interpreted scanning digital data with a pre-saved data, the whole operation is called "Optical Character Verification/ OCV".

#### 5.8. IMPACT STRESS RESISTANCE TEST

During using the booklet MRP<sub>s</sub>, their visas pages are inky stamped with arrival and departure airports seals & marks. This test is simulating the stamping of the MRP visas pages by exposed them to a specified impact force load. This load is applied using a steel solid flat surface covered with a rubber blanket. Of course the MRP holder datapage is not passed through this test because it is never being stamped.

#### 5.9. BACK POCKET STRESS RESISTANCE TEST

Simulating the stresses which the whole MRP booklet body exposed to when its holder sits down while the MRP is in the back pocket of his trousers. In other wards: this test simulates the stresses of the humanly sitting down on a MRP. During testing, a detected load which simulates the standard MRP holder average weight pushes the MRP body to be bent around a curved elastic sponge base. This sponge base simulates the MRP holder's bottom.

#### 5.10. DYNAMIC BEND STRESS RESISTANCE TEST

As explained in ISO/IEC 10373-1, it's the determination of the MRP booklet body bending resistance against fully reversed (opposite) force loads applied on its two parallel short edges simultaneously (in the same time).

#### 5.11. SHEET TURNING STRESS RESISTANCE TEST

Determining the folding strength profile of any page in the MRP booklet (the holder's datapage or a visa page) at the binding spine line. During testing, the whole other MRP pages are being clamped.

#### 5.12. SHEET PULL STRESS RESISTANCE TEST

Determining the tearing strength profile of any page in the MRP booklet (the holder's datapage or a visa page) at the binding spine line. The MRP page is exposed to a detected pull out force load perpendicular to the MRP booklet binding spine line. During testing, the cross cutting of the page (with or without its separation out from the binding spine) is a bad sign; it means that the tensile strength profile of the page material itself is weak and not standard.

#### 5.13. ABRASION STRESS RESISTANCE TEST

determining the abrasion resistance profiles of the informative components produced on the MRP pages under perpendicular known moving mechanical rubbing forces. The samples which are to be tested must be finished completely personalized MRP<sub>s</sub>. During abrasion stress testing, the mechanical rubbing forces may be applied on the digitally printed or laser engraved two OCR lines of the machine-readable zone (MRZ) or be applied on any of the Visual Inspection Zones (VIZs) locates on the MRP holder's datapage.

Also the mechanical rubbing forces can be applied on the visas entries (usually made of self adhesive paper stickers) or the inky stamps pre-created on the MRP visas pages. Here, the abrasive material to be used should be of elastic rubber with physical properties profiles similar to those of the facing page which in permanent fully contact with the tested page.

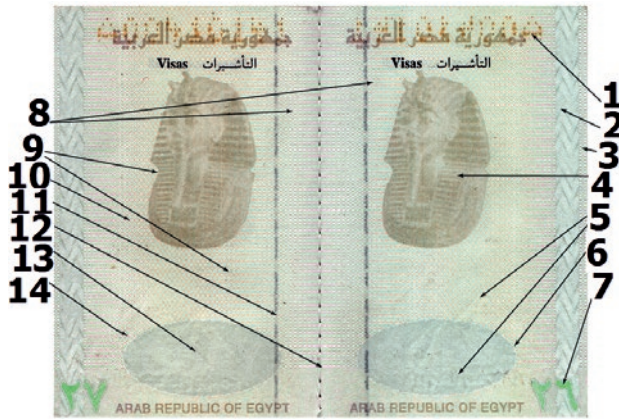
#### 5.14. TOP EDGE OF THE MRP

The MRP long edge which parallels to its binding spine line.



The figure keys			
The key	The explanation	The key	The explanation
1	Data personalization by dye sublimation printing	10	Lower saturation, smaller repeat of the holder's photo.
2	The OCR two lines	11	3 dimensions guilloche background
3	2 dimensions barcode	12	3 dimensions watermark
4	The holder CMYK personal photo	13	CMYK halftones screen printed vignette
5	Silver metallic hot stamping	14	Latent image (the word: COPY)
6	Optical variable devices lamination plastic overlay	15	Laser perforation of the passport number
7	Invisible fluorescent ink	16	Full embedded fluorescent security thread with clear text
8	Guilloche & solid linear printing areas	17	Zigzag shape micro texts
9	Visible fluorescent fibers	18	Solid linear printing areas

Figure 1. The holder page of the Egyptian MRP with its security components



The figure keys			
The key	The explanation	The key	The explanation
1	Laser perforation of the passport number	8	Pages numbers printed with invisible fluorescent ink
2	3 dimensions guilloche background	9	Invisible fluorescent ink
3	Visible fluorescent fibers	10	Visible fluorescent fibers
4	1 color halftones screen printed portrait	11	Full embedded fluorescent security thread with clear text
5	3 dimensions watermark	12	Rainbow color fluorescent sewing thread
6	Ellipse shape micro texts	13	Latent image (the word: COPY)
7	Pages numbers printed with visible fluorescent ink	14	3 dimensions watermark

Figure 2. The two middle visas pages of the Egyptian MRP with their security components.

## 6. MRP durability tests

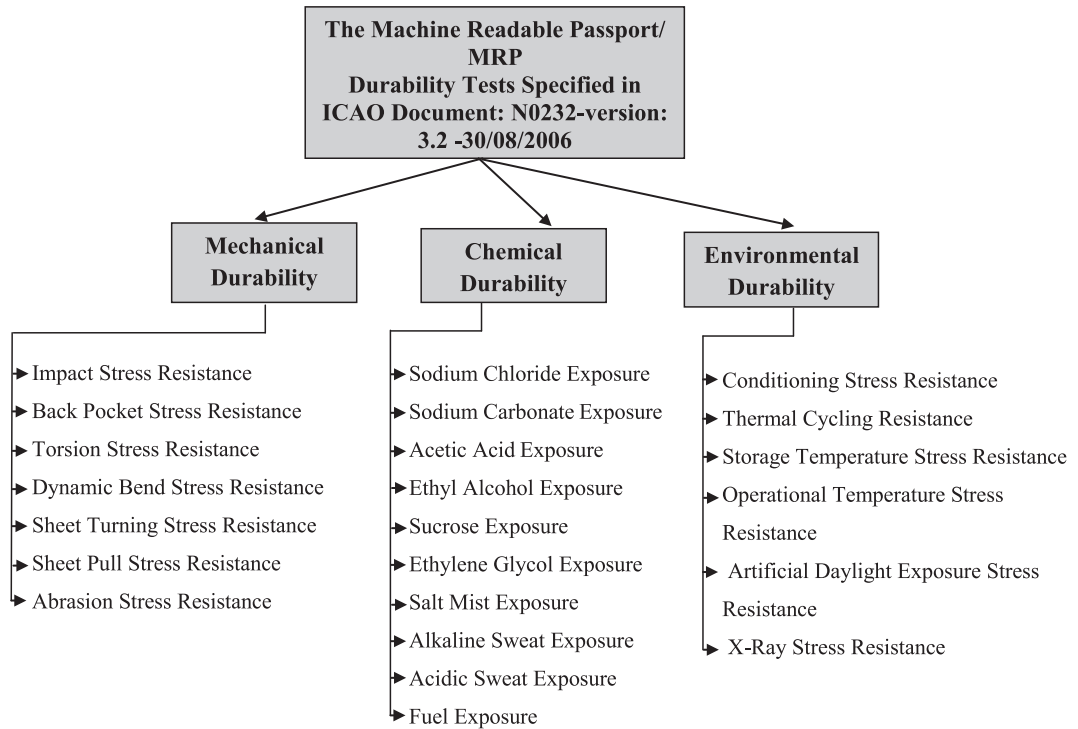


Figure 3. The all (Mechanical / Chemical / Environmental) MRP durability tests

## 7. Testing ambient circumstances

All the Egyptian MRP samples had been pre-conditioned for 24 hours at a (25 °C temperature & 50% relative humidity) environments before being tested. All the mechanical durability tests also have been comprehensively conducted under the same ambient circumstances. The standard pre-conditioning & testing environments specified in ISO/IEC 10373-1 are; (20:26) °C temperature & (40:60) % relative humidity labs.

## 8. Methods

The scopes, parameters and requirements of the next MRP's mechanical durability tests are specified in the ICAO DOC 232-version: 3.2 - 2006. In this research the tests' steps,

procedures and sequences have been explained in simpler more details. Also, all the tests figures are new, more clear and have been created by the researcher.

### 8.1. IMPACT STRESS RESISTANCE TEST

The 180 degrees open MRP visas pages are hit by a 12 mm thick, 29 mm diameter circle steel stamp. The steel is covered with a 2 mm thick rubber gravure inked surface. The hardness of the rubber surface is 50 Shore and it's etched to a 0.3 mm depth with 10 concentric grooves lines in (0.9-1.1) mm thickness. The hitting distances (H) = (5-20) cm. The stamp weight (M) varies according to the equation:  $[M = (0.02 / H) \text{ Kg}]$ . The stamp impacts (prints) must entirely cover all the visa page area with a 10.5 mm static displacement between every two horizontally or vertically adjacent stamp prints. (See figure 4)



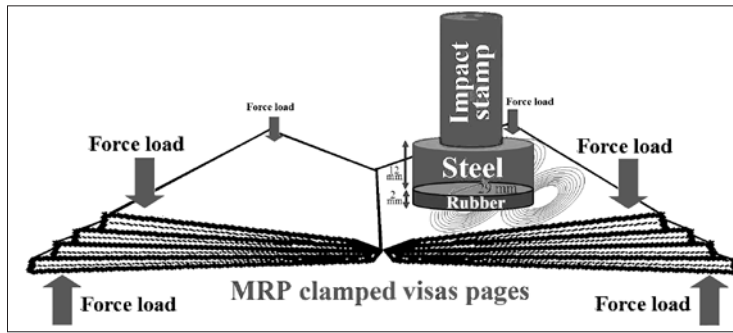


Figure 4 — The MRP impact test

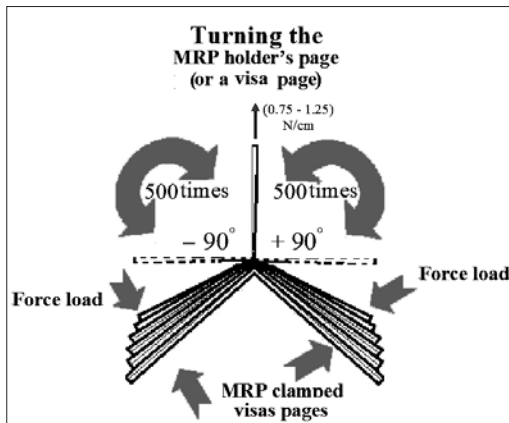


Figure 5. The MRP sheet turning test

### 8.2. SHEET TURNING STRESS RESISTANCE

The vertical free (unclamped) datapage or any visa page of the booklet MRP is turned with a 90° bending angle, at a frequency of 0.5 Hz for 1000 times in reverse directions (500 times in each direction). During testing, the turned page is subjected to a (0.75 - 1.25) N/cm pull load. (See figure 5)

### 8.3. SHEET PULL STRESS RESISTANCE (BINDING STRENGTH TEST)

The vertical free (unclamped) MRP datapage or a visa page is pulled out from the binding spine by a 60 N perpendicular pull load at 5 mm/s speed, using a clamping area which is more than 130 mm<sup>2</sup>. Because the whole other MRP pages must be clamped, so the opposite page of the tested page has to be cut before testing. During the pulling out, the tested page must resist the separation from the binding spine. (See figure 6)

### 8.4. ABRASION STRESS RESISTANCE

The targeted personalization information on the MRP holder datapage (or any visa page) is mechanically rubbed for 500 times under a (13300-14700) N/m<sup>2</sup> perpendicular abrasion load force. The abrasion load is applied using a 15 mm diameter moving abrasion circle head at a (2.5-25) cm/s speed. The abrasion movement axis must be parallel to the MRP horizontal axis. (See figure 7)

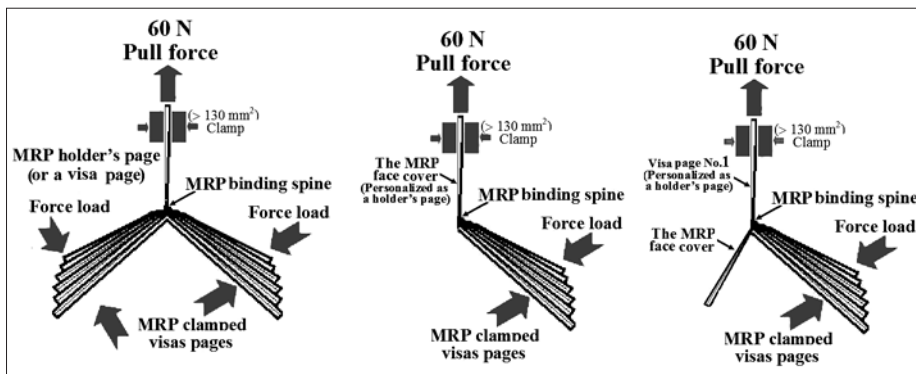


Figure 6. The MRP sheet pull test

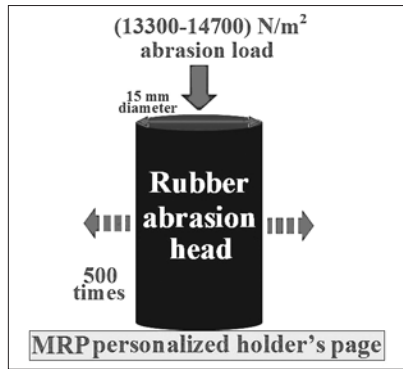


Figure 7. The MRP abrasion test

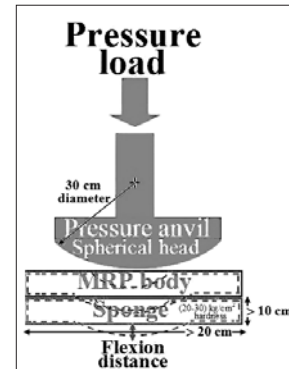


Figure 8. The MRP back pocket stress test

#### 8.5. BACK POCKET STRESS RESISTANCE

The MRP booklet body is pressed against a (20-30) kg/cm<sup>2</sup> hardness sponge cushion located underneath it with a 30 cm diameter spherical metal surface attached in an upper horizontal anvil. The sponge cushion thickness must be more than 10 cm and with dimensions more than 20 cm in any direction. By the spherical surface MRP, which may be put into a flexible support pocket (ex. a denim pocket), is exposed to a 350 N load force for 5 seconds. At any moment during testing the pressure anvil mustn't be in a direct touch (contact) with the sponge cushion. The test sequence is repeated on the other MRP cover. (See figure 8)

#### 8.6. TORSION STRESS RESISTANCE

The MRP is horizontally clamped with its two short edges and exposed to 1000 torsion cycles at a frequency of 0.5 Hz. The maximum

torsion angle must be less than 15°. Before starting the test, the torsion distance is determined by a 0.3 N-m torque load applied for 1 minute on the clamped MRP in the torsion tester. (See figure 9)

#### 8.7. DYNAMIC BEND STRESS RESISTANCE

The vertically clamped MRP booklet body is bent (flexed) in reversed horizontal directions using a dynamic flexion device for 1000 times (500 times in each direction) at a frequency of 0.05 Hz. This device consists of 4 rollers; two of them are unmovable (fixed) 20 mm diameter rollers and the two others are 23 mm diameter movable pushing rollers. During testing the distance between the fixed & pushing rollers' centers (H) varies according to which is the clamped MRP edge.

If the MRP binding spine is the clamped edge, H must = (the MRP booklet width – 4 cm).

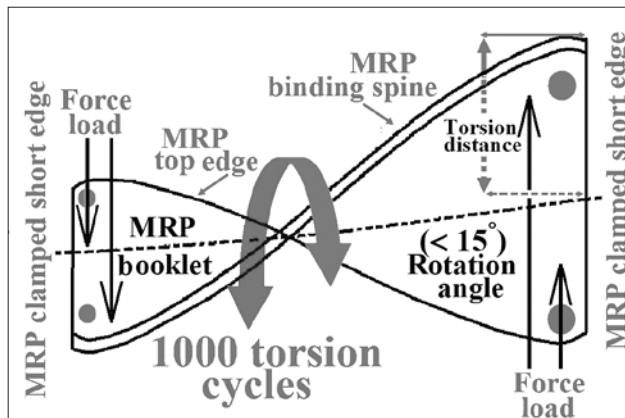


Figure 9. The MRP torsion test



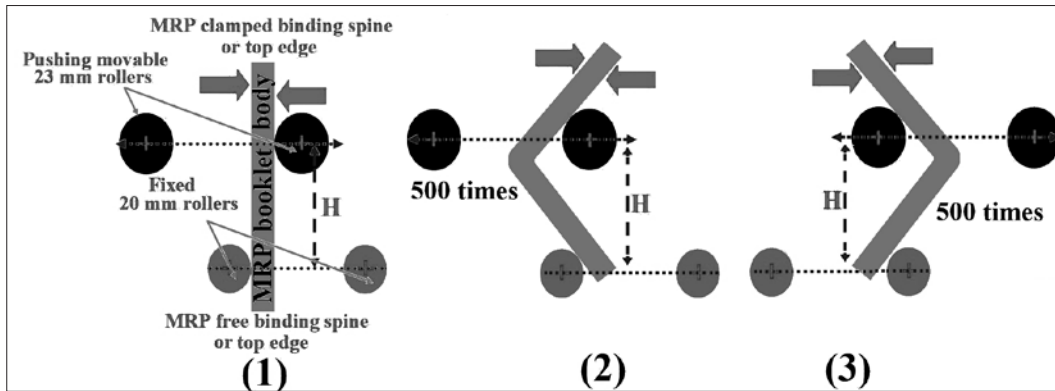


Figure 10. The MRP dynamic bending test

But, if the MRP top edge is the clamped edge,  $H$  must = (the MRP booklet width – 5.8 cm).

Before starting the test and by a 40N force load applied for 1 minute on the clamped MRP, the flexion (bending) distance is determined. The test is repeated for 1000 flexion times after changing the MRP clamped edge. (See figure 10)

## 9. Results

The targeted values of the MRP<sub>s</sub> mechanical durability tests, which are detected in the ICAO DOC 232-version: 3.2 - 2006, are presented in the next table (Table No.1). Also, the acquired results of the Egyptian MRP mechanical durability testing are displayed in the same table. This table shows that the Egyptian MRP mechanical durability profiles have recognized superiority to the standard targeted values with good ratios.

Table 1. The results of testing the Egyptian booklet MRP mechanical durability profiles

The MRP mechanical durability tests	The standard targeted values of the MRP mechanical durability tests as detected in the ICAO DOC. 232-version: 3.2 -2006	The acquired results of the Egyptian MRP mechanical durability testing	The Egyptian MRP mechanical durability profiles superiority ratios comparing to the standard targeted values
Impact stress resistance test, Sheet turning stress resistance test, Sheet pull stress resistance test & Abrasion stress resistance test	<ul style="list-style-type: none"> <li>- The MRP datapage (holder's page) must be in a complete condition without any missed parts.</li> <li>- The MRP holder's digital printed or laser burned photo on the datapage must be still recognizable.</li> <li>- The MRP datapage digital printed (or laser burned) personalization data must be still complete.</li> <li>- The OCR two lines in the MRZ on the datapage must be still readable.</li> </ul>	<ul style="list-style-type: none"> <li>- There is no any missed part of the Egyptian MRP datapage.</li> <li>- The Egyptian holder's photo is still recognizable.</li> <li>- The Egyptian MRP datapage digital printed data is complete.</li> <li>- The OCR two lines on the Egyptian MRP datapage are still readable.</li> </ul>	<p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p>

The MRP mechanical durability tests	The standard targeted values of the MRP mechanical durability tests as detected in the ICAO DOC. 232-version: 3.2 -2006	The acquired results of the Egyptian MRP mechanical durability testing	The Egyptian MRP mechanical durability profiles superiority ratios comparing to the standard targeted values
	- Any page of the booklet MRP (the datapage or a visa page) mustn't be completely separated from the MRP binding spine.	- No page has been entirely separated from the binding spine of the Egyptian MRP.	_____
	- The separation ratio of the datapage from the binding spine must equal or be less than 10 %.	- The datapage of the Egyptian MRP has rendered a 5% separation average ratio from the binding spine.	$[(10 / 5) \cdot 100] = 200\%$
Impact stress resistance test, Sheet turning stress resistance test, Sheet pull stress resistance test & Abrasion stress resistance test	- The ratio of the separation parts of the hot stamping design (usually the symbol of the issuing country in a metallic form) from the MRP face leather cover must equal or be less than 50 %.	- The metallic hot stamped slogan on the Egyptian MRP face cover rendered a 25% separation ratio.	$[(50 / 25) \cdot 100] = 200\%$
	- The complete flat opening (180° opening) of the MRP booklet to any page must not cause any kind of damage to its structure.	- The flat opening of the Egyptian MRP booklet hasn't caused any kind of damage to its structure.	_____
	- The diameter of any hole in any page of the MRP (the datapage or any visa page) must equal or be less than 2 mm.	- There was no any hole in any page of the Egyptian MRP.	_____
	- The delaminating between the paper MRP datapage and the secured polymer lamination layer hot stamped above it (if there's a layer) must equal or be less than 3 mm in length, regardless that if the delaminating has occurred on the datapage borders or inside its area.	- The hot stamped lamination polymer layer above the Egyptian MRP datapage has rendered few separation parts (with an average length of 2 mm).	$[(3 / 2) \cdot 100] = 150\%$
Back pocket stress resistance test, Torsion stress resistance test & Dynamic bend stress resistance test	The all previous above mentioned targeted results & values besides:	The Egyptian MRP samples had yield the all previous above mentioned results & values besides:	_____
	- (If the datapage of the MRP is made of polymer material), its warpage must equal or be less than 3 mm.	- The datapage of the Egyptian MRP booklet is made of paper.	_____
	- After testing, the whole MRP booklet body warpage must equal or be less than 1 cm.	- The whole Egyptian MRP booklet body warpage after exposed to the all mentioned mechanical durability tests was equal 0.5 cm.	$[(0.5 / 1) \cdot 100] = 200\%$

## 10. Discussion & Conclusions

After exposed to the ( Impact, sheet turning, sheet pull, torsion, back pocket, dynamic bending & abrasion ) mechanical durability tests, the Egyptian booklet MRP has achieved values which are better and higher than the standard targeted values detected in the ICAO-Doc 232: Durability of Machine Readable Passports - Version: 3.2.

That's to say:

There is no any missed part of the Egyptian MRP datapage & the holder's photo is recognizable.

The digital printed data on the MRP datapage is complete & the two OCR lines are still readable.

The datapage average separation ratio from the bending spine was 5 %, with a 200% superiority ratio comparing to the ICAO targeted value.

The metallic hot stamped slogan on the Egyptian booklet MRP lather cover rendered a 25% separation ratio, with a 200% superiority ratio comparing to the ICAO targeted value.

There was no any hole in any page of the Egyptian booklet MRP after the all tests.

The hot stamped lamination polymer layer above the Egyptian MRP datapage has rendered few 2 mm average length separation parts from the datapage itself, with a 150% superiority ratio comparing to the ICAO targeted results.

After the completion of all the durability tests, the average warpage of the Egyptian booklet MRP body equals 0.5 cm, with a 200% superiority ratio comparing to the ICAO targeted results.

The mechanical durability profiles of the Egyptian booklet Machine Readable Passport / MRP conform to all the mandatory requirements specified in the ICAO Doc 232-version: 3.2 -2006, with a (100%) approved compliance ratio. Also there's no need to any standard adaptation or reconfiguration of the mechanical durability profiles of the current Egyptian booklet MRP for reaching the full conformance with the international standard obligatory requirements.

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