

# **QC Procedures of Gaps for RE4 RPCs in Upscope**

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# **QC Procedures**

## **1. HPL**

**1) Discharge & restoration on flat tables**

**2) Barcode check**

**3) Visual inspection to reject bad HPLs**

- Scratches on surfaces**
- Check the condition for polished surfaces**
- Edge: requiring no damage**

**4) Registration of the barcode # for qualified HPLs**

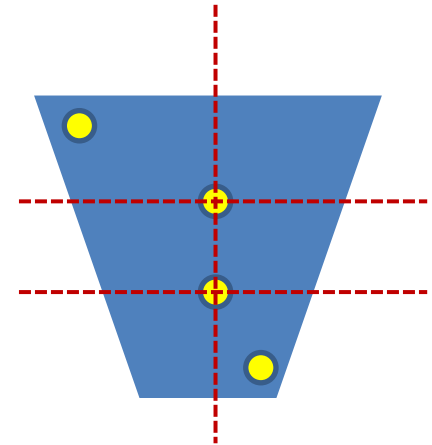
## 2. Graphite procedure

1) Cleaning surfaces with IPA

2) Silk masking for graphite offsets with **22-mm wide tape**.

3) Graphite by silkscreen ink

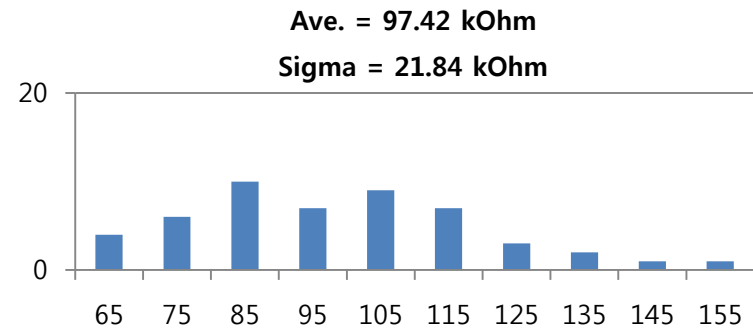
- Dry the silk surface for **7 days at 18 ~ 22 °C**
- # of prints in a single production batch **~ 90 sheets**
- Check the local variation each sheet by measuring resistivity at **2 points inside & 1 ~ 2 near corners**
- For the qualification .



The mean should lie in  **$80 \text{ k}\Omega < \rho_{\text{mean}} < 130 \text{ k}\Omega$**

Record the **mean resistivity** for each sheet in the data base

120	86	106	104	129	113	111	109	155	129	116.2
148	110	108	110	116	103	104	102	138	137	117.6
116	104	90	98	110	90	99	93	104	91	99.5
84	82	84	82	86	79	76	92	82	81	82.8
60	61	70	77	80	72	65	67	82	76	71
105.6	88.6	91.6	94.2	104.2	91.4	91	92.6	112.2	102.8	97.42
										$\sigma = 21.84$



### 3. Selection of parts

- 1) Coin spacers: accepted if  $d = 1.96, 1.97, 1.98, 1.99$  mm
- 2) Edge spacers: accepted if  $d = 1.95, 1.96, 1.97, 1.98, 1.99, 2.00$  mm
- 3) Gas in/outlet profiles: accepted if  $d = 1.95, 1.96, 1.97, 1.98, 1.99, 2.00$  mm  
- have to check carefully any defect in gas-pipe holes -> impedance
- 4) PET film (SH71S, SKC,  $d = 0.188$  mm)  
- Should always use fresh PET

### 4. Insulation of electrodes with PET

- 1) Attach the PET-film layer to graphite HPL surfaces with a hot-melt extrusion method  
- EVA model TANEL-100: **extrusion of gel at 170 ~ 180 °C**
- 2) Should be careful for keeping no scratch especially on the cathode sides
- 3) Check the condition for EVA glue layers: minor bubbles accepted.

## 5. Gluing

- 1) Clean inner HPL surfaces with IPA
- 2) Temperature for gluing & hardening: **21 °C**
- 3) Glue working time: maximum **25 mins**
- 4) Glue hardening time: **24 hours**
- 5) Shielding for leak current: filling along the all peripheries with EVA glue

## 6. Oil process

- 1) Quick leak test bfr oiling: rejection when the pressure drop  $> 2$  mm (by using a water column)
- 2) Oil mixture: **40% Linseed oil + 60% Heptane**
- 3) Filling the oil+HEP mixture of **120-liter in a 200-liter tank**
- 4) The old oil replaced every 3 months (1 oil batch to produce  $\sim 150$  gaps)
- 5) Temperature for oiling & drying: **30 °C**
- 6) Velocity of lifting & draining for oil coating = **4 cm/min**
- 7) Sucking the remained oil in the gaps for **10 mins with a compressor**
- 8) Dry of oil surfaces for 96 hours with filtered air (relative humidity = 40%)
  - Flow rate = **60 liter/hour for RE4/2(3) TW(TN) gaps**
  - = **90 liter/hour for RE4/2(3) BT gaps**
- 9) We open 1 gap/200 gaps to check the condition for oil surfaces



# 7. HV tests

1) Range of the HV test: 1 ~ 10.0 kV

2) Gas mixture: 95% C<sub>2</sub>H<sub>2</sub>F<sub>4</sub> + 5% i-C<sub>4</sub>H<sub>10</sub>

3) Selection criteria

- At 6.0 kV (checking Ohmic currents)

Current Limits at 6.0 kV	RE4/2 TW	RE4/2 TN	RE4/2 BT
	1.5 μA	1.5 μA	1.5 μA
	RE4/3 TW	RE4/3 TN	RE4/3 BT
	1.5 μA	1.5 μA	1.5 μA

- At 10.0 kV (200 V higher than the avalanche-mode limit: should be finalized after the first batch test)

Current Limits at 10.0 kV	RE4/2 TW	RE4/2 TN	RE4/2 BT
	5.0 μA	5.0 μA	10.0 μA
	RE4/3 TW	RE4/3 TN	RE4/3 BT
	5.0 μA	5.0 μA	10.0 μA

- At the final stage of the 84-h test at 9.6 kV

Current Limits at 9.6 kV	RE4/2 TW	RE4/2 TN	RE4/2 BT
	2.0 μA	2.0 μA	3.5 μA
	RE4/3 TW	RE4/3 TN	RE4/3 BT
	2.0 μA	3.5 μA	5.0 μA

- At 9.6 kV,  $i(120h)/i(60h) < 1.5$  for the previous production

*The current increasing slope is utmost important. Have to be decided after the first batch test.*

## 4. HV test

$$HV_0(293 K, 1013 hPa) = HV_{\text{applied}} \frac{1013 hPa}{P} \frac{T}{293 K}$$

Starting date of test		Dec. 23, 2011		Total gas rate		20 l/h	Gas mixture	
Time from test start	Date/ Time	P (hPa)	T (°C)	HV <sub>applied</sub> (kV)	HV <sub>0</sub> (kV)	36 h	0.95 Freon + 0.05 i-Bu	
						Initial Current in period (μA)	Final Current in period (μA)	
0.0 h	06.12.2011/14.23	1023	20.4	1.0				
1.0 h				2.0				
2.0 h				3.0				
3.0 h				4.0				
4.0 h				5.0				
5.0 h				6.0				
				12 h test				
17.0 h				7.0				
18.0 h				8.0				
19.0 h				9.0				
19.5 h				9.1				
20.0 h				9.2				
20.5 h				9.3				
21.0 h				9.4				
21.5 h				9.5				
22.0 h				9.6				
22.5 h				9.7				
23.0 h				9.8				
23.5 h				9.9				
24.0 h				10.0				
36.0 h								
48.0 h								
60.0 h								
72.0 h								
84.0 h								
96.0 h								
108.0 h								
120.0 h								
					9.6			X
					94 h test			

### Qualification for HV test

Current Limits at 6.0 kV	RE4/2 TW	RE4/2 TN	RE4/2 BT	i(5h) at 6.0 kV		Test Result	Certified	O
	1.5 μA	1.5 μA	2.0 μA	0.35				
	RE4/3 TW	RE4/3 TN	RE4/3 BT					
1.5 μA	1.5 μA	2.0 μA						
Current Limits at 10.0 kV	RE4/2 TW	RE4/2 TN	RE4/2 BT	i(24h) at 10.0 kV				
	5.0 μA	5.0 μA	10.0 μA	2.95				
	RE4/3 TW	RE4/3 TN	RE4/3 BT					
Current Limits at 9.6 kV	RE4/2 TW	RE4/2 TN	RE4/2 BT	i(60h)	1.83	Not certified		
	2.0 μA	2.0 μA	3.5 μA	i(120h)	2.42			
	RE4/3 TW	RE4/3 TN	RE4/3 BT	Criterion i(120h)/i(60h) < 1.5				
	2.0 μA	3.5 μA	5.0 μA	1.32				

### 5. Overall qualification

Leak test	Certified	O	Pop test	Certified	O	HV test	Certified	O	Overall	Certified	O
	Not certified			Not certified			Not certified			Not certified	

# 8. Gas leak & pop spacer test

## Quality-Control Data Sheets for RE4 RPCs in Upscope

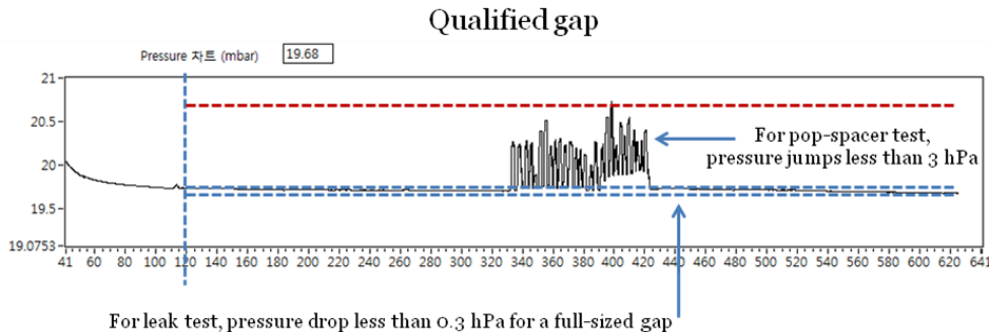
### 1) Gas leak

- Load + 20 hPa pressure to each gap
- Limits of gas leaks (still under R&D)

RE4/2 TW	RE4/2 TN	RE4/2 BT
0.2 hPa	0.2 hPa	0.3 hPa
RE4/3 TW	RE4/3 TN	RE4/3 BT
0.2 hPa	0.3 hPa	0.4 hPa

### 2) Pop spacer test

- Load + 20 hPa pressure to each gap
- No pop spacer allowed
- Shift (by pressing the spacer positions) to be regarded as a failure: 3 hPa



Gap code	KODEL-RE42P-BT0024		
HPL code (GND)		HPL code (HV)	

### 1. Visual Inspections

	Good	Not good	Descriptions
Bar code label	O		N/A
Gas inlet and outlet- pipes	O		N/A
Edges and gas corner piece	O		N/A
HPL (HV)	O		Minor scratches
HPL (GND)	O		N/A
HV cable	O		N/A
GND cable	O		N/A
Graphite (HV) quality & surf. value (kΩ)	O		85
Graphite (GND) quality & surf. value (kΩ)	O		113
PET coating (HV)	O		Some bubbles bubbles on edges
PET coating (GND)	O		N/A

### 2. Leak test (require 2 mins to reach equilibrium)

Time (mins)	Pressure drop (hPa)	
10		0.11

### Qualification for leak test

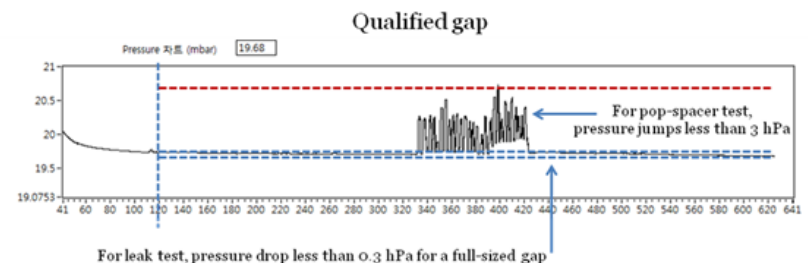
Leak limit	RE4/2 TW	RE4/2 TN	RE4/2 BT	RE4/3 TW	RE4/3 TN	RE4/3 BT	Certified	O
	0.2 hPa	0.2 hPa	0.3 hPa	0.2 hPa	0.3 hPa	0.4 hPa	Not certified	

### 3. Test for popped spacers

Number of spacers	Number of popped spacers	Largest shift (hPa)
120	0	1.1

### Qualification for popped-spacer test (for a pop spacer the shift is assumed to be > 3 hPa)

# of pop-spacers allowed	0	Certified	O
Shift allowed	3 hPa	Not certified	





## 9. Packing & shipping

### 1) Visual inspection

- PET shielding
- Gas pipes & edges (EVA shielded)

### 2) Place protection films on both surfaces of each gaps

### 3) Vertical mounting in the dedicated boxes

- 50 RE4/2(3)TW + 50 RE4/2(3)TN -> 1 box
- 50 RE4/2(3)BT -> 1 box

### 4) Be sure that the all gas pipes -> open

### 5) Transportation to the airport by a 5-ton truck

