FORTE
TESTING AND CONSULTANTS CO., LTD.

HOKLAS 191
TEST

SMOKE CONTROL TEST REPORT

DOUBLE LEAF COMPOSITE TIMBER DOOR with GLAZED ELEMENTS, OVERHEAD PANEL and SIDE GLAZED PANEL

in accordance with ***BS EN 1634-3: 2004***

Test Sponsor: **Garish Crown Fire Engineering & Consultancy**
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Report Number: IT 13-147

Date of Issue: **2013-08-05**

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HOKLAS Approved Signatory:

Ir. Dr Chan Yuk Kit

1. Scope of Test

This report is a record of a smoke control test conducted by Forte Testing and Consultants Co., Ltd. in conformity with requirements in *BS EN 1634-3: 2004 "Fire resistance and smoke control tests for door, shutter and openable window assemblies and elements of building hardware Part 3: Smoke control test for door and shutter assemblies"*. References were also made to the standards and documents given in the normative reference list in *BS EN 1634-3: 2004*.

The test subject was a single acting double leaf composite timber door with seven glazed elements. The test subject also consisted of an overhead composite timber panel and a side glazed panel; and it was installed with intumescent fire seals, intumescent strips with side plastic fins, rebate corner smoke seal and conceal bottom smoke seal. Two specimens with identical constructions were manufactured and supplied for test by Leung's Wooden Company Limited, the Sponsor, for tests on both sides exposure. The Sponsor designated the specimens to be tested to procedures for ambient together with medium temperature.

2. Test Information

Test Laboratory:	FORTE Testing and Consultants Company Limited	
Testing Location:	West Side of Huan Xiang Shan, Xin Yu Road, Shajin, Baoan District, Shenzhen, Guangdong Province, China.	
Test Sponsor:	Leung's Wooden Company Limited Garish Crown Fire Engineering & Consultancy	
ID no. of the Specimens:	QT 13-060A	QT 13-061A
Date Received:	2013-04-22	2013-04-22
Test Number:	Ambient: QT 13-060A Medium: QT 13-060B *This report (Report no. IT13-147) is issued in additional to the report (Report no. IT13-067) issued on 2013-08-01 on this test	Ambient: QT 13-061A Medium: QT 13-061B
Date Tested:	2013-04-25	2013-04-30
Approved Test Operator from FORTE:	Mr. Mak Chi Kit	
Witness of the Test:	Mr. C.K. Leung – Official Delegate of the Sponsor	

3. Construction Details of Specimen

3.1 Specimen Description

3.1.1 Framework

The timber framework was overall sized 2764 mm (**w**idth) x 2961 mm (**h**eight). The sectional dimension of the perimeter framework was 50 mm (w) x 100 mm (t) with 20 mm single door stop rebate. The transom and mullion between door leaves and panel had a sectional dimension 70 mm (w) x 100 mm (t) with 20 mm single rebate on two sides.

The film ply-wood sub-frame was sized 100 mm (w) by 18 mm (t). The sub-frame was fixed onto the back of the framework by 10 x 112 mm screws at approximate 200 mm centre to centre.

The framework with sub-frame was fixed into the opening on the drywall partition system by 10 x 72 mm self-tapping screws. There were 8 numbers of fixings on each jamb and head.

Wooden architraves sized 45 mm (w) x 12 mm (t) were fixed over the framework and sub-frame on both sides by wood nails at approximate 250 mm centre to centre.

1 number of 20 mm (w) x 4 mm (t) intumescent seal and 1 number of 10 mm (w) x 4 mm (t) intumescent seal were fitted aside into groove on the jambs and head of door frame.

1 number of 30 mm (w) x 4 mm (t) intumescent seal was fitted aside into groove on the framework perimeter the overhead panel. 1 number of rebate corner smoke seal was adhered along the rebate corners of the framework.

The space between the supporting frame and the framework was fully filled with backer rod and fire sealant.

3.1.2 Door Leaves

The specimen comprised of two composite timber door leaves. The active leaf sized 1100 mm (w) x 2338 mm (h) x 50 mm (t) and the inactive leaf sized 1200 mm (w) x 2338 mm (h) x 50 mm (t).

The main stiles and rails of the door leaf were made of 3 numbers of wooden slabs sized 45 mm (w) x 38 mm (t). The slabs were fixed together by brackets and glue. The mid rails were made of wooden slab sized 45 mm (w) x 38 mm (t).

The core of the door leaves was filled with 38 mm (t) perlite board.

Both sides of the core were covered by a layer of 3 mm (t) fire board sub-facing. The fire boards on both sides of door core were fixed together by ø4 x 25 mm wood screws at approximate 200 mm - 400 mm centre to centre onto the door core.

Both sides of the door leaves were finished with 3 mm (t) medium density fibreboard (MDF) facing. The facings were fixed onto the sub-facing by glue.

The meeting edge was unequal single rebated type.

1 number of 20 mm (w) x 4 mm (t) intumescent seal with side plastic fins was fitted into groove on along meeting edge close to the rebate corner of the active leaf. The intumescent seal was not interrupted.

1 number of 10 mm (w) x 4 mm (t) intumescent seal was fitted into groove along meeting edge close to rebate corner of the inactive leaf. The width of intumescent seal was reduced at strike plate position.

1 number of rebate corner smoke seal was adhered along the meeting edge rebate corner on the inactive leaf. The smoke seal was not interrupted except being halved at the strike plate position.

The door lippings were made of wooden strips.

3.1.3 Glazed Elements

The specimen comprised of seven glazed elements.

On the inactive leaf there were six glazed elements: the top most glazed element was overall sized 775 mm (w) x 225 mm (h); the second top glazed element was overall sized 325 mm (w) x 450 mm (h); and there were four glazed elements sized 115 mm (w) x 200 mm (h) at the bottom. On the active leaf there were one glazed element overall sized 275 mm (w) x 1625 mm (h). The positions of the glazed elements refer to the drawings provided by the test sponsor.

The glazed elements were comprised of nominal 25 mm (t) interlayered glass pane. The glass pane was lined by ceramic fibre and clamped by 1 mm (t) stainless steel (SS) angles. The stainless steel angles were fixed onto the door leaf by ø4 x 25 mm wood screws. On top of that was 25 mm (width, parallel to the glass) x 14.5 mm (thick, perpendicular to the glass) chamfered glazing beads with bolection return. The glazing beads were fixed onto the door leaf by wood nails at approximate 200 mm centre to centre.

The edges of the glass panes were caulked with fire sealant.

3.1.4 Overhead Panel

The specimen comprised of an overhead panel. The overhead panel was sized 2698 mm (w) x 550 mm (h).

The framework of the overhead panel was made of 3 numbers of 45 mm (w) x 38 mm (t) wooden slabs. The core of the overhead panel was filled with 38 mm (t) perlite board.

The overhead panel was fixed to the framework by ø5 x 75 mm wood screws at approximate 250 mm centre to centre.

3.1.5 Side Glazed Panel

The specimen comprised of a glazed side panel visually sized 325 mm (w) x 2270 mm (h).

The glazed elements were comprised of nominal 25 mm (t) interlayered glass pane. 1 mm (t) stainless steel angle was pre-fixed onto the framework at the aperture rebate. The glass pane was lined by ceramic fibre and pushed to the aperture rebate by another angle. The stainless steel angles were fixed onto the framework by ø4 x 25 mm wood screws. On top of that 20 mm (width, parallel to the glass) x 28 mm (thick, perpendicular to the glass) rounded glazing beads were fixed onto the framework by wood nails at approximate 200 mm centre to centre.

3.1.6 Ironmongeries

Each door leaf was supported into the door frame by 4 numbers of butt hinge. The top and bottom hinges were installed approximate 150 mm away edges.

1 number of mortised lock with lever handle was installed at 1100 mm above the bottom edge of the active leaf.

1 number of door closer was regular arm surface mounted at the top rim of each door leaf approximate 250 mm away from the hinge edge on the pull side.

1 number of flush bolt was installed at the top of meeting edge on the inactive leaf. The flush bolt was NOT locked during the QT13-061 test; while the flush bolt was locked during the QT13-060 test.

1 number of barrel bolt was installed at the bottom edge near the meeting edge on the push side of inactive leaf.

1 number of conceal bottom active drop seal was installed at the bottom edge on each door leaf.

Fire sealant was applied to the mortised area of ironmongeries.

The door locks and flush bolts were NOT locked nor latched during the QT13-060 and QT13-061 tests.

3.2 Material Schedule

Parts specifications were summarized in the following tables. The specifications are shared by both Door A and Door B unless specified.

A star mark "*" indicates those not being verified by FORTE.

Conceal Bottom Smoke Seal

Supplier:	Garish Crown Fire Engineering & Consultancy
Brand:	Raven
Model:	RP8Si / RP308Si (replacement)

Rebate Corner Smoke Seal

Supplier:	Garish Crown Fire Engineering & Consultancy
Brand:	Raven
Model:	RP120
Sizes:	12 mm by 12 mm
Material:	Rigid and Flexible Flame Retardant PVC *

Intumescent Material – Door Edges

Supplier:	Leung's Wooden Co., Ltd.	
Brand:	Lorient	
Model:	LP3004 / LP2004 / LP1004	
Sizes:	Door Frame	20 mm by 4 mm and 10 mm by 4 mm
	Door Meeting Edge	20 mm by 4 mm (with plastic fins) and 10 mm by 4 mm
	Bottom Edge	30 mm by 4 mm
	Framework around Panels	30 mm by 4 mm

Door Sub-frame

Supplier:	Leung's Wooden Co., Ltd.
Material:	Flim Plywood
Density:	350 kg/m^3 *
Sizes:	18 mm by 100 mm
Fixing Method to Structural Opening:	Screws with Plastic Plug

Door Frame

Manufacturer:	Leung's Wooden Co., Ltd.
Materials:	Hardwood
Density:	550 - 700 kg/m^3 *
Overall Sizes:	2764 mm by 2961 mm
Dimensions:	100 mm by 50 mm
Rebate:	20 mm
Connection Method of Head to Jamb:	Mitered Joint with Groove and Tongue; Fixed by Wood Screws
Connection Method of Transom to Jamb:	Mortise and Tenon; Fixed by Wood Screws
Fixing Method to Sub-frame:	Wood Screws and Metal Pins
Gap Filling between Door Frame and Sub-frame:	Fire Sealant

Architraves

Manufacturer:	Leung's Wooden Co., Ltd.
Material	Hardwood
Density of hardwood:	550 - 700 kg/m^3 *
Density:	950 ±100 kg/m^3 *
Overall Sizes:	45 mm by 12 mm

Door Leaves

Manufacturer:		Leung's Wooden Co., Ltd.
Overall Sizes:		1100+1200 mm by 2338 mm by 50 mm
Stiles and Rails	Material:	Wooden Slabs
	Width:	45 mm
	Thickness:	38 mm
	Density:	350 - 450 kg/m^3 *
	Moisture Content:	12 - 17% *
Core	Supplier:	Leung's Wooden Co., Ltd.
	Material:	Perlite
	Thickness:	38 mm
	Density:	380 kg/m^3 *

Door Leaf Lippings

Manufacturer:	Leung's Wooden Co., Ltd.
Material:	Hardwood
Density:	550 - 700 kg/m^3 *
Thickness:	8 mm

Door Leaf Facings

Supplier:	Leung's Wooden Co., Ltd.
Material:	Medium Density Fiberboard
Density:	350 - 450 kg/m^3 *
Thickness:	3 mm

Door Leaf Sub-facings

Supplier:	Leung's Wooden Co., Ltd.
Brand:	Gemtree *
Description	Fire Rated Board
Density:	950 ± 100 kg/m^3 *
Thickness:	3 ± 0.5 mm

Glazed Element – Glass Pane

Supplier:	Leung's Wooden Co., Ltd.		
Brand - Model:	Hangbao *		
Nominal Thickness:	25 mm		
Full Sizes / Visual Sizes:		Full Sizes	Visual Sizes
	Pane1 – Active Leaf	275 mm by 1625 mm	225 mm by 1575 mm
	Pane 2 - Inactive Leaf	775 mm by 225 mm	725 mm by 175 mm
	Pane 3 - Inactive Leaf	325 mm by 450 mm	275 mm by 400 mm
	Pane 4 - Inactive Leaf	115 mm by 200 mm	65 mm by 150 mm
	Pane 5 - Inactive Leaf	115 mm by 200 mm	65 mm by 150 mm
	Pane 6 - Inactive Leaf	115 mm by 200 mm	65 mm by 150 mm
	Pane 7 - Inactive Leaf	115 mm by 200 mm	65 mm by 150 mm
Fixing Method:	Lined by Mineral Wool, Clamped by Stainless Steel Angles and Wooden Glazing Beads on Both Sides		

Glazed Element – Fixing Angles

Supplier:	Leung's Wooden Co., Ltd.
Material:	Stainless Steel *
Thickness:	1 mm

Glazed Element – Mineral Wool

Supplier:	Garish Crown Fire Engineering & Consultancy
Material:	Fire Resistant Wool (Ceramic Fiber Tape) *
Density:	200 kg/m^3 *
Locations of Application:	Glass Pane Liner

Glazed Element – Glazing Beads

Manufacturer:	Leung's Wooden Co., Ltd.
Material:	Hardwood
Density:	550 - 700 kg/m^3 *
Sizes:	25 mm by 14.5 mm
Fixing Method:	Wood Nails at Approximate 200 mm Centre to Centre

Door Selector

Supplier:	Leung's Wooden Co., Ltd.
Brand:	BONCO
Model:	B5-DS-053

Butt Hinges

Supplier:	Leung's Wooden Co., Ltd.
Brand:	Valance
Model:	3044-2BB
Sizes:	102 mm by 102 mm by 3 mm

Door Closers

Supplier:	Leung's Wooden Co., Ltd.
Brand:	Bonco
Model:	B3-2003

Flush Bolts

Supplier:	Leung's Wooden Co., Ltd.
Brand:	Valance
Model:	FB-150-ST
Sizes:	150 mm long and 200 mm long

Door Lock

Supplier:	Leung's Wooden Co., Ltd.
Brand:	Miwa
Model:	U9 LHTA64-1-B / S76-D.7.50-58-ST
Sizes:	105 mm by 175 mm by 25 mm

Fixing – Door Frame

Supplier:	Leung's Wooden Co., Ltd.
Brand:	Howin – HMF
Size:	10 by 72 mm Screws with Metal Plug

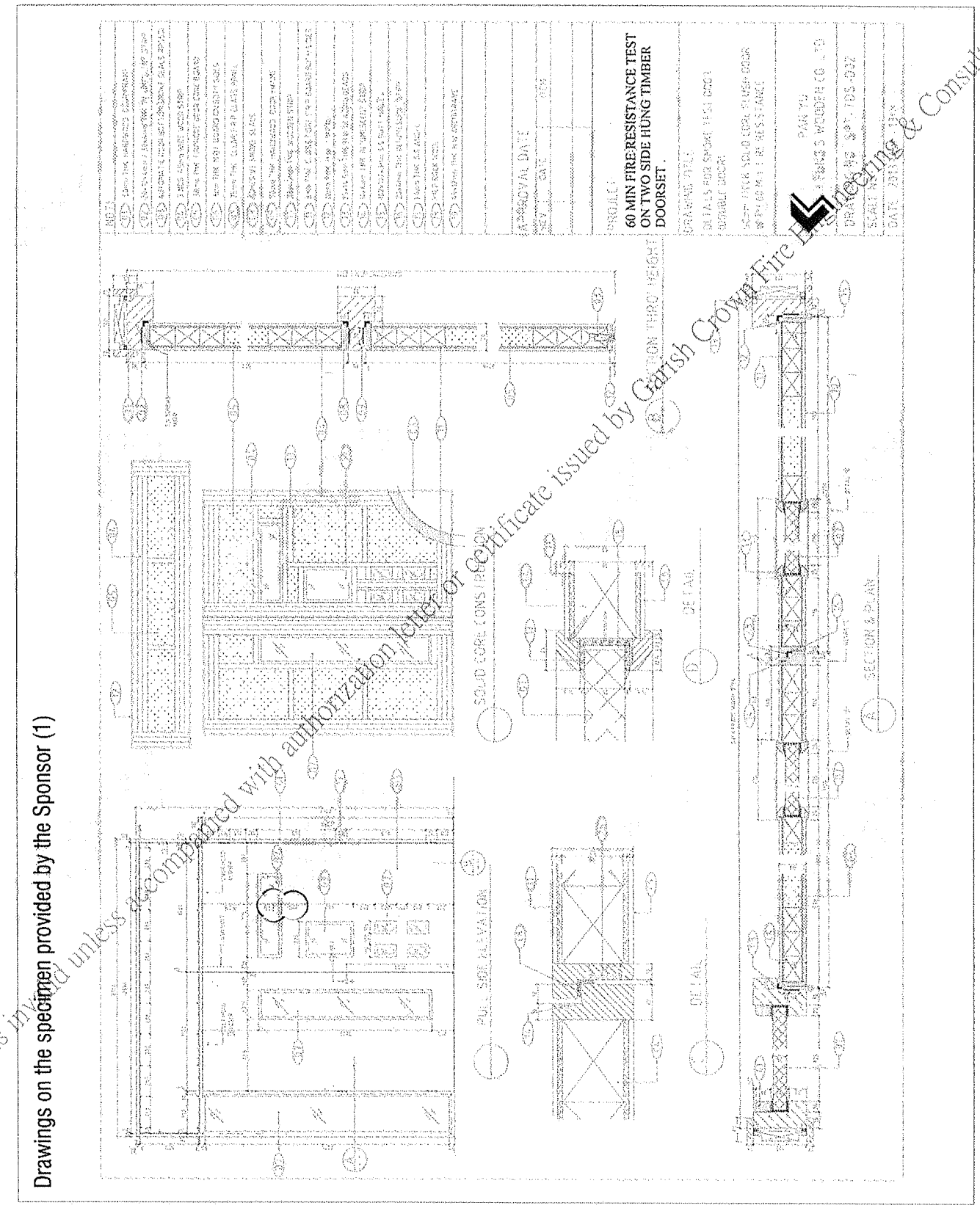
Fire Sealant

Supplier:	Garish Crown Fire Engineering and Consultancy
Brand:	FIREMATE
Model:	Not Provided

Glue

Supplier:	Leung's Wooden Co., Ltd.
Brand:	Not Provided
Type:	木膠粉 *

3.3 Drawings on the Specimen provided by the Sponsor (Total 1 page)



Drawings on the specimen provided by the Sponsor (1)

4. Specimens Condition

4.1 Selection of the Specimens

The specimens were selected by the Sponsor and submitted to the Test Location. FORTE did not involve in the selection of the specimens.

All the components of the test specimens were supplied by the Sponsor.

4.2 Verification of the Specimens

In *section 3.2* of this report, items which had been verified by FORTE was clearly identified and distinguished from those relying on Sponsor's declaration.

4.3 Supporting Construction

The specimens were fixed into a structural opening sized 2816 mm (w) x 3000 mm (h) made of steel hollow sections. The space between specimen and the test frame was sealed by a drywall partition.

The drywall partition was constructed by steel studs and channels with single layer gypsum board fixed on both sides.

4.4 Installation of the Specimens

The specimens were assembled and installed by workers delegated by the Sponsor on 2013-04-23 for QT13-060A and on 2013-04-27 for QT13-061A.

Specimen No.	Orientation	Test No.	
QT 13-060A	Door leaf could only be swung outwards the test chamber	Ambient	QT 13-060A
		Medium	QT 13-060B
QT 13-061A	Door leaf could only be swung inwards the test chamber	Ambient	QT 13-061A
		Medium	QT 13-061B

4.5 Specimens Conditioning

The specimens were stored in the Test Location from 2013-04-22; the date which specimens were received, to 2013-04-25 for QT13-060A and 2013-04-30 for QT13-061A, the date which smoke leakage test was performed.

The average environment parameters in the Test Location within this period were:

Ambient Temperature (°C)	Relative Humidity (%)
30 ± 10	50 ± 10

5. Test Method

5.1 Pre-test Conditioning

The pre-test conditionings of the specimens were carried out on 2013-04-25 for QT13-060A and 2013-04-27 for QT13-061A prior to the smoke leakage test with reference to *BS EN 1634-3: 2004* and *clause 5.1, BS EN 14600: 2005.*

5.2 Smoke Leakage Test

5.2.1 Symbols and Designation

Symbol	Unit	Designation
Q	m^3/h	Leakage rate
Q_{app}	m^3/h	Apparatus leakage rate
$Q_{sup/assoc}$	m^3/h	Supporting/associated construction leakage rate
Q_{spec}	m^3/h	Test specimen leakage rate
Q_t	m^3/h	Total leakage rate
Q_l	$m^3/h/m$	Linear leakage rate

5.2.2 Sequence of Testing

For each specimen, the test was carried out in the following sequence:

a) Determine the leakage rate through the test chamber and any supporting or associated construction at ambient temperature i.e. $Q_{app}^{(20)} + Q_{sup/assoc}^{(20)}$

b) Determine the total leakage rate at ambient temperature i.e. $Q_t^{(20)}$

c) Determine the total leakage rate at medium temperature i.e. $Q_t^{(200)}$

d) Determine the leakage rate through the apparatus and any supporting and associated construction at medium temperature 200°C i.e. $Q_{app}^{(200)} + Q_{sup/assoc}^{(200)}$

5.2.3 Ambient Temperature

The leakage rate through the specimen was measured at pressure difference 10 Pa, 25 Pa and 50 Pa, or for at the pressure difference specified by the Sponsor. During the measurement of the leakage rate the pressure difference was maintained for 2 minutes and the value of $Q_{spec}^{(20)}$ was established at the end of this period using:

$$Q_{spec}^{(20)} = Q_t^{(20)} - \left(Q_{app}^{(20)} + Q_{sup/assoc}^{(20)}\right)$$

$$Q_l^{(20)} = Q_{spec}^{(20)} / "length\ of\ gap^*"$$

*where the "length of gap" is defined in *Clause 10.2.2.1; BS EN 1634-3: 2004.*

5.2.4 Medium Temperature

The average air temperature close to the face of the specimen was raised from ambient temperature to the 200 ± 20 °C in 30 ± 5 minutes. The temperature distribution over the face of the specimen was monitored by 9 numbers of type K (*Figure 1*) thermocouples positioned 100 ± 50 mm from the exposed face of the test specimen. During the heating up period, neutral pressure was maintained in the test chamber.

The leakage rate through the test specimen was measured at pressure differences of 10 Pa, 25 Pa and 50 Pa, or at pressure difference specified by the Sponsor. These measurements were taken within 10 minutes of achieving the test temperature. During measurement of the leakage rate the pressure difference was maintained for 2 minutes and the value of $Q_{spec}^{(200)}$ established at the end of this period using:

$$Q_{spec}^{(200)} = Q_t^{(200)} - \left(Q_{app}^{(200)} + Q_{sup/assoc}^{(200)}\right)$$

5.3 Deflection Measurements

Measurements of the deflection of the test specimens were taken with a steel rule from cross line lasers across the top, mid-height and bottom of the specimens during the medium temperature smoke leakage test.

The positions of deflection measurement points are shown in *Figure 3*.

Figure 1. Position of thermocouples and pressure measuring probe inside the pressure chamber.

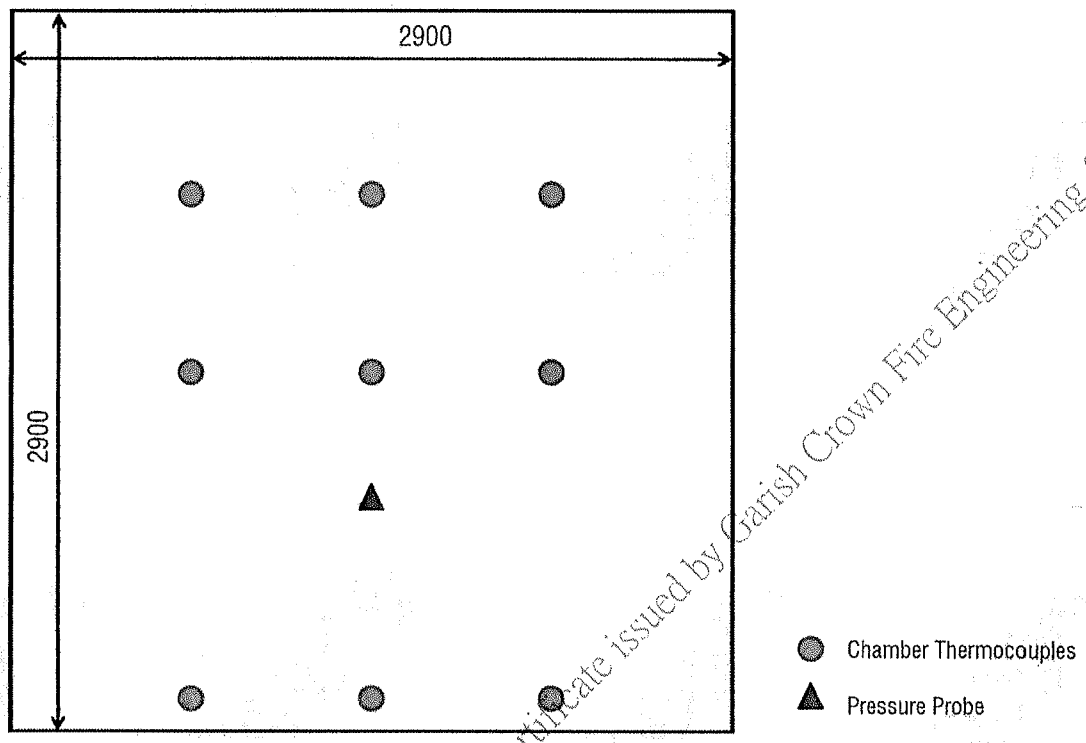


Figure 2. Primary gaps measurement positions.

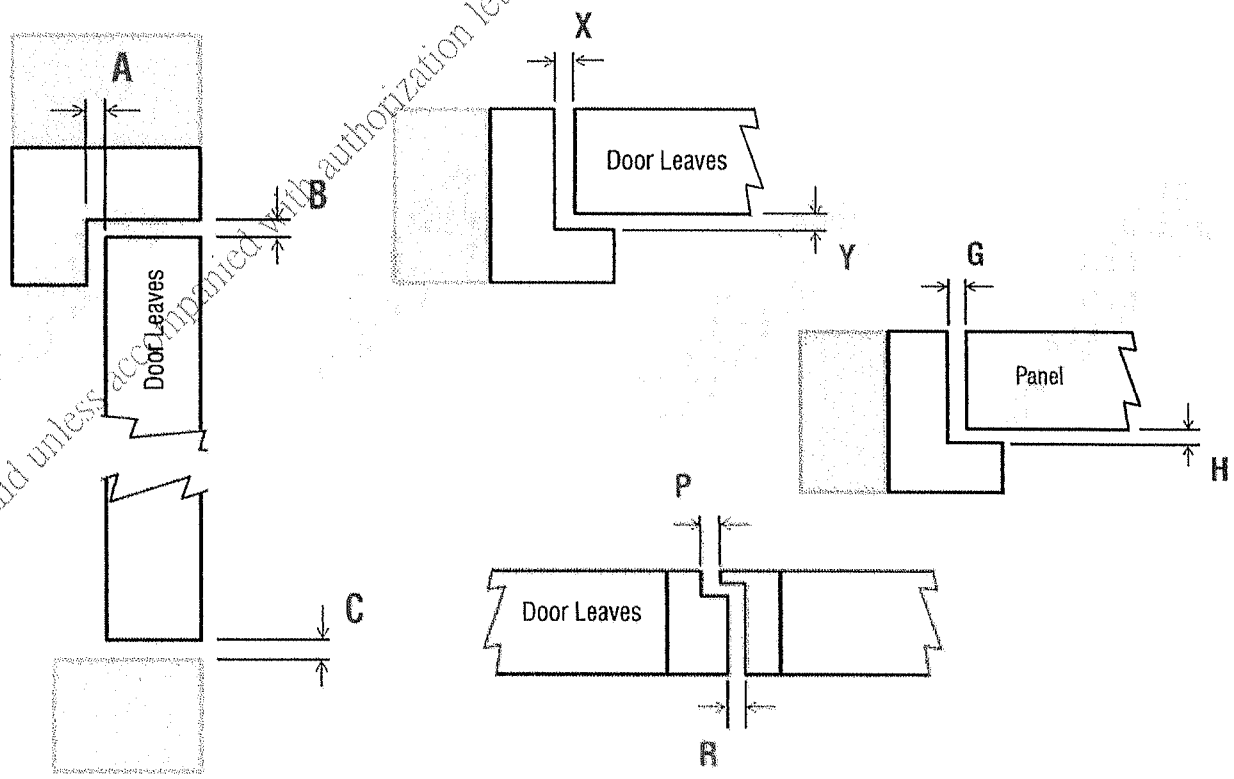


Figure 3a. Position of deflection measurement on Specimen QT13-060A (outward movement)

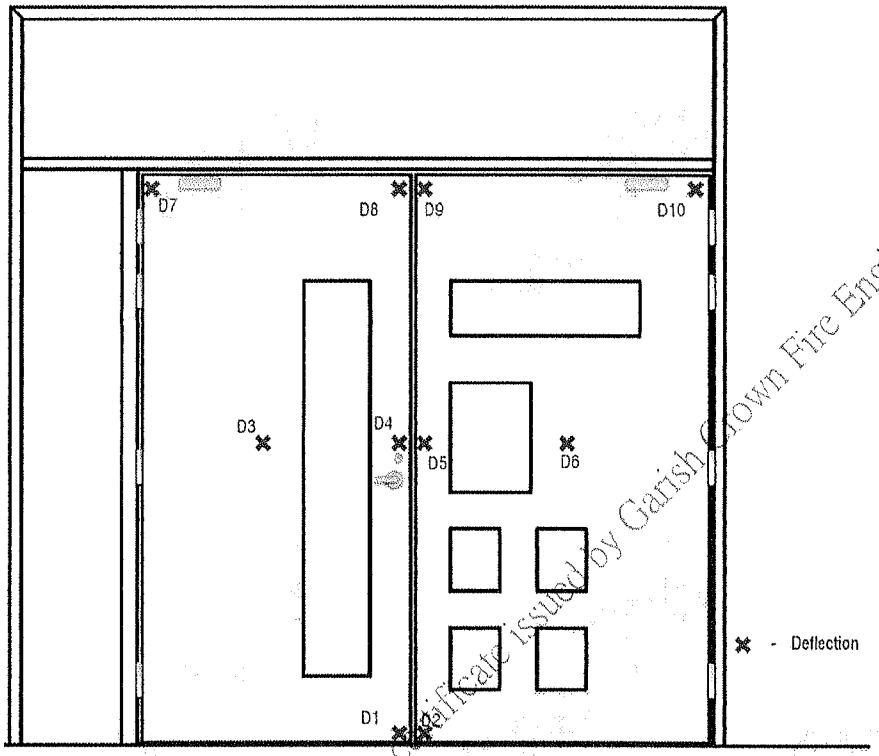
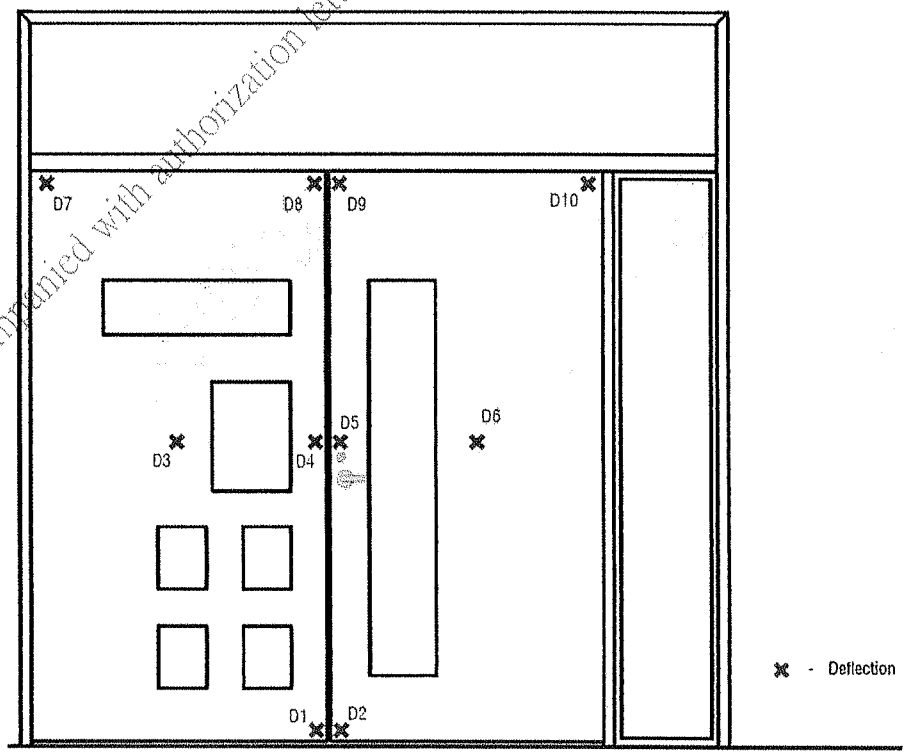


Figure 3b. Position of deflection measurement on Specimen QT13-061A (inward movement)



6. Test Data

6.1 Specimen QT13-060A [Test QT13-060A & QT13-060B]

6.1.1 Ambient Temperature

The ambient temperature at the commencement of test was 28.4°C.

6.1.2 Retention Forces

The retention forces on the door leaf of the specimen for each direction of opening were determined. The respective highest gauge measurements are summarized in the following table.

Leaf	Push	Pull
Active	95.6 N	97.2 N
Inactive	77.9 N	67.3 N

6.1.3 Gap Measurements

6.1.3.1 Primary gap width

Primary gap widths of the specimen were measured and summarized in the following table. The measurement positions are shown in *Figure 2*.

Measurements were taken in mm.

Primary Gap Width			
Gap	Measured		
	Minimum	Maximum	Average
A	2.6	4.0	3.2
B	1.5	3.1	2.1
C	5.0	9.8	6.9
X	2.3	4.2	3.0
Y	3.0	4.9	3.9
P	1.5	3.0	2.4
R	1.8	4.0	3.0
G	1.7	4.1	2.8
H	1.3	2.7	2.0

6.1.3.2 Length of Gap

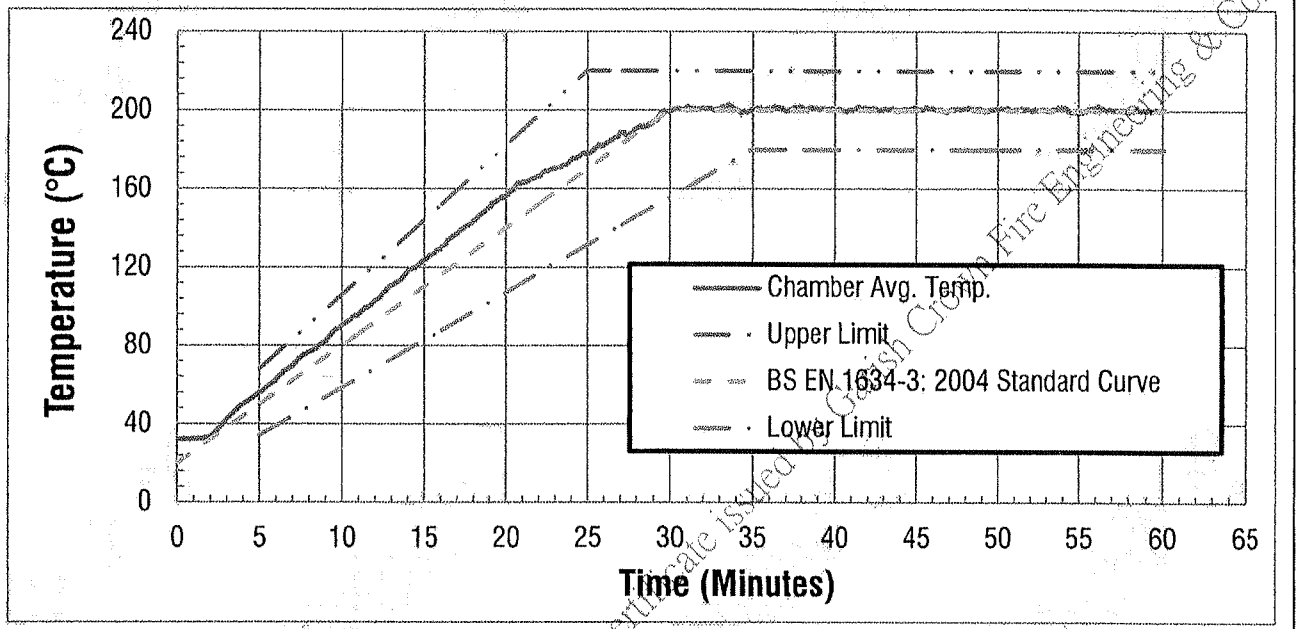
"Length of Gap" of the specimen

= 2269 mm + (2325 mm x 3) = 9.224 m

6.1.4 Chamber Temperature

The chamber temperature over the medium temperature smoke leakage test period is shown in *Figure 4*.

Figure 4. The chamber temperature over the medium temperature smoke leakage test.



6.1.5 Lateral Deflections

Measured lateral deflections over the medium temperature smoke leakage test period are summarized in the following table.

A positive measurement indicates a movement towards into the pressure chamber and vice versa.

Measurements were taken in mm.

Maximum deflection measured was -6 mm at D4, D5 and D6 at 60 minute of test.

Position \ Time (min)	0	5	10	15	20	25	30	31.5	34	36.5	60
D1	+0	+0	+0	+0	+0	+0	+0	+0	+0	-2	+0
D2	+0	+0	+1	+0	+0	-2	-2	-2	-2	-2	-2
D3	+0	+1	+3	+4	+4	+5	+4	+4	+4	+2	-1
D4	+0	+1	+2	+3	+3	+4	+4	+3	+1	+0	-6
D5	+0	+1	+2	+1	+2	+4	+2	+2	+2	+0	-6
D6	+0	+1	+2	+2	+3	+4	+4	+4	+3	+2	-6
D7	+0	+1	+1	+1	+1	+1	+1	+1	+1	+0	+0
D8	+0	+0	+1	+0	+0	+1	+0	+0	-1	-2	-1
D9	+0	+1	+1	+1	+1	+1	+0	+0	-1	-2	-3
D10	+0	+0	+0	+0	+0	+0	+1	+1	+0	+0	+1

6.1.6 Observations

Significant behaviours of the specimen during the test period are summarized in the following table.

Photos taken during the test period are also attached.

6.1.6.1 Ambient Temperature Smoke Leakage Test

No significant changes of the specimen were observed.

6.1.6.2 Medium Temperature Smoke Leakage Test

Time (min.sec)	Observation (from unexposed side)
00.00	Test started.
31.04	The interlayer on the glass pane of side panel started to react. Bubble-like features developed on the glass pane.
34.52	Smoke was released from the hinge positions and the top of meeting edge.
36.13	The interlayer on the glass pane of the active leaf started to react.
60.05	Termination of heating and pressurization.
After the end of heating and pressurization	**Damages on the specimen:** The cases of the intumescent strips and the rebate corner smoke seal were softened. Some reacted intumescent was observed at the end of intumescent strip. The door lipping separated slightly from the door leaves. Cracks were observed at several positions on the door frame of the specimen. **Door operability after test:** The door leaf could be fully-opened manually.

6.1.7 Photos

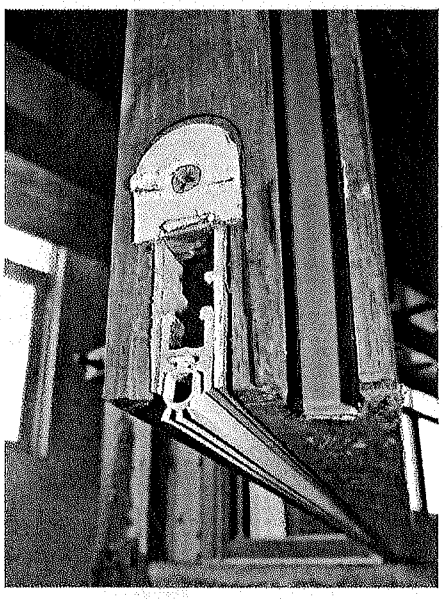


Photo 1. Bottom smoke seal on the active leaf before medium smoke test.

Photo 2. Door lock before medium temperature test.

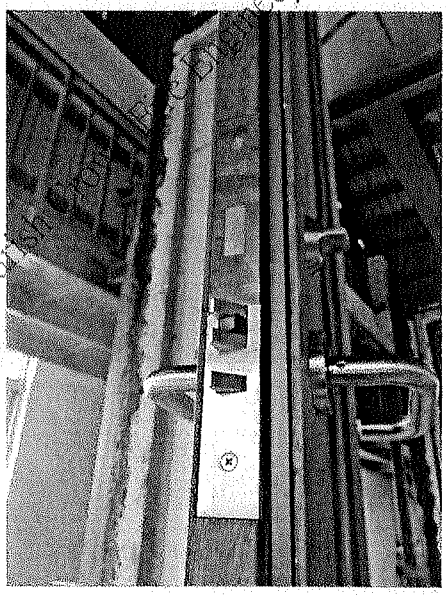


Photo 3. Bottom smoke seal on the inactive leaf before medium temperature test.

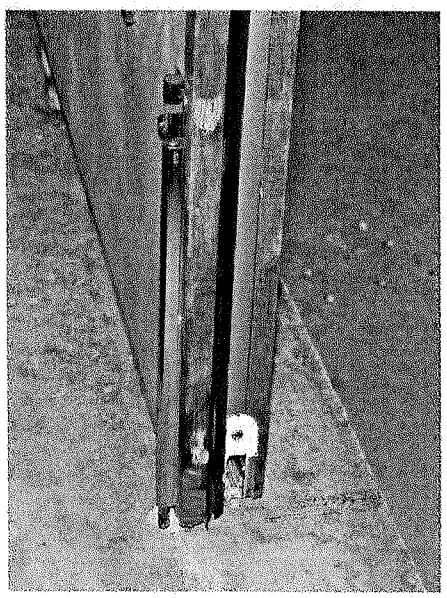


Photo 4. Barrel bolt on the inactive leaf before medium temperature test.

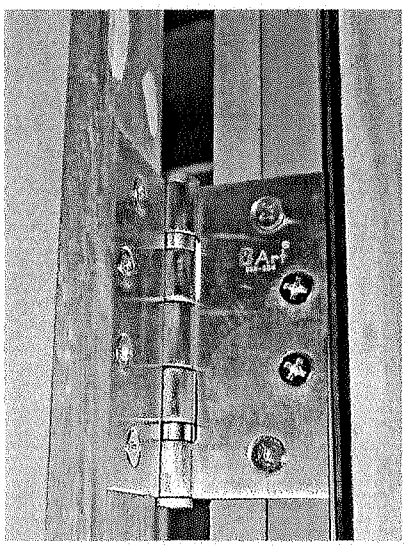


Photo 5. Door hinge on the inactive leaf before medium temperature test.

Photo 6. Exposed side of the specimen before medium temperature test.

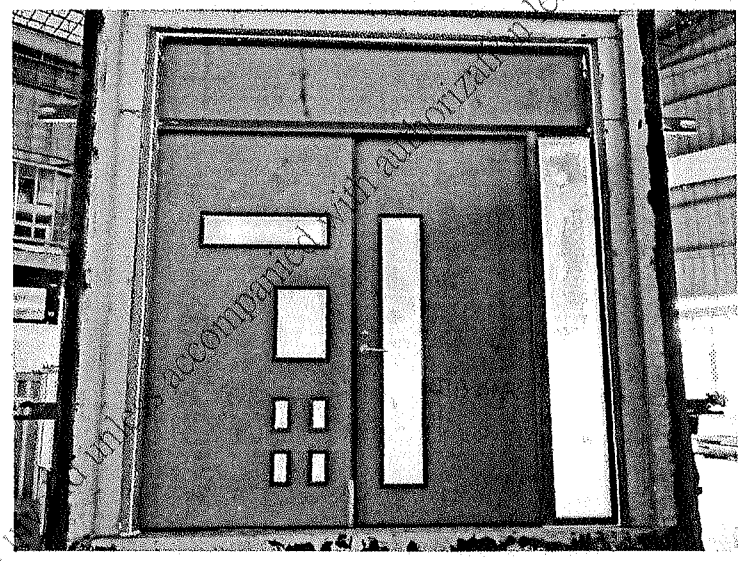


Photo 7. Exposed side of the specimen after medium temperature test.

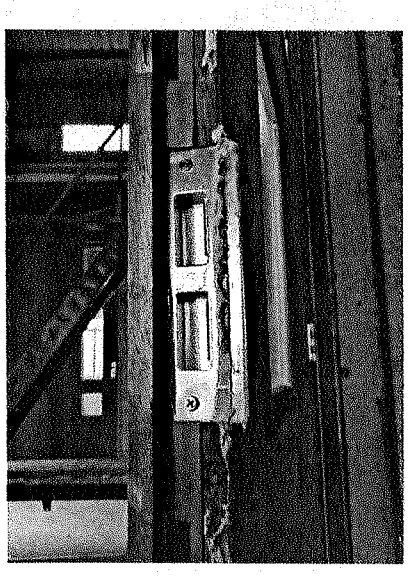


Photo 8. Strike plate position after medium temperature test.

6.2 Specimen QT13-061A [Test QT13-061A & QT13-061B]

6.2.1 Ambient Temperature

The ambient temperature at the commencement of test was 29.4°C.

6.2.2 Retention Forces

The retention forces on the door leaf of the specimen for each direction of opening were determined. The respective highest gauge measurements are summarized in the following table.

Leaf	Push	Pull
Active	92.9 N	88.2 N
Inactive	91.2 N	87.5 N

6.2.3 Gap Measurement

6.2.3.1 Primary gap width

Primary gap widths of the specimen were measured and summarized in the following table. The measurement positions are shown in *Figure 2*.

Measurements were taken in mm.

Primary Gap Width			
Gap	Measured		
	Minimum	Maximum	Average
A	1.2	6.0	3.9
B	1.0	2.7	3.7
C	4.4	8.0	5.9
X	2.0	3.8	2.7
Y	1.0	3.5	2.3
P	1.9	2.9	2.2
R	2.2	3.5	2.9
G	0.5	2.9	1.7
H	1.0	2.6	1.6

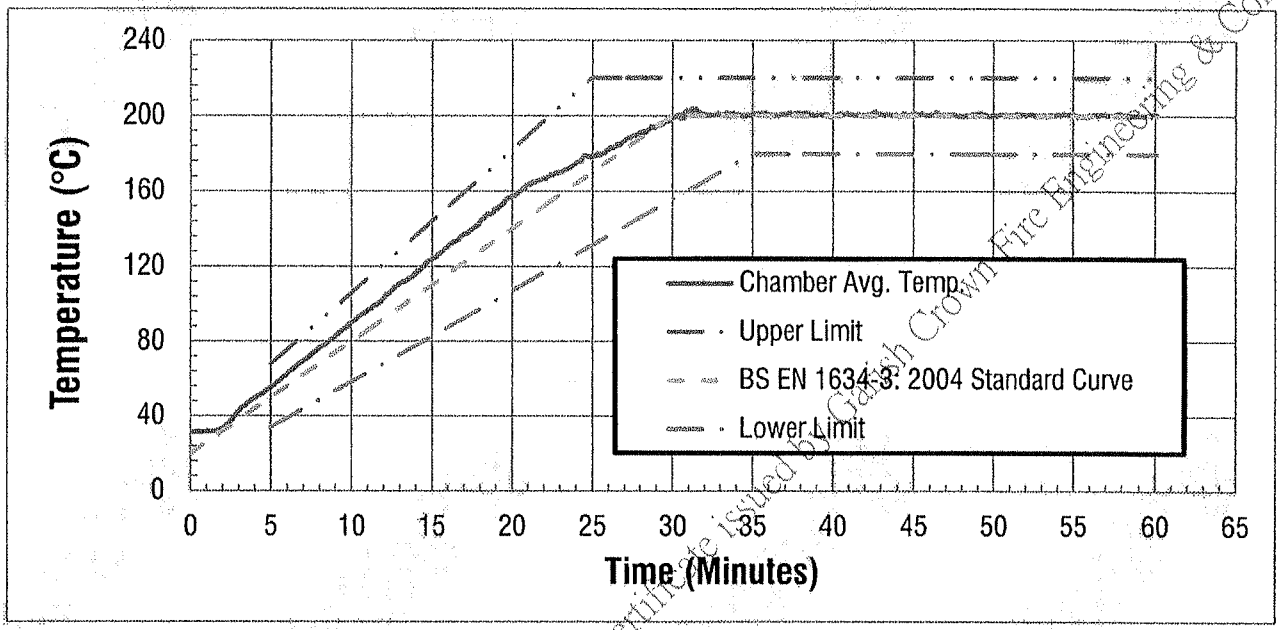
6.2.3.2 Length of Gap

"Length of Gap" of the specimen
= 2309 mm + (2345 mm x 3) = 9.334 m

6.2.4 Chamber Temperature

The chamber temperature over the medium temperature smoke leakage test period is shown in figure 5.

Figure 5. The chamber temperature over the medium temperature smoke leakage test.



6.2.5 Lateral Deflection

Measured lateral deflections over the medium temperature smoke leakage test period are summarized in the following table.

A positive measurement indicates a movement towards into the pressure chamber and vice versa.

Measurements were taken in mm.

Maximum deflection measured was -11 mm at D4 at 60 minute of test.

Position \ Time (min)	0	5	10	15	20	25	30	31.5	34	36.5	60
D1	+0	+0	+1	+1	+1	+1	+0	-1	+0	-4	-5
D2	+0	+0	+1	+1	+1	+1	+0	-1	-1	-4	-5
D3	+0	+0	+2	+3	+5	+4	+3	+3	+2	+1	-8
D4	+0	+0	+3	+3	+4	+4	+2	+2	+0	-2	-11
D5	+0	+0	+4	+4	+6	+5	+3	+3	+1	-1	-10
D6	+0	+6	+3	+5	+5	+7	+5	+5	+4	+2	-7
D7	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+1
D8	+0	+3	+1	+3	+1	+4	+1	+1	+0	-1	-3
D9	+0	+2	+1	+2	+2	+2	+1	+0	+0	-2	-5
D10	+0	+2	+2	+2	+2	+2	+2	+1	+1	+1	+0

6.2.6 Observations

Significant behaviours of the specimen during the test period are summarized in the following table.

Photos taken during the test period are also attached.

6.2.6.1 Ambient Temperature Smoke Leakage Test

No significant changes of the specimen were observed.

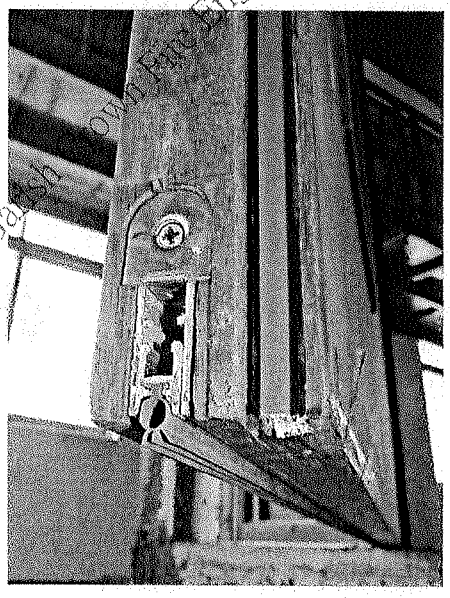
6.2.6.2 Medium Temperature Smoke Leakage Test

Time (min.sec)	Observation (from unexposed side)
00.00	Test started.
32.30	The interlayer of glass pane on the side panel started to react and turning translucent.
36.11	Smoke was released from the bottom edge of the door leaves. The glass panes on the door leaves reacted and formed bubble-like features in the interlayer.
60.14	Termination of heating and pressurization.
After the end of heating and pressurization	**Damages on the specimen:** The cases of the intumescent strips and the rebate corner smoke seal were softened. Some reacted intumescent was observed at the end of intumescent strip. Cracks were observed at several positions on the door frame of the specimen. The door lipping and glazing beads separated slightly from the door leaf. The casing of the door closer on the active leaf deformed. **Door operability after test:** The door leaf could be fully-opened manually.

6.2.7 Photos

Photo 1. Door lock before the medium temperature test.

Photo 2. Bottom smoke seal on the active leaf before the medium temperature test.



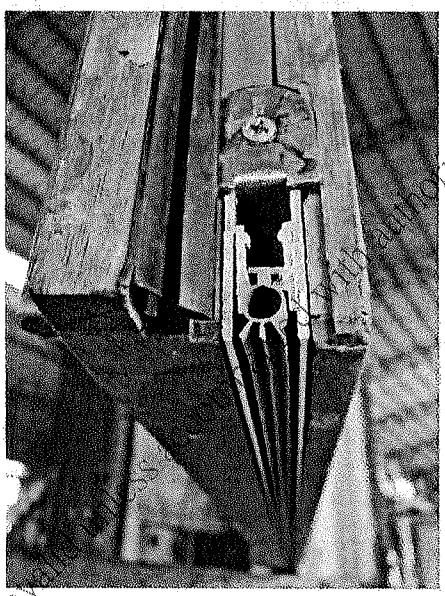


Photo 3. Bottom smoke seal on the inactive leaf before the medium temperature test.

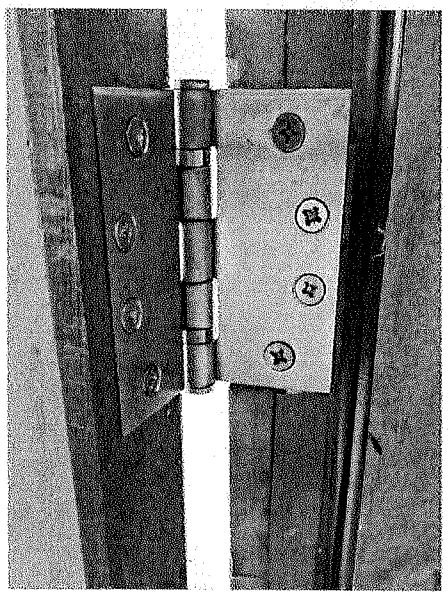


Photo 4. Door hinge before the medium temperature test.

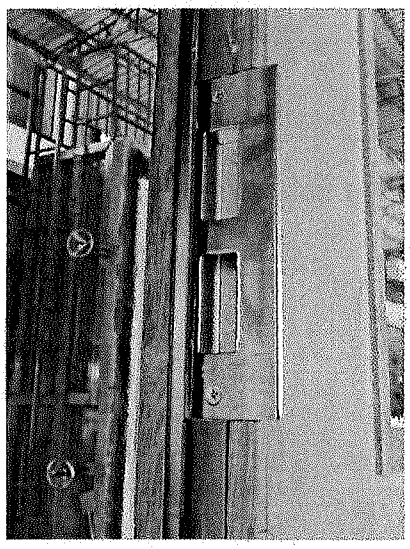


Photo 5. Strike plate position before the medium temperature test.

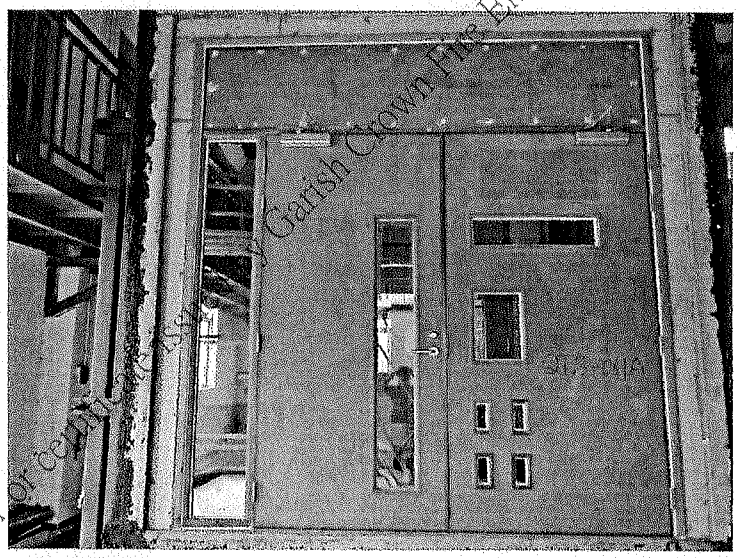


Photo 6. Expose side of the specimen before medium temperature test.

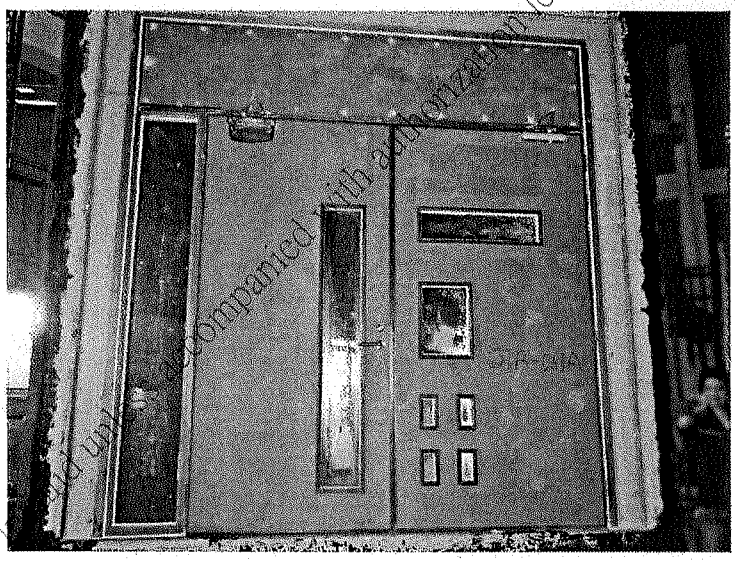


Photo 7. Expose side of the specimen after medium temperature test.

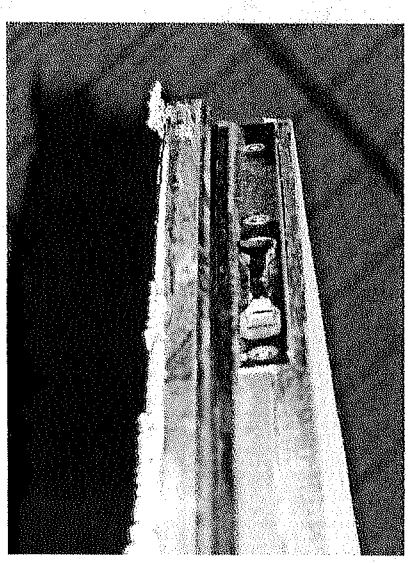


Photo 8. Top flush bolt after the medium temperature test.

7. Test Results

7.1 Standard Test Results

From the test data obtained from the smoke leakage tests, leakage rates for each test specimen were calculated and are summarized in the following table.

No. of Test	Test no. (Face exposed to pressure)	Temperature & Conditions	Leakage rate Q_{spec} (m^3/h) at pressure difference of			Linear Leakage Rate Q_l ($m^3/h/m$) at pressure difference of	
			10 Pa	25 Pa	50 Pa	25 Pa	50 Pa
1	QT13-060A (Swing Outwards)	Ambient (threshold sealed)	2.33	8.74	15.96	**0.95**$^{+}$	1.73
		Ambient	2.51	6.51	**11.02***	0.71	1.19
2	QT13-060B (Swing Outwards)	Medium (200°C)	<0.1	1.33	**4.39***		
3	QT13-061A (Swing Inwards)	Ambient (threshold sealed)	2.39	10.48	19.60	**1.12**$^{+}$	2.10
		Ambient	1.07	3.87	**7.01***	0.41	0.75
4	QT13-061B (Swing Inwards)	Medium (200°C)	<0.1	3.99	**9.15***		

[$^{+}$ & *] Description on smoke leakage performance criteria for classification of smoke control door and shutter assemblies are quoted in *Appendix A*.

7.2 Additional Test Results

Additional smoke leakage tests were carried out to obtain information on smoke leakage performance on particular parts of the specimen. The additional test data were calculated and are summarized in the following table. These data was obtained for information only.

No. of Test	Test no. (Face exposed to pressure)	Temperature & Conditions		Leakage rate Q_{spec} (m^3/h) at pressure difference of		
				10 Pa	25 Pa	50 Pa
1	QT13-060A (Swing Outwards)	Ambient	Door Leaves Only; Side & Overhead Panels Sealed	2.01	8.69	15.86
			Side & Overhead Panels Only; Door Leaves Sealed	<0.1	0.22	0.41
3	QT13-061A (Swing Inwards)	Ambient	Door Leaves Only; Side & Overhead Panels Sealed	2.95	9.85	17.63
			Side & Overhead Panels Only; Door Leaves Sealed	<0.1	0.83	1.77

8 Limitations

This report details the method of construction, the test conditions and the results obtained when the specific element of construction described herein was tested following the procedure outlined in *BS EN 1363-1*, and where appropriate *BS EN 1363-2*. Any significant deviation with respect to size, construction details, loads, stresses, edge or end conditions other than those allowed under the field of direct application in the relevant test method is not covered by this report.

Because of the nature of fire resistance testing and the consequent difficulty in quantifying the uncertainty of measurement of fire resistance, it is not possible to provide a stated degree of accuracy of the result.

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9 Field of Direct Application

The field of direct application of test results is restricted to the allowable changes which a sponsor may make to the tested specimen following a successful smoke leakage test. These variations may be introduced automatically without the need for the sponsor to seek additional evaluation, calculation or approval.

The series of rules and guidelines are defined in *Clause 13 "Field of direct application of test results", BS EN 1634-3: 2004* and relevant clauses and annexes. Permitted variations away from the test specimen include 1) construction of assembly, 2) size and aspect ratio, 3) glazing, 4) supporting constructions and 5) Seals.

Appendix A

Definitions on Smoke leakage S_a and S_m in *BS EN 1634-3: 2004*

Statements concerning definitions on smoke leakage S_a and S_m stated in *BS EN 1634-3* are quoted:

British Standards Institution, London, 2007 - BS EN 1634-3: 2004 Incorporating corrigendum no. 1 "Fire resistance and smoke control tests for door and shutter assemblies, openable windows and elements of building hardware – Part 3: Smoke control test for door and shutter assemblies", 3.1.4 & 3.1.5

3.1.4 **Smoke leakage S_a**

Ambient temperature smoke leakage classification as defined in *7.5.6.3.1 of EN 13501-2: 2003*.

3.1.5 **Smoke leakage S_m**

Ambient plus medium temperature (200°C) smoke leakage classification as defined in *7.5.6.3.1 of EN 13501-2: 2003*.

Performance Criteria of Smoke Leakage in *BS EN 13501-2: 2003*

Statements concerning performance criteria of smoke leakage in *BS EN 13501-2: 2003* are quoted:

British Standards Institution, London, 2003 - BS EN 13501-2: 2003 "Fire classification of construction products and building elements – Part 2: Classification using data from fire resistance tests, excluding ventilation services", 5.2.7 & 7.5.6.3.1

5.2 **Resistance to fire performance characteristics**

5.2.7 **S – Smoke leakage**

Smoke leakage S is the ability of the element to reduce or eliminate the passage of gases or smoke from one side of the element to the other.

$^{+}$ **S_a** considers smoke leakage at ambient temperature only.

* **S_m** considers smoke leakage at both ambient temperature and at 200°C.

7.5.6.3 **Performance criteria**

7.5.6.3.1 **Smoke leakage**

This is the ability of the element to reduce or eliminate the passage of smoke from one side of the door to the other. The following performance levels are defined:

a) *smoke leakage **S_m** – when the maximum leakage rate measured at both ambient temperature and 200°C and up to a pressure of 50 Pa does not exceed 20 m^3/h for a single leaf doorset, or 30 m^3/h for a double leaf doorset;

b) $^{+}$ smoke leakage **S_a** – when the maximum leakage rate measured at ambient temperature, and at a pressure of up to 25 Pa only, does not exceed 3 m^3/h per meter length of gap between the fixed and movable components of the doorset (e.g. between the door leaf and door frame), excluding leakage at the threshold.

END OF REPORT