

**A**  
**Calibration Report**  
**of the**  
**Heat Soak Process Oven Serial No.: CS-HST-1507**  
**For**  
广东中融玻璃科技有限公司  
**To**  
**BS EN 14179-1:2016**

Prepared by: **JAS (Inspection & Testing) Ltd.**

Test Date: 8<sup>th</sup> October 2024

Report Date: 10<sup>th</sup> October 2024

Our Ref.: J24-190-R01-241010



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## 1. INTRODUCTION

### 1.1 Heat Soak Test Process

This test was conducted at the request of the glass manufacturer – 广东中融玻璃科技有限公司 to calibrate their Heat Soak Test Process Serial No.: CS-HST-1507, which is located at 肇慶高新區迎賓大道 6 號之二.

The European Standard EN 14179-1:2016 "Glass in building - Heat soaked thermally toughened soda lime silicate safety glass – Part 1: Definition and description" describes the methodology required to calibrate a heat soak test. The procedure adopted for the methodology described herein was taken from the Heat Soak Process calibration method described in this standard. This was used as the test method for all general and particular requirements.

Heat Soak Testing (HST) is a destructive test method for detecting the presence of Nickel Sulphide (NiS) inclusions in tempered glass. NiS is recognized as a major cause of spontaneous fracture that can occur in tempered glass. The process of HST involves holding the temperature of the glass at 260°C for a period of several hours.

广东中融 Heat Soak Serial No.: CS-HST-1507, manufactured by Foshan Cusen Glass Machinery Co., Ltd. was selected for the calibration.

广东中融

Heat Soak Oven  
"CS-HST-1507"

Internal size

1.9m (h) x 2.8m (w) x  
6.5m (d)

(Front Door)



## 1.2 Spontaneous Breakage due to NiS

The sudden fracture of tempered glass can be caused by an expansion of NiS stones as a result of the slow allotropic transformation from the  $\alpha$ -NiS (high temperature/low volume state) to  $\beta$ -NiS (low temperature/high volume state).

During the tempering process the NiS transforms to the high temperature  $\alpha$  state, however when the rapid cooling, necessary to achieve the surface compression for FT glass, takes place the NiS cannot transform to the  $\beta$  status. Instead this reversal process occurs over a long period of time that can take to up to 10 years to complete.

The HST involves the glass being kept at an elevated temperature of 260°C for several hours so that the  $\alpha$  to  $\beta$  transformation is accelerated.

The panels of glass that have been subjected to HST and have potentially destructive NiS inclusions should break during the HST process, however until the EN-14179 standard was developed, there was no a firm guarantee that failures would not occur in the installed condition.

## 2. WITNESSES

Test Consultant

Mr. Jin Chen

**JAS (Inspection & Testing) Ltd.**

Glass Manufacturer

Mr. Zhong Liang Jin

广东中融玻璃科技有限公司

### 3. TEST INFORMATION

#### 3.1 Sample and Preparation

Heat Soak Oven

Internal size

1.9m (h) x 2.8m (w) x  
6.5m (d)

One Double sided stillage

Classified as 1<sup>st</sup> category



In order to evaluate the performance of the Heat Soak Oven, test with a full load trial were conducted. As there was 1 double sided stillage in the oven, its category was defined as 1<sup>st</sup> category.

In this evaluation, JAS was co-operating with 广东中融玻璃科技有限公司 to establish the air temperature and time required for all specified glass surface locations to reach 250°C for a full load operation to fulfill the EN14179-1:2016 requirement.

##### 3.1.1 Full Load

| Height (mm) | Width (mm) | Thickness (mm) | Qty. | Surface Area (m <sup>2</sup> ) | Weight (kg)<br>Density (2,500kg/m <sup>3</sup> ) | Weight (kg)<br>Density (2,650kg/m <sup>3</sup> ) |
|-------------|------------|----------------|------|--------------------------------|--------------------------------------------------|--------------------------------------------------|
| 2499        | 1854       | 8              | 5    | 23.2                           | 463.3                                            | 491.1                                            |
| 1270        | 1160       | 6              | 114  | 167.9                          | 2519.2                                           | 2670.3                                           |
| 1160        | 2035       | 8              | 1    | 2.4                            | 47.2                                             | 50.0                                             |
| 360         | 1100       | 8              | 5    | 2.0                            | 39.6                                             | 42.0                                             |
| Total:      |            |                |      | 195.5                          | 3069.3                                           | 3253.5                                           |

\* Control Panels

### 3.2 Heat Soak Process System

- a. The maximum internal size of the Oven for the evaluation is 1.9m (h) x 2.8m (w) x 6.5m (d).
- b. Hot air heated by an electric heater is introduced into the oven by means of convection. The heated air in the box is extracted with an air blower.
- c. The air circulation is unhindered around each glass pane.
- d. In the event of glass breakage, the airflow is not hindered.
- e. The airflow in the oven moves from bottom to top and is parallel to the long side of the oven. Due to the ovens configuration, the glass is orientated to this direction, parallel to the long sides.
- f. Distribution of glass temperature was monitored with 20 thermocouples that electronically connected to a data acquisition unit. The temperature figures were shown in 'real time' on the screen and were monitored during the entire process.

### 3.3 Control Settings

|                            |
|----------------------------|
| Full Load Setting          |
| Heating Time: 035sec /°C   |
| Holding Temperature: 260°C |
| Holding Time: 160 minutes  |
| Glass Temperature: 250°C   |
| Cooling Temperature: 50°C  |

### 3.4 Separator

20mm thick polyamide cubes were used at the top and bottom edges between glass panels.

## **4. TEST PROCEDURE**

The following procedures as required by EN 14179-1:2016 were carried out.

- a. Check and record the sizes of the glass panels.
- b. Ensure a minimum spacing of 20mm is present, recommended for separation of the glass panels to ensure that the heated air can circulate between the glass panels.
- c. For full load evaluation - Attach 20 nos. thermocouples on the glass panels' surfaces according to BS EN 14179-1:2016, Figure A.2 (1<sup>st</sup> category – 1 double sided stillage – full load).
- d. Close the oven door and record the start up Temperature of all thermocouples on the indicators.
- e. Start the automatic heating program.
- f. Record all thermocouple readings at 1 minute intervals.
- g. Record the time when the first thermocouple reaches 250°C and note the thermocouple reference number.
- h. Record the time when the last thermocouple reaches 250°C and note the thermocouple reference number.
- i. Record the time when the holding phase begins.
- j. Record the time when the cooling phase begins.
- k. Confirm that the doors of the oven were not allowed to open until the reading of the control element dropped to 70°C.
- l. Check the glass status; record any breakage of the glass panels.
- m. End.

## **5. OBSERVATION**

### **5.1 Heating Phase**

During the Heating Phase, the temperature recorded by each of the thermocouples increased at different rates. This is a normal occurrence in a HST chamber; the temperatures were different because of their respective distances from the hot air inlet, the pattern of air flow through the chamber, the location of the thermocouple on the glass and other variables.

The end of the heating phase (or the beginning of the holding phase) is defined as being when the last thermocouple reaches 250°C. This temperature was reached at 170 minutes for this evaluation.

JAS noted that no thermocouple on the glass surface exceed 290°C during the heating phase. The result was satisfactory.

### **5.2 Holding Phase**

The holding phase was ended on 314 minutes for this evaluation.

JAS noted that the Heat Soak Process Oven of 广东中融玻璃科技有限公司 was very stable, none of the thermocouples fell below 250°C during test. This fulfilled the requirements specified in EN 14179-1:2016.

### **5.3 Cooling Phase**

The Cooling Phase was started when the heaters switched off and the cooling fans switched on automatically to allow the oven temperature to drop as soon as possible. The door was only allowed to be opened when the control temperature was below 70°C.

#### 5.4 Record of the Full Load Test (Serial No.: CS-HST-1507)

Weight of Glass = 3,069.3 kg (2,500kg/m<sup>3</sup>)

Starting Time: 16:59 8<sup>th</sup> October 2024

Starting Temperature of the control element: 30°C

| Heating Phase                                                                  | Parameters  | Records           |
|--------------------------------------------------------------------------------|-------------|-------------------|
| Temperature of the control element (at any time).                              | $T_c$       | Refer to Fig.1    |
| Time for the first thermocouple and the glass to reach a temperature of 250°C. | $t_1$       | 125 minutes (#14) |
| Temperature of control element at time $t_1$ .                                 | $T_{c1}$    | 247°C             |
| Time for the last thermocouple and the glass to reach a temperature of 250°C.  | $t_{2a}$    | 170 minutes (#17) |
| Maximum temperature of the control element during the heating phase.           | $T_{cmax}$  | 265°C             |
| Time at which $T_{cmax}$ occurred.                                             | $t_{cmax}$  | 219 minutes       |
| Temperature of glass surfaces, measured by thermocouples (at any time).        | $T_{glass}$ | Refer to Fig.2    |

| Holding Phase              | Parameters  | Records           |
|----------------------------|-------------|-------------------|
| Started at                 | $t_{2b}$    | 170 minutes       |
| Glass surface temperatures | $T_{glass}$ | Between 250-270°C |

| Cooling Phase          | Parameters  | Records                            |
|------------------------|-------------|------------------------------------|
| Started at 314 minutes | $t_{2b+2h}$ | Actual Holding time = 144 minutes. |
| Ended at 420 minutes   | $T_c$       | 49°C                               |

| Results                           | Parameters | Records     |
|-----------------------------------|------------|-------------|
| Glass specimens status during HST | -          | No Breakage |

The Heat Soak Process was ended at 23:59 8<sup>th</sup> October 2024.

Total time 7 hours

## 6. SUMMARY OF THE TEST RESULT

### 6.1 Evaluation Summary

In this evaluation, JAS found that if the control settings as listed in section 3.3 were kept unchanged, the holding phase will be started at 170 minutes for a full load heat soaking.

The Heat Soak Process System Oven Serial No.: CS-HST-1507 of 广东中融玻璃科技有限公司 was calibrated and met the criteria as laid down in EN14179-1:2016 A.1. The time  $t_2$ , in this case 170 minutes (Heating Phase) will be used for all regular production irrespective of actual loading for these production runs.

Typical Time Chart

| Loading   | Test in October 2024    | Comment                            |
|-----------|-------------------------|------------------------------------|
|           | Heating Phase (minutes) |                                    |
| Full Load | *170                    | To be used for all production runs |

## 6.2 Heat Soak Temperature Records

### Records of Full Load

| Location | Heat up time (minute) to 250°C | Remark         | Max. Temp. Records | Remark      | Max. Heating Rate °C/minute | Occurs Time (minute) |
|----------|--------------------------------|----------------|--------------------|-------------|-----------------------------|----------------------|
| #1       | 135                            | -              | 259                | -           | 1.87                        | -                    |
| #2       | 145                            | -              | 257                | -           | 1.75                        | -                    |
| #3       | 126                            | 2nd to reach   | 264                | 3rd Highest | 2.11                        | -                    |
| #4       | 135                            | -              | 259                | -           | 1.74                        | -                    |
| #5       | 139                            | -              | 260                | -           | 1.75                        | -                    |
| #6       | 153                            | -              | 256                | -           | 1.77                        | @47 minute           |
| #7       | 155                            | -              | 255                | 3rd Lowest  | 2.02                        | -                    |
| #8       | 150                            | -              | 257                | -           | 1.76                        | -                    |
| #9       | 130                            | -              | 263                | 4th Highest | 1.80                        | -                    |
| #10      | 134                            | -              | 263                | -           | 1.78                        | -                    |
| #11      | 133                            | -              | 263                | -           | 1.84                        | -                    |
| #12      | 140                            | -              | 258                | -           | 1.80                        | -                    |
| #13      | 139                            | -              | 258                | -           | 2.01                        | -                    |
| #14      | 125                            | First to reach | 266                | The Highest | 2.27                        | -                    |
| #15      | 132                            | -              | 265                | 2nd Highest | 1.79                        | -                    |
| #16      | 155                            | -              | 256                | 4th Lowest  | 1.68                        | -                    |
| #17      | 170                            | Last           | 250                | The Lowest  | 1.68                        | -                    |
| #18      | 164                            | 2nd Last       | 252                | 2nd Lowest  | 1.80                        | -                    |
| #19      | 131                            | -              | 262                | -           | 1.76                        | -                    |
| #20      | 132                            | -              | 261                | -           | 1.78                        | -                    |

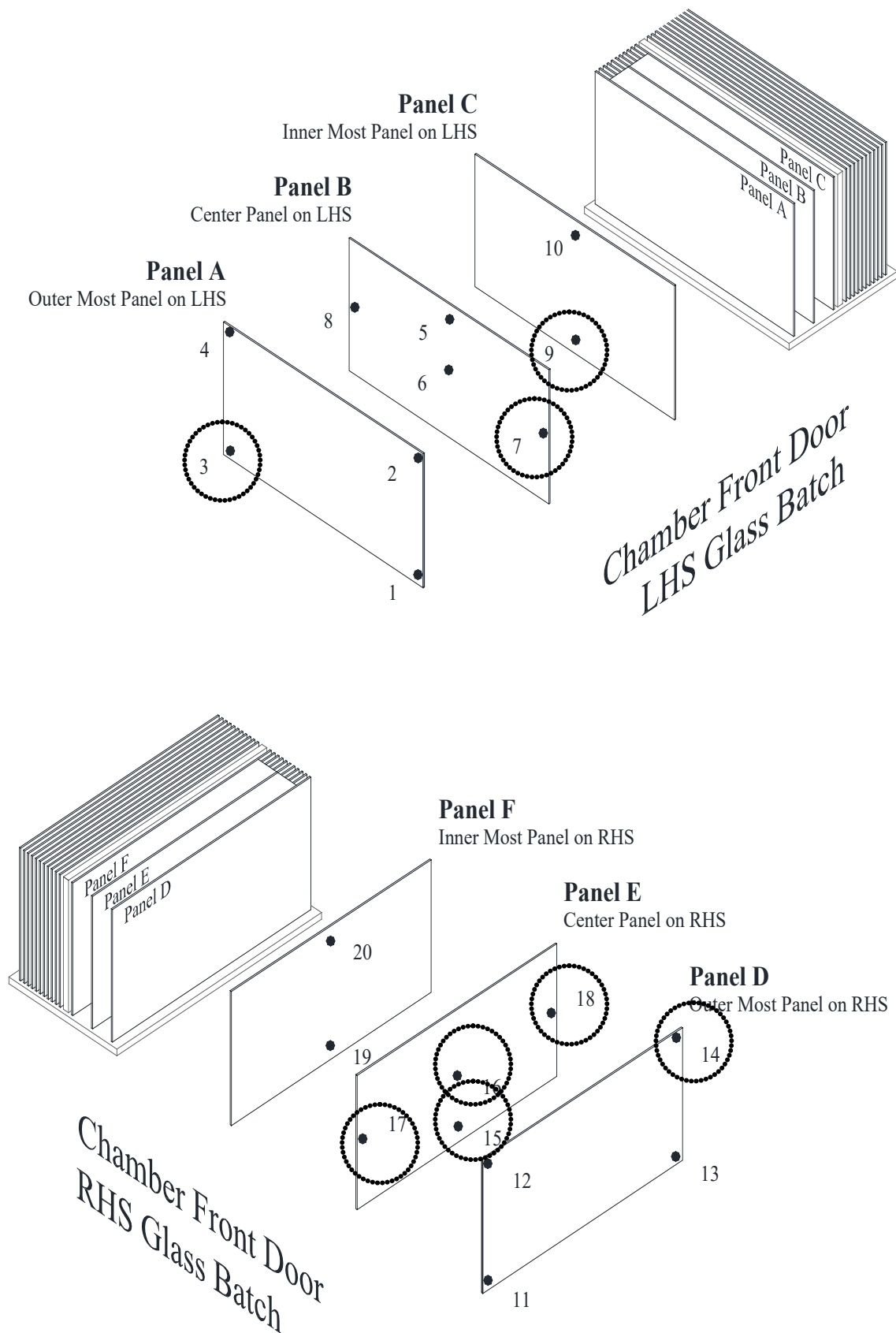
## 6.3 Records Summary

JAS suggest the 8 thermocouples to be used as follows:

| LHS glass batch |             | RHS glass batch |             |
|-----------------|-------------|-----------------|-------------|
| #3              | 3rd Highest | 14              | The Highest |
| #7              | 3rd Lowest  | 15              | 2nd Highest |
| #9              | 4th Highest | 16              | 4th Lowest  |
| -               | -           | 17              | The Lowest  |
| -               | -           | 18              | 2nd Lowest  |

For recalibrating and checking, all of the thermocouples should be used as required by the test.

## 6.4 Thermocouples Locations



## 6.5 JAS Suggestion

### Calibration of heat soak chamber / furnace

#### (a) Heat Soak Furnace Calibrate Schedule

The furnace shall be calibrated at least once a year.

#### (b) Thermocouples Calibrate Schedule

The thermocouples used for the temperature monitoring shall be calibrated at a minimum of every six months.

A minimum no. of 8 monitoring points on the glass surface are required, including the positions where the minimum and maximum surface temperatures for each side stillage during the calibration.

#### (c) Thermocouples Calibrate Schedule

The rate of heating shall be steadily increased. After an initial 15 minutes of Heating, the rate of heating of all glass panels shall be less than 3°C/min.

The maximum heating rate was recorded as follows:

| Max. rate of heating records | Location | Occurred Time (@ minute) | Allowable <3°C/min | Results      |
|------------------------------|----------|--------------------------|--------------------|--------------|
| 2.77                         | #14      | 89                       | <3°C/min           | Satisfactory |

## 6.6 Report Reviewed

### Reviewer

Mr. Michael P. K. Lam

**C. Eng, MIMechE, MHKIE**

## 7. CONCLUSION

The Heat Soak Process System Oven Serial No.: CS-HST-1507 of 广东中融玻璃科技有限公司 was tested in accordance to EN 14179-1:2016. With the control settings as listed in section 3.3 kept unchanged, the actual Holding phase will be more than the minimum 2 hours for the full loading test shown in this evaluation trial. Therefore the Result is Satisfactory.

The Heat Soak Process System Oven Serial No.: CS-HST-1507 of 广东中融玻璃科技有限公司 is capable of achieving, and operating in accordance with, the requirements of the Heat Soak Process to the requirements of EN14179-1:2016 and BD PNAP APP 37 under the following conditions.

1. Heating Time: 035sec/°C
2. Holding Temperature: 260°C
3. Holding Time: 160 minutes
4. Glass Temperature: 250°C
5. Cooling Temperature: 50°C
6. A minimum spacing of 20mm for separation of the glass panels.
7. Full Load = 3.07 Tonnes (< 8 Tonnes defined by Oven Manufacturer)
8. The maximum height of the tested glass = 2.499m
9. The Largest and the thickest glass panes should be monitored by one of the eight thermocouples in the oven for regular operation.
10. Due to the variation of the weight of glass, the setting parameters may change to achieve a minimum of the 170 minutes heating phase requirement.

I certify this is a true record of the test conducted.

Reported by



Mr. Mark Lau  
Test Engineer

Certified by



Mr. Sam Lau  
Managing Director



## **Appendices**

### I) Photographs

### II) Time Temperature graphs

- a. Fig. 1
- b. Fig. 2
- c. Fig. 3

### III) EN14179-1:2016 (E)

- d. Fig. A.2

# Appendix I

## Photo Records

# JAS (Inspection & Testing) Ltd.

## Inspection of Work - Photo Record

Project : Heat Soak Test for 广东中融玻璃科技有限公司



**Photo 1**

The heat soak oven CS-HST-1507 for  
广东中融玻璃科技有限公司



**Photo 2**

The heat soak oven was manufactured by  
Foshan Cusen.



**Photo 3**

Hot air inlet at the bottom of the oven.



**Photo 4**

Hot Air Return.



**Photo 5**

The heat soaking operation program.



**Photo 6**

Setting parameters.

# JAS (Inspection & Testing) Ltd.

## Inspection of Work - Photo Record

Project : Heat Soak Test for 广东中融玻璃科技有限公司



**Photo 7**

Separators were used to provide more than 20mm gap between glass panels.



**Photo 8**

Separators were used to provide more than 20mm gap between glass panels.



**Photo 9**

The highest pane was checked and recorded.



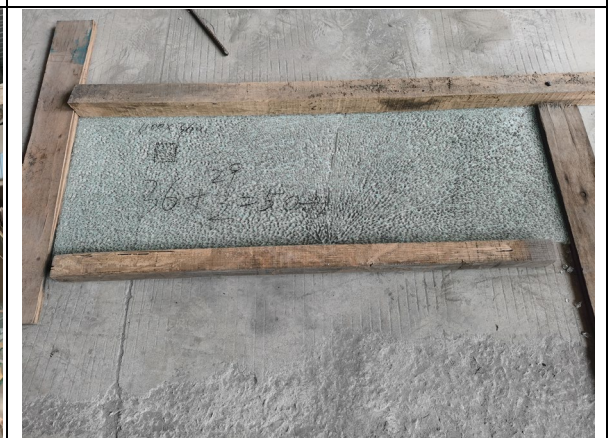
**Photo 10**

Full Loading Test



**Photo 11**

Control Panels

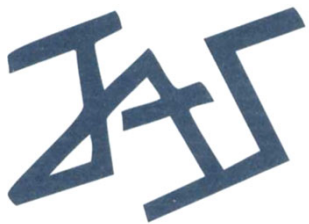


**Photo 12**

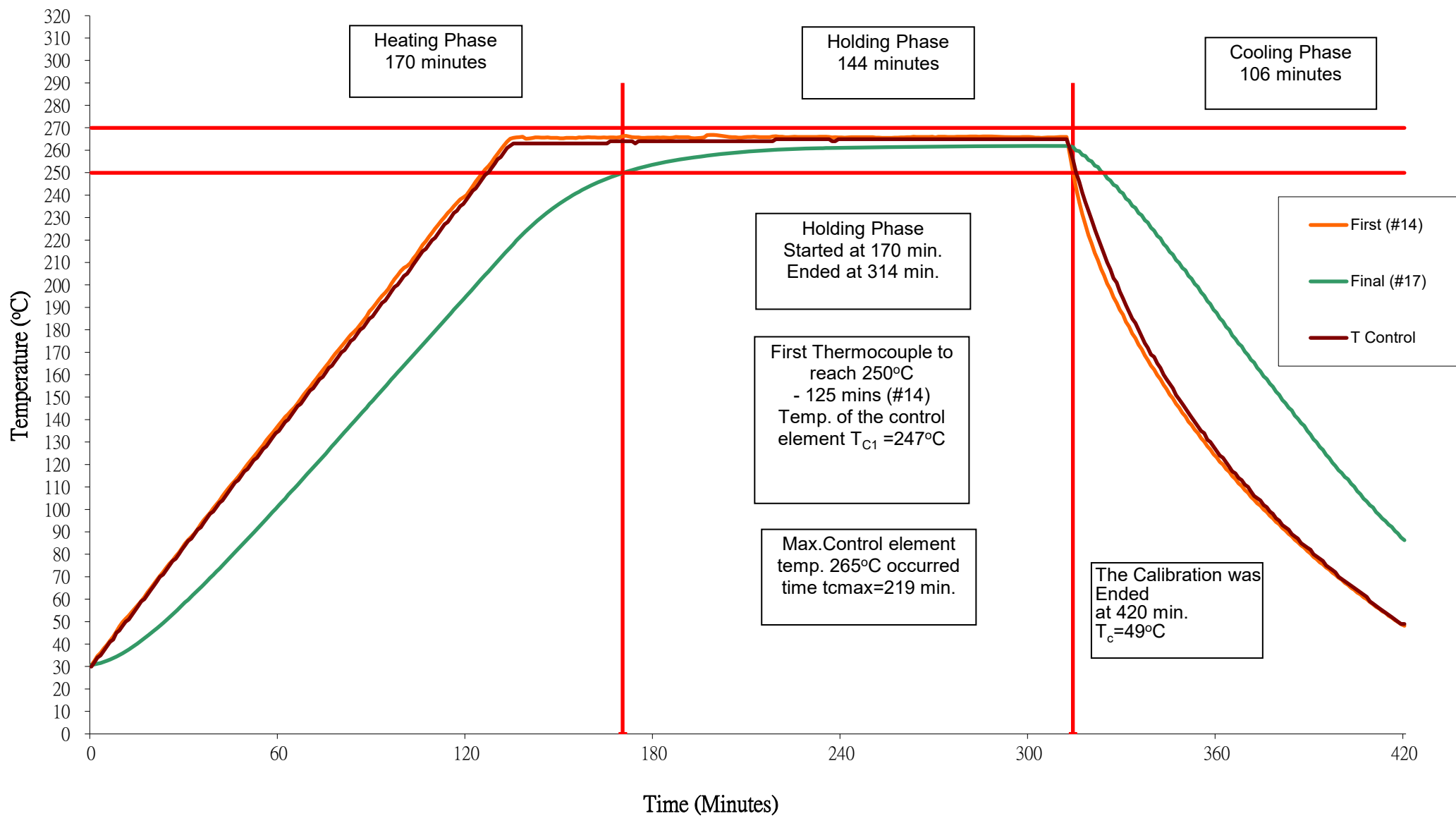
Fragmentation test  
The result was Satisfactory

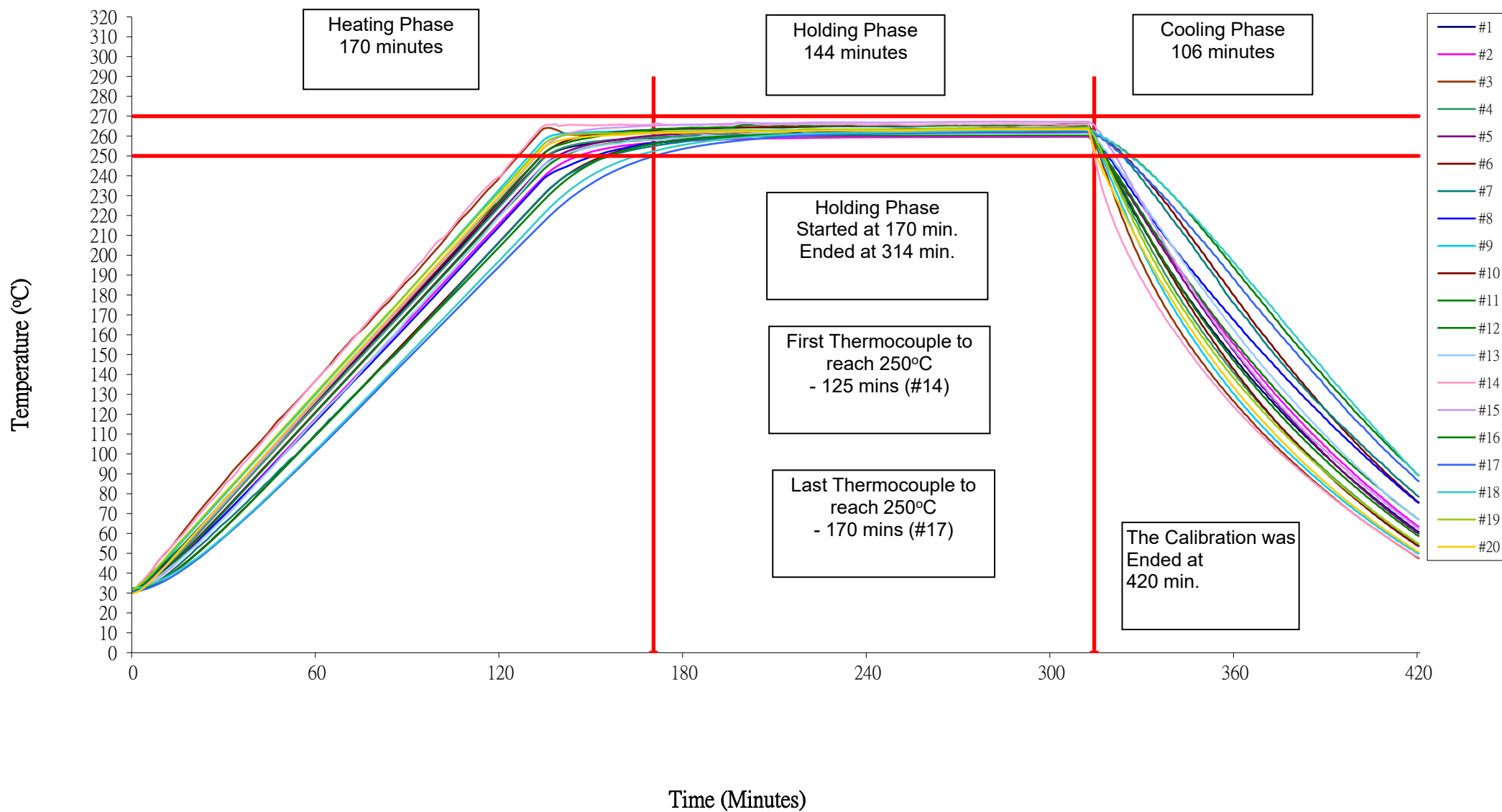
## Appendix II

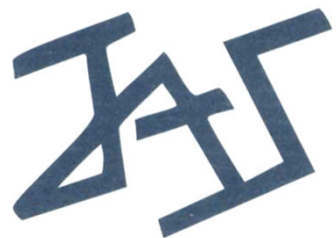
### Time Temperature graphs



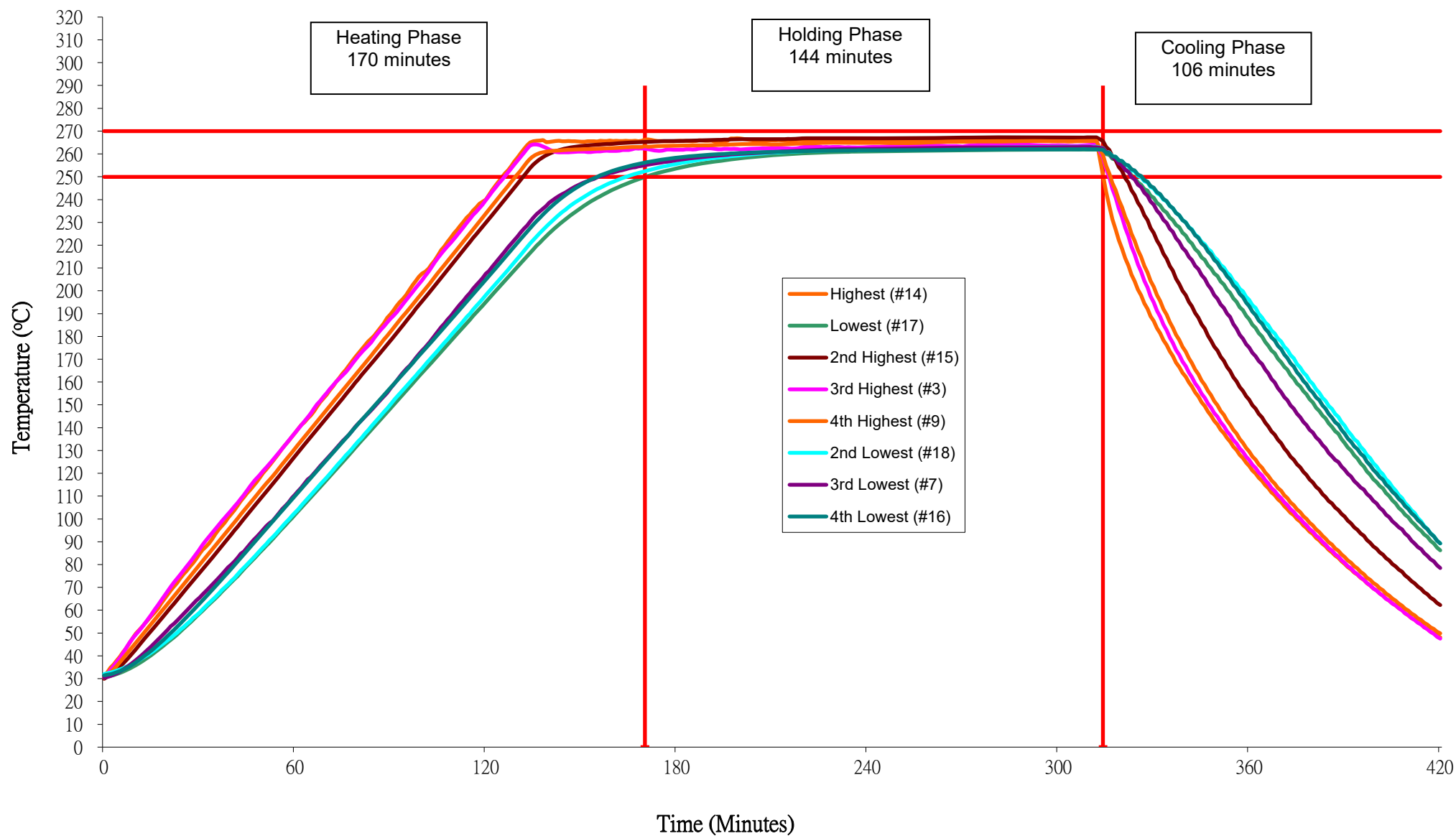
广东中融玻璃科技有限公司 (CS-HST-1507)  
**Heat Soak Test Oven Full Load Calibration**  
**Fig.1 Control Element Temperature Record**





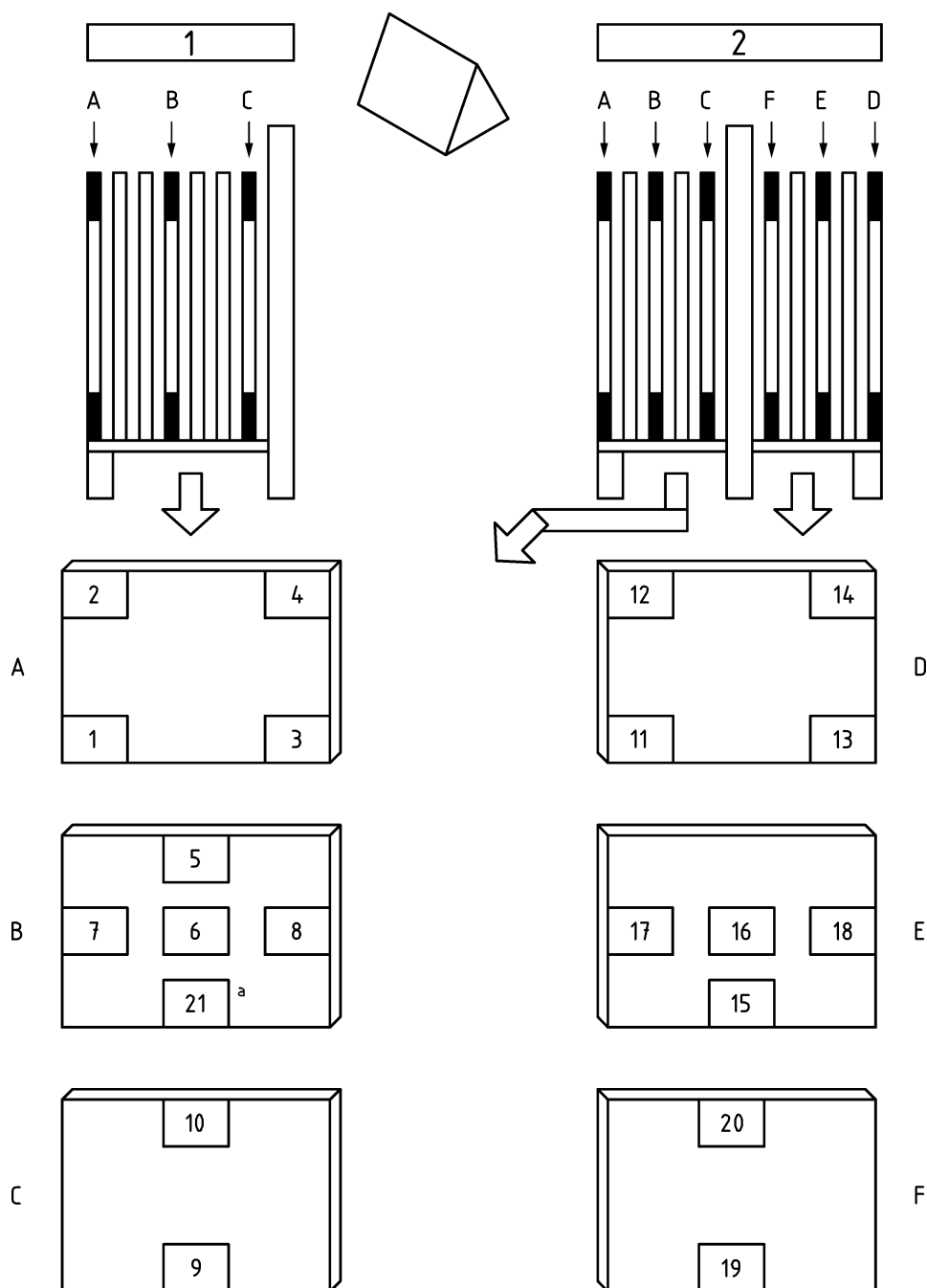


广东中融玻璃科技有限公司 (CS-HST-1507)  
**Heat Soak Test Oven Full Load Calibration**  
**Fig.3 4 x Highest and 4 x Lowest Temperature Records**



## Appendix III

EN14179-1:2016 (E)



Thermocouples should not be fixed nearer to the edge than 25 mm.

#### Key

<sup>a</sup> is only used for mono side stillages

1 mono side stillage

2 double sided stillage

**Figure A.2 — 1st category – 1 stillage – full load**