



Internet of Things and Food: ITaaU/FSA programme	
Project title:	Application of tiny tag data recorder to monitor the continuum of cold chain for long-life sandwiches and use of score safe hygiene software to evaluate their integrity
Principal investigator (institution):	<a href="#">Madeleine Smith</a>
Co-investigators/partners	Alaa Alaizoki
Description	The storage and distribution temperatures were monitored over the shelf life of ready to eat sandwiches in sample of 19 sandwich retailers and 2 distributors. The results were compared with self-reported storage temperatures.
Keywords	Sandwiches; temperature control; cold chain integrity
Project timeframe	January 2016-March 2016
Report date	23 March 2016

## 1. Executive summary

A survey of nineteen sandwich retailers in Birmingham revealed that 39% of the participants did not keep ready to eat sandwiches under correct temperature control. In two cases sandwiches were above the legal maximum of 8<sup>0</sup> C for more than 50% of their shelf life. Products stored in refrigerators reflected good temperature control while sandwiches in display chillers were frequently above 8<sup>0</sup> C for significant periods of time. The two participating distributors were fully compliant through the distribution and delivery. Food Business Operators' self-reported temperatures indicated no periods above 8<sup>0</sup> C, suggesting that the monitoring carried out by Food Business Operators as part of their food safety management systems may not accurately reflect the product temperatures, especially where products are kept in chillers.

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### 3. Aims, objectives and methods

The sandwich industry is a significant sector of the food industry. The British Sandwich Association suggests sandwiches contribute as much as £7.85bn to the UK economy. Sandwiches are ready to eat foods which have the potential to cause food borne illness in consumers if they are not hygienically made and properly stored (Boxall *et al* 2011; Little *et al* 2012). The normal shelf life of sandwiches is production plus 2-3 days, but Environmental Health Officers have noticed shelf lives of production plus 5 days (O'Neill, personal communication) and some long-life sandwiches have a 14 day shelf life (Brooks 2011) or longer (22 days) -see for example <http://www.quickfill.co.uk/> . Surveys of sandwiches have revealed unsatisfactory or unacceptable microbiological results in some of the sandwiches tested which were correlated with poor storage temperatures (FSAI 2010).

Food Business Operators are obliged under Article 5 of Regulation (EC) No 853/2004 of The European Parliament and of The Council to keep records of the monitoring at Critical Control Points in their Food Safety Management Systems. For Food Business Operators (FBOs) selling ready to eat sandwiches the storage temperature of the sandwiches and of the fillings would be a Critical Control Point (CCP) which they would be required to monitor and record. For the majority of small businesses, the operatives will make point measurements of temperature at pre-agreed times during the operation. However these are normally air temperatures in the chillers or refrigerators rather than actual food temperatures. The monitoring equipment used across the industry is not consistent. Some Food Business Operators use probes but many prefer laser thermometers as being easier to use. Others rely on the readout on the refrigerator or chiller (if there is one) or use static thermometers lying in the chiller.

Between May and October 2015, Public Health England conducted a survey of long-life sandwiches. The results are not yet published but officers at Birmingham City Council identified some unacceptable and some borderline ACC samples during their participation in this survey (O'Neill, personal communication). Given the link between poor quality microbiological results in sandwiches and poorly controlled temperatures during storage it was decided to assess the temperature storage regimes of sandwich retailers in Birmingham.

#### **Aim**

The aim of this study was to determine if the chilled storage of sandwiches on sale in Birmingham was compliant with the requirements of schedule 4 of The Food Safety and Hygiene (England) Regulations 2013.

The objectives of the study were:

- To collect data on the time: temperature profile of sandwiches on sale in Birmingham
- To compare the collected temperature data with self-reported temperature data from the Food Business Operators collected through the Scoresafe app
- To assess the value of the technology chosen for use in the sandwich production chain.

**Method:**

To determine the storage temperatures of the sandwiches surveyed in this study it was decided to use a temperature logger known as Tiny Tag<sup>™</sup> manufactured by Gemini data loggers of Chichester. This type of logger has a number of advantages:

- It measures the surface temperature of the contact rather than the air temperature
- It is small enough to be inserted within the sandwich thereby measuring the temperature in the middle of the product
- The researcher sets the measurement interval and start/finish time
- It cannot be altered or tampered with by anyone apart from the researcher
- It records temperatures between -40 and +70 °C
- The data can be used to calculate the amount of time the product spends at any given temperature

The Tiny Tags<sup>™</sup> were set to record at three minute intervals for three days to account for the maximum shelf life used by the participants. They were inserted into the sandwich (see figures 1, 2, 3). After three days they were retrieved by the researcher and the sandwich discarded.



Figure 1



Figure 2

Tiny Tag



Figure 3

To compare the sandwich temperatures with the self-reported temperature monitoring carried out by the Food Business Operators, it was decided to use an Android application being developed by the University of Birmingham and Scoresafe Ltd. This is a bespoke computer programme which provides the FBO with a HACCP plan which can be customised. The main use of the app is for multi site businesses so the monitoring data can be accessed by head office in real time. According to the customised plan, the FBO is prompted when CCP's need monitoring and the monitoring results can be input to the programme. This data is then stored on Google Cloud in the section allocated to the business. It can be accessed by anyone authorised by the FBO. Participants were presented with a Samsung Galaxy tablet containing the preloaded app and instructed on its use.

Using online advertising and local knowledge, forty one retail sandwich premises in Birmingham were approached and invited to participate in the study. Nineteen (46%) agreed to allow Tiny Tags <sup>™</sup> to be inserted into their products and nine of these agreed to also use the Scoresafe app. The Tiny Tags <sup>™</sup> were activated and inserted into the sandwiches by the researcher. Recordings were carried out for 2-3 days according to shelf life, at three minute intervals.

Twelve of the participants made sandwiches on site and sold directly to the public. Seven participants were supplied from sandwich manufacturers, so two distributors were also approached and both agreed to participate in the study. Their sandwiches had a three day shelf life and were delivered to the retailers within 24 hours of production.

Data collection was carried out between Jan 15 and March 2, 2016.

#### 4. Key findings

##### **Tiny Tag™ results**

In ten (55%) of the premises the sandwiches were mainly stored below 8°C as required by Schedule 4 of The Food Safety and Hygiene (England) Regulations 2013. These products had limited periods above 8°C but this was typically <10% of the shelf life, as a result of transfer, equipment defrost etc. in accordance with schedule 4 (5)(2). Both Distributors were fully compliant for the time the sandwiches were under their control.

Seven retailers (39%) had sandwich temperatures above 8°C for substantial periods (Table 1).

Min recorded temp	Max recorded temp	Total time above 8 °C
1.1	17.2	40 h: 9 min
3.8	16.2	22 h: 18 min
1.1	11.8	10 h: 54 min
7.4	17.7	40 h: 12 min
7.7	17.2	21 h: 56 min
6.1	12.7	32 h: 59 min
4.9	16.4	7 h: 12 min
4.4 (shelf)	15.6	3h: 54 min

Table 1  
Tiny Tag™ results

For products on display for service or sale, Schedule 4 of The Food Safety and Hygiene (England) Regulations 2013 allows upward variation from 8°C for a single period of up to four hours. From table 1 it can be clearly seen that seven premises held the products above the maximum for considerably longer than permitted by the legislation. In two cases the products were above 8°C for more than 50% of their shelf life. All the noncompliant temperatures were measured in chillers. None of the sandwiches stored in refrigerators recorded temperatures above 8°C.

In an eighth premises the Tiny Tag™ was placed on the chiller shelf rather than in the product to accommodate the demands of the FBO. In this premises the chiller showed a total time of 3hours 54 minutes above 8°C. This is likely to be due to auto defrost processes in the chiller and the total time was within the upward variation permitted although it was not a single period.

##### **Self-reported temperatures**

Not all participants agreed to use the Scoresafe app. The main reason given was lack of time. Nine participants agreed to use the app. They monitored temperatures twice a day as they would normally but used the app to record them. Table 2 shows a summary of the maximum and minimum temperatures recorded by the participants compared with

the maximum and minimum temperatures recorded by the Tiny Tags<sup>™</sup> data recorder in the same premises. The data marked with an \* indicates pairs of recordings where the Tiny Tags<sup>™</sup> indicated noncompliance (>8°C) which was not indicated by the FBO monitoring and self-reported records.

Premises	Tinyag	Self - reported	Tiny Tags <sup>™</sup>	Self - reported
	max	max	min	min
A	4.2	4.5	4.6	3.1
B	1.3	3.3	-0.1	2.3
C	10.2*	6.0*	9.3*	4.3*
D	1.5	3	13.5*	0*
E	5.6	4.5	8.6*	2.3*
F	14.9*	5*	5.1	4.2
G	6.9	5.4	6.6	4.1
H	9.4*	5.5*	6.2	3
I	10*	3.2*	4.5	2.4

Table 2  
Comparison of Tiny Tags<sup>™</sup>  
records and self-reported  
records

Anecdotal evidence suggests that not all recorded temperatures were actually the result of a measurement using a thermometer. In some cases a number was recorded based on an estimate from touching the product or from observing the reading on the delivery van thermometer or the chiller.

Food Business Operators also used the Scoresafe app to record other CCP's, cleaning schedules and details of their food safety management systems such as deliveries, cooking, equipment and structure. Feedback from the nine FBO's testing the system indicate that seven would be prepared to use it as their recording system. An advantage of the Scoresafe App is that it prompts the operator to take the measurement at the appropriate time and indicates when the information is acceptable (green), moving towards the critical limit (orange) and above the critical limit (red). Corrective action is prompted and recorded. A screenshot from one participant's records is shown in Figure 4 below. This information is stored in the space allocated to the business on google cloud and accessible by anyone with authority to access it. Authority is given by the FBO through Scoresafe Ltd.



Hot Holding  
Cooling Logs  
Chilled Food

Clear filters

Date	Fridge	Time	Temperature	By whom	Comment/Corrective Actions
29/01/2016 to 11/02/2016	All Fridge	AM/PM	All	staff	
03/02/2016	Dairy Cabinet	08:15:28	5.1	A	Refrigerator turned up
03/02/2016	Deli Display Fridge	08:15:28	3.8	A	No Action required
03/02/2016	Dessert Fridge	08:15:28	3.9	A	No Action required
03/02/2016	Upstanding kitchen Fridge	08:15:28	3.2	A	No Action required
02/02/2016	Dairy Cabinet	15:43:19	4.2	A	No Action required
02/02/2016	Deli Display Fridge	15:43:19	4.0	A	No Action required
02/02/2016	Dessert Fridge	15:43:19	3.9	A	No Action required
02/02/2016	Upstanding kitchen Fridge	15:43:19	3.2	A	No Action required
02/02/2016	Dairy Cabinet	10:11:26	3.5	A	No Action required
02/02/2016	Deli Display Fridge	10:11:26	3.1	A	No Action required

Figure 4  
Screen shot from the Scoresafe App  
showing a participant's records

## 5. Key issues

- A. The data shows that from an opportunistic, volunteer sample of 19 sandwich retailers in Birmingham, 39% (seven premises) stored sandwiches above the maximum of 8°C permitted by The Food Safety and Hygiene (England) Regulations 2013. The time out of temperature control could be substantial and ranged from 7 -40 hours. This has significant implications for the microbiological quality and safety of the products as the shelf life relies on the product being stored below 8°C.
- B. The noncompliant products were all stored in chillers (display units, open to the atmosphere), not refrigerators (closed units with doors). None of the products stored in refrigerators were recorded to rise above 8°C.
- C. The temperature monitoring carried out by the Food Business Operators did not indicate when the products' storage temperature was above the legal maximum.
- D. Some Food Business Operators were not measuring the temperatures they recorded. The records were based on estimates or readings from equipment such as delivery vans.
- E. The Tiny Tag™ recorders were appropriate for use in sandwiches but further work is needed to validate issues such as any variation between sandwich and air temperature.

## 6. Next steps

- A. The temperature monitoring of sandwiches on retail sale should be extended to determine the extent of the problem.
  - The survey should extend beyond Birmingham to give an indication of the extent of non-compliance nationwide.
  - The survey should include long-life sandwiches. None were included in this survey because none of the retailers selling them were willing to participate.
- B. Inspectors could be invited to report on how Food Business Operators monitor and record the temperatures of chilled products, especially ready to eat products such as sandwiches. Depending on the findings, some training for Food Business Operators may be appropriate.
- C. Air temperatures are typically recorded by the FBO. Work needs to be carried out to determine the variation between product temperature and air temperature measured by the same type of recorder so the relationship can be established and air temperatures can be correctly interpreted. The Food Safety and Hygiene (England) Regulations 2013 specify product temperature should be below 8°C.
- D. Ideally a system which combines the automatic temperature recording of Tiny Tags™ with the cloud based storage of the Scoresafe app could be developed. By using this combination temperatures could be monitored by head office/professional organisations such as the British Sandwich Association/

competent authority or anyone authorised to do so and problems identified and highlighted.

**7. Engagement and impact**

According to the British Sandwich Association, 3.5 billion sandwiches are sold in Britain annually (J.Winship, personal communication). If 39% are outside temperature control, as indicated by this pilot study, it could have significant implications for public health and legal compliance.

**8. Additional outputs**

The Scoresafe App for monitoring and recording food safety management systems was tested by nine Food Business Operators.

**9. Dissemination activities**

- A. The findings will be disseminated in accordance with the Food Standards Agency and ITaaU strategy.
- B. Anonymized results will be delivered to all participants who wished to be informed
- C. Anonymized results will be delivered to the officers at Birmingham City Council, food inspection team.
- D. The British Sandwich Association will be appraised of the outcomes which may be of interest to their members.

**10. Funding strategy for future activity**

- A. No funding sources have been specifically identified but any general or specific Food Standards Agency opportunities will be pursued.
- B. The British Sandwich Association will be consulted with a view to possible collaboration with members, although it is unlikely any funding will be made available.

## 11. Key references

Brooks; B (2011) Booker's sandwich: a 14-day shelf life to keep wastage down; The Grocer;  
<http://www.thegrocer.co.uk/companies/bookers-sandwich-a-14-day-shelf-life-to-keep-wastage-down/219222.article>; accessed March 17, 2016

Boxall, NS; GK Adak; E DE Pinna; I.A Gillespie IA (2011) A *Salmonella* Typhimurium phage type (PT) U320 outbreak in England, 2008: continuation of a trend involving ready-to-eat products Epidemiol Infect. 139(12):1936-44

British Sandwich Association  
<http://www.sandwich.org.uk/> accessed March 17, 2016

Food Safety Authority Ireland (2010) Microbiological safety of pre-packaged sandwiches (09NS1)  
[https://www.fsai.ie/uploadedFiles/Monitoring\\_and\\_Enforcement/Monitoring/Surveillance/Prepackaged\\_sandwiches.pdf](https://www.fsai.ie/uploadedFiles/Monitoring_and_Enforcement/Monitoring/Surveillance/Prepackaged_sandwiches.pdf) accessed March 17, 2016

Little CL; C.F. Amar; A Awofisayo; K.A. Grant (2012) Hospital-acquired listeriosis associated with sandwiches in the UK: a cause for concern. J Hosp Infect. 82(1):13-8

Quickfill  
<http://www.quickfill.co.uk/> accessed March 17, 2016

Regulation (EC) No 852/2004 of The European Parliament and of The Council on the Hygiene of Food stuffs <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:226:0003:0021:EN:PDF> accessed March 17, 2016  
The Food Safety and Hygiene (England) Regulations 2013 Statutory Instrument 2013 No. 2996  
<http://www.legislation.gov.uk/uksi/2013/2996/made/data.pdf> accessed March 17, 2016

## **Acknowledgements**

Thanks to Jim Winship of the British Sandwich Association and Sally O'Neil of Birmingham City Council for their advice.

## Appendix A: technology review

Technology	Description	Evaluation	Used in project ?	Verdict
Tiny Tags <sup>TM</sup>	Temperature:time recorder	Effective and consistent?	yes	Work very well but standardization needed between product temperature and air temperature
Scoresafe Android application	Food safety management system which records monitoring data on google cloud	User friendly and accurate?	yes	Needs further development to include sampling data (where relevant) and clear some technical details.

## **Appendix B: literature review**

See Page 1 for brief background to the project. Literature review needs to be carried out in the future.



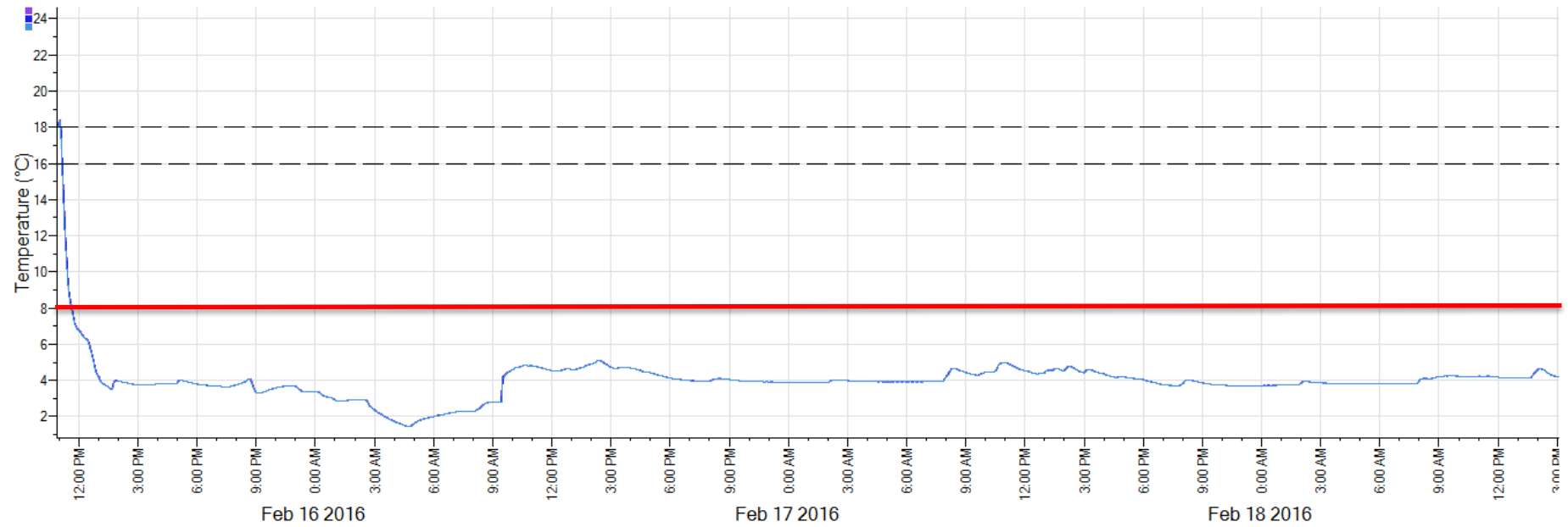
**Food  
Standards  
Agency**

## **Appendix C**

### **Data sets**

#### **Tiny Tags™ data**

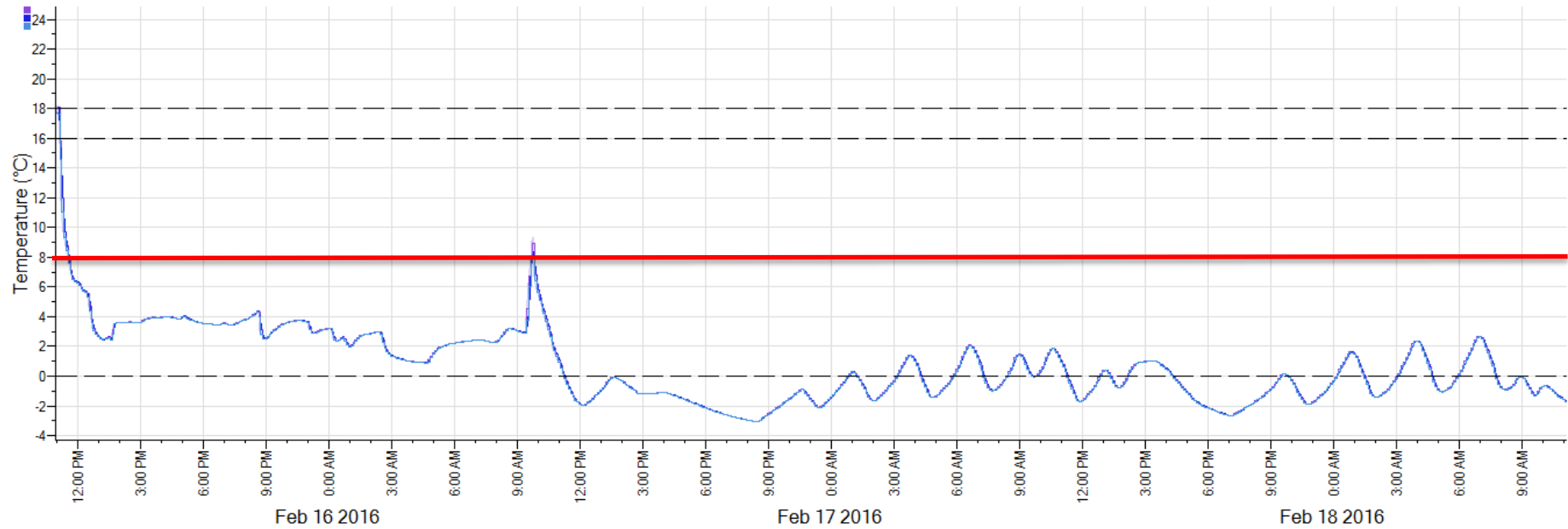
Premise (1)/ 3 day-shelf life



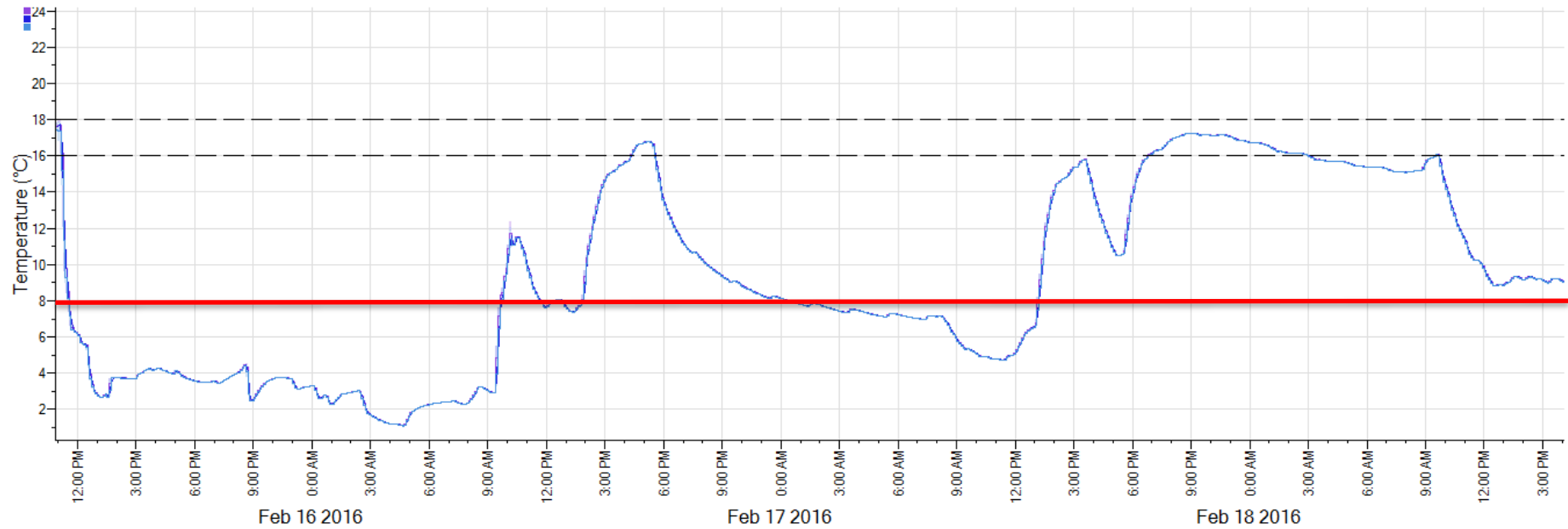




Premise (2)/ 3 day-shelf life

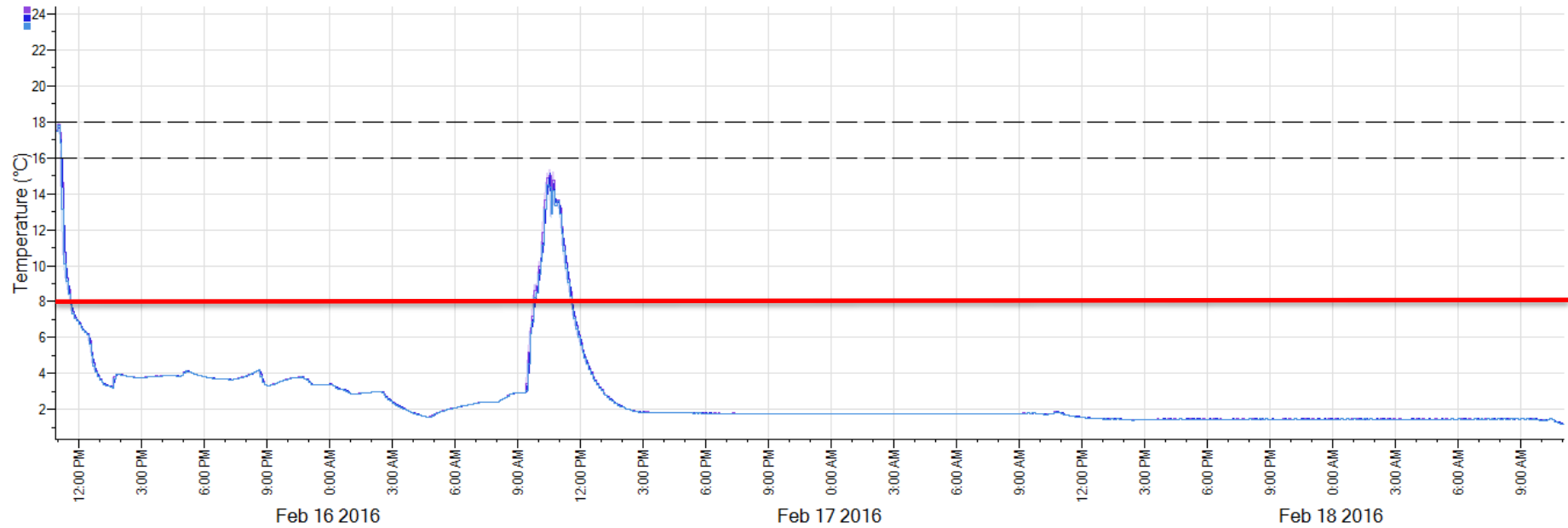


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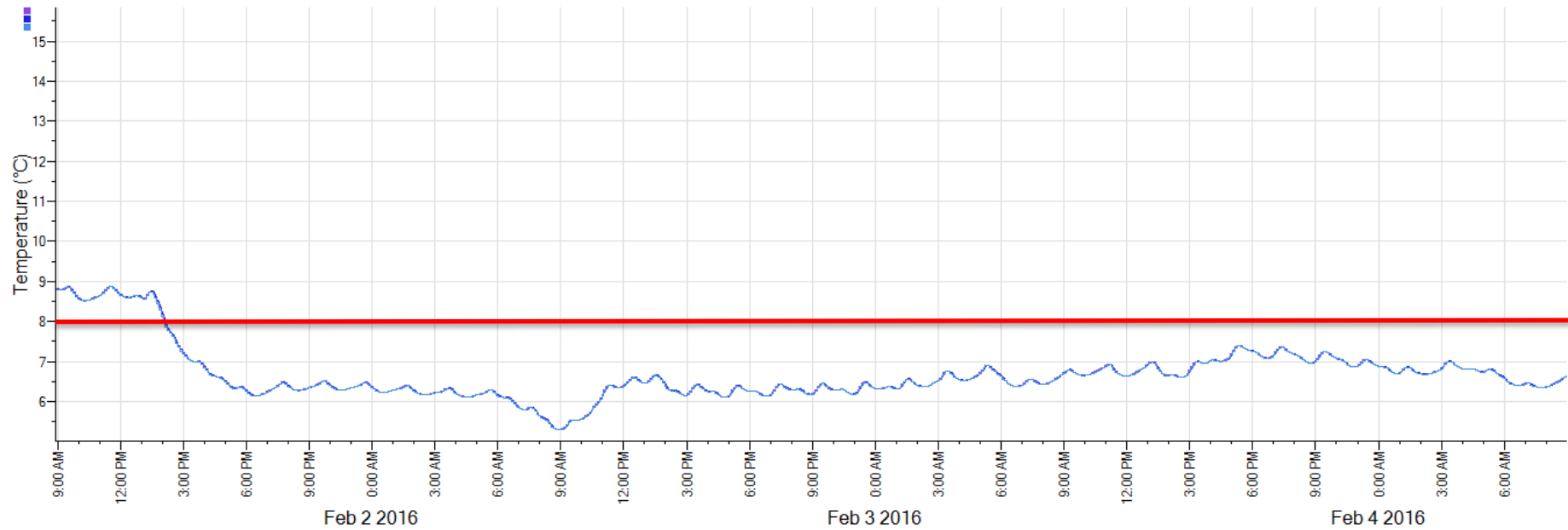


Premise (4)/ 3 day-shelf life

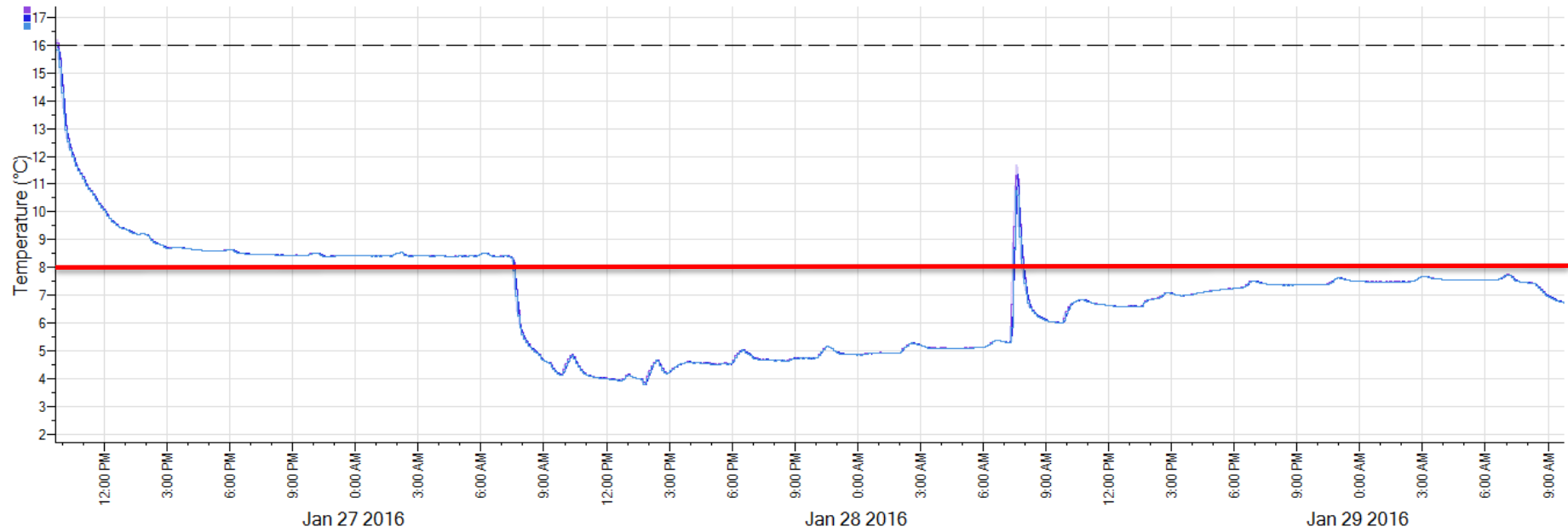




Premise (5)/ 3 day-shelf life

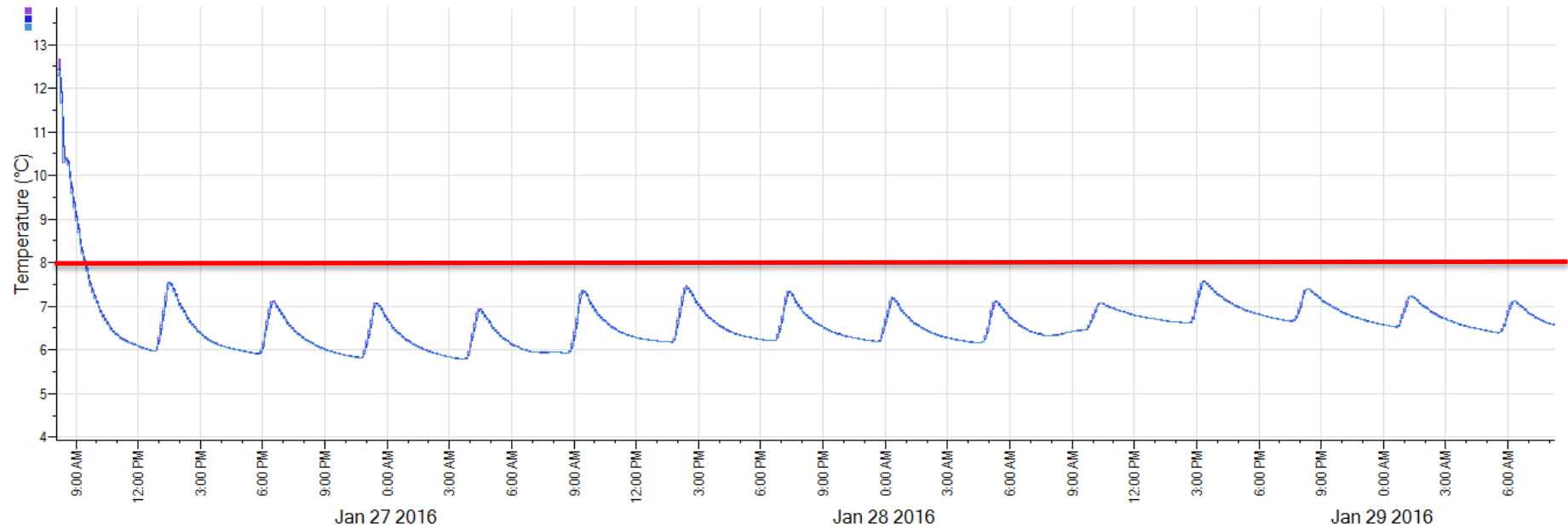


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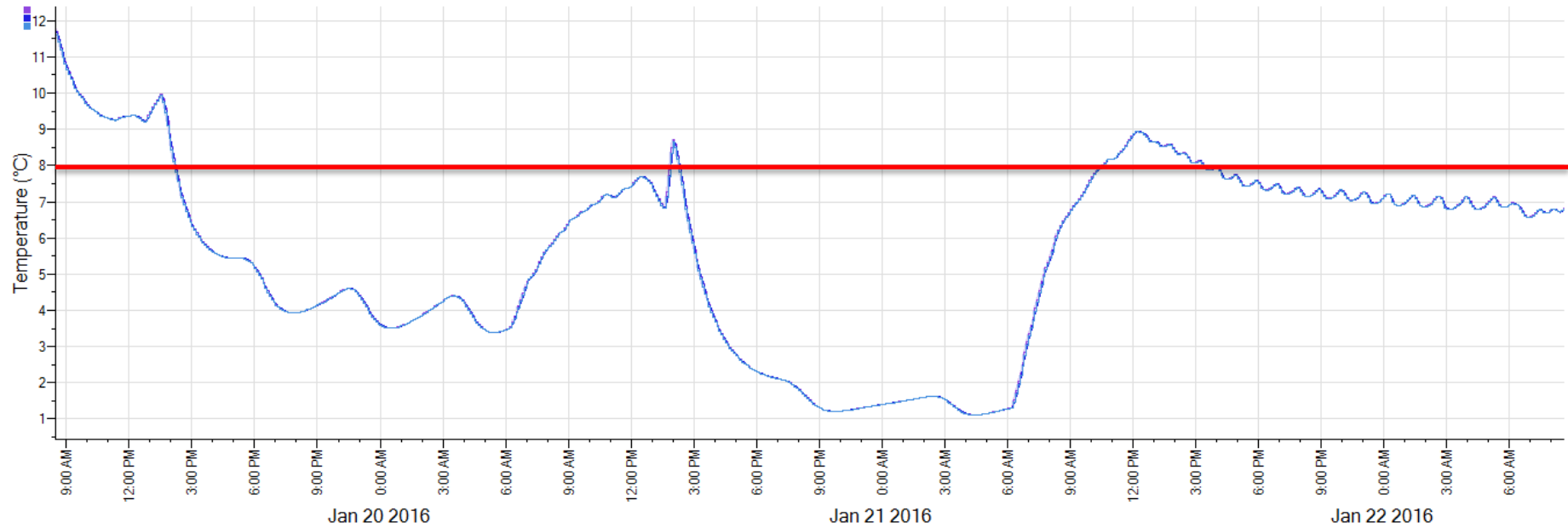


Premise (7)/ 3 day-shelf life

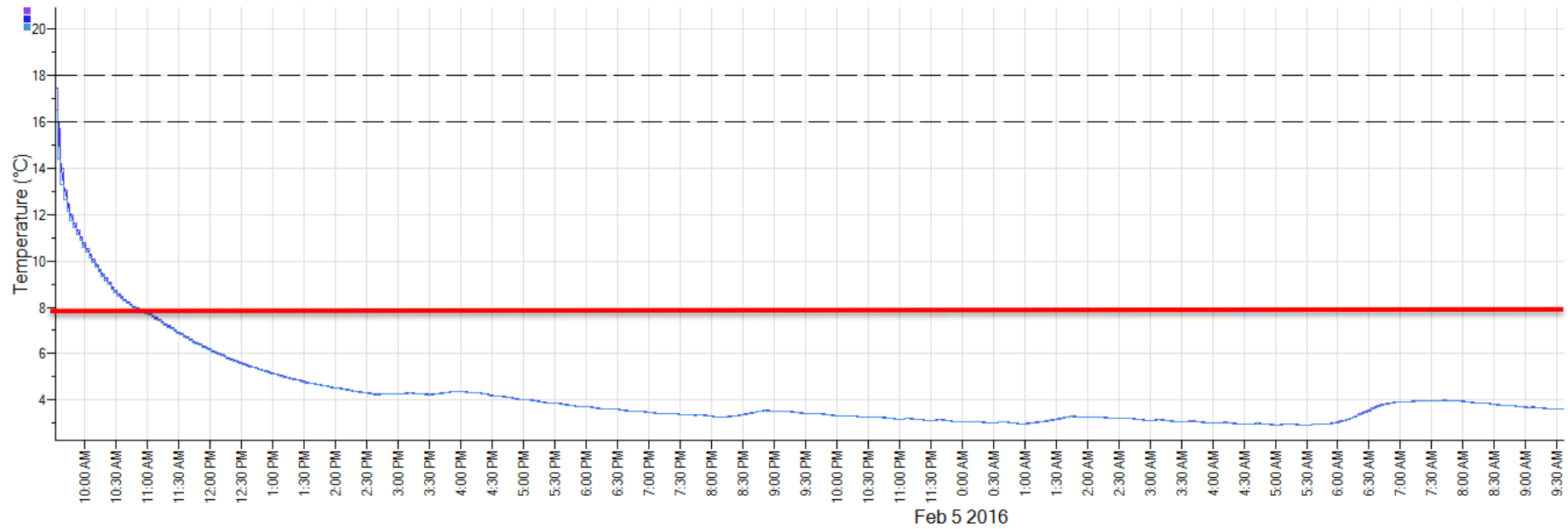




Premise (8)/ 3 day-shelf life



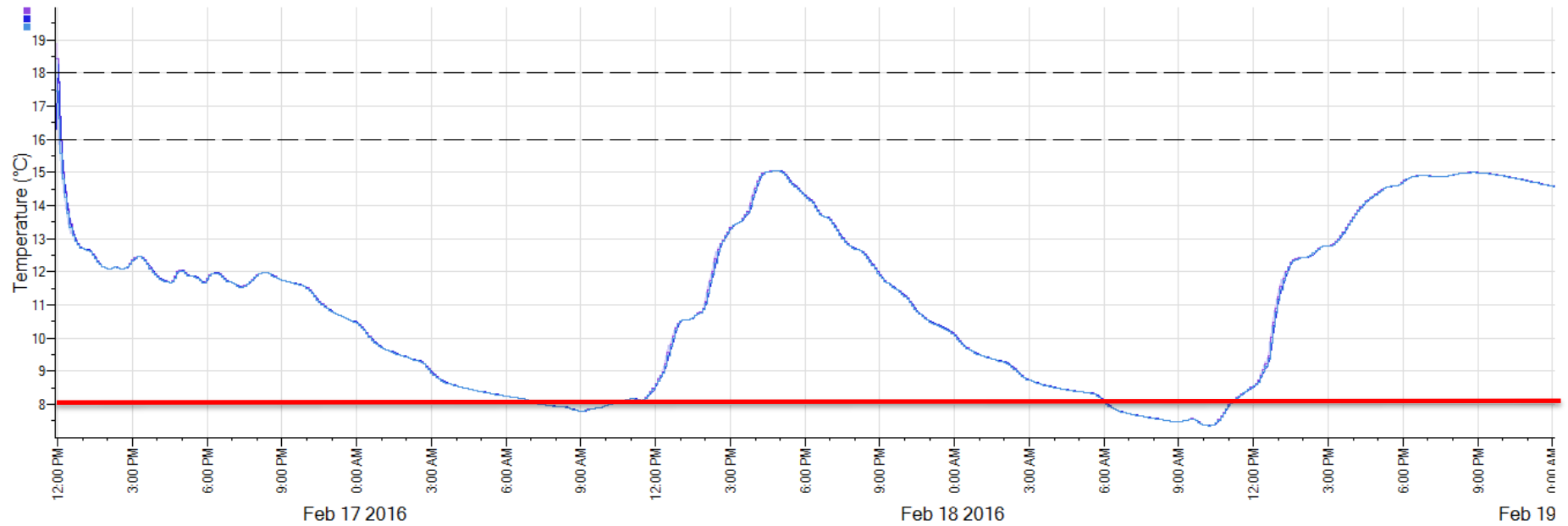
Premise (9)/ 1 day-shelf life



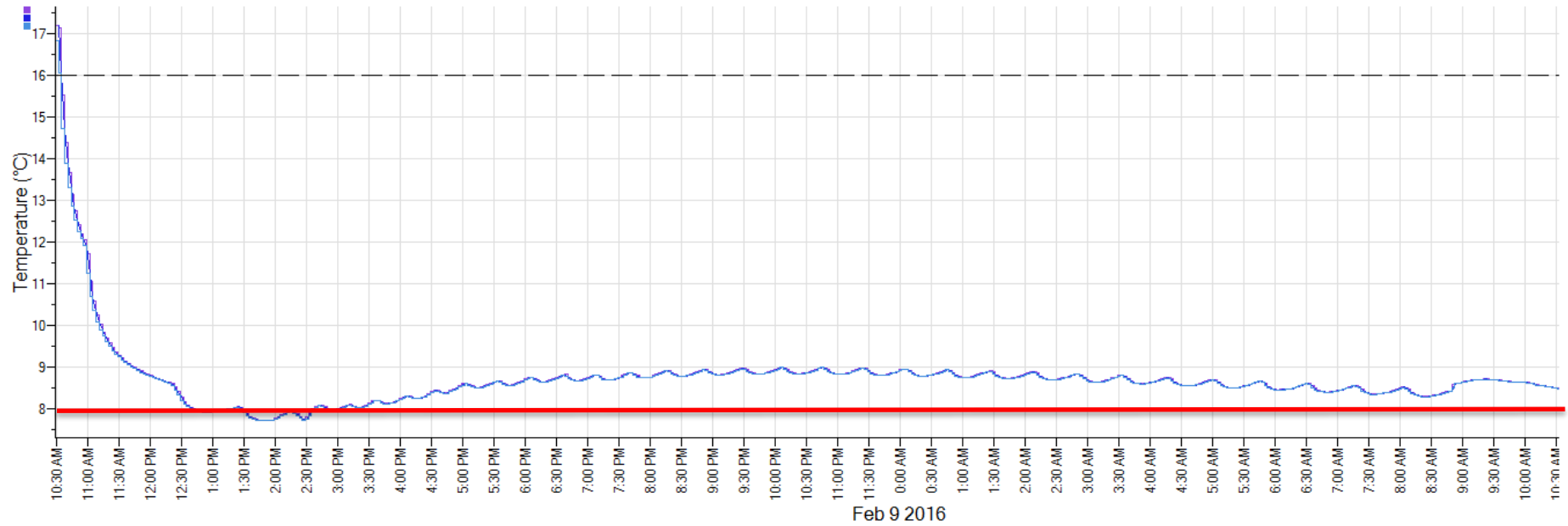




Premise (10)/ 3 day-shelf life

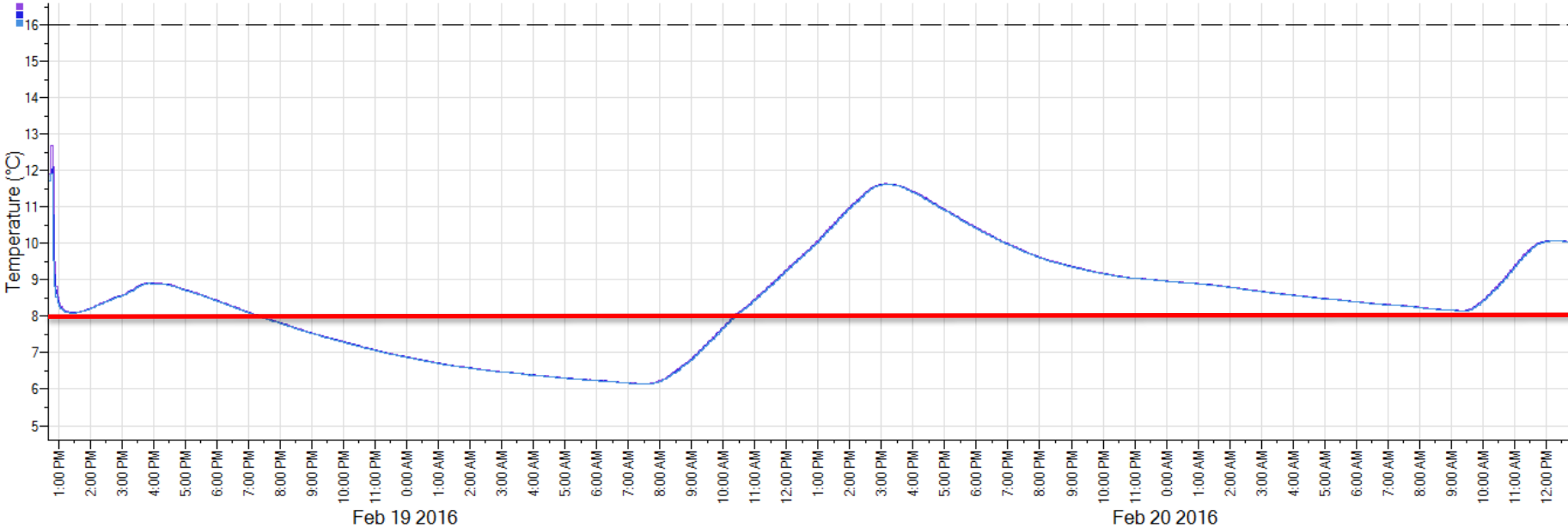


Premise (11)/ 1 day-shelf life



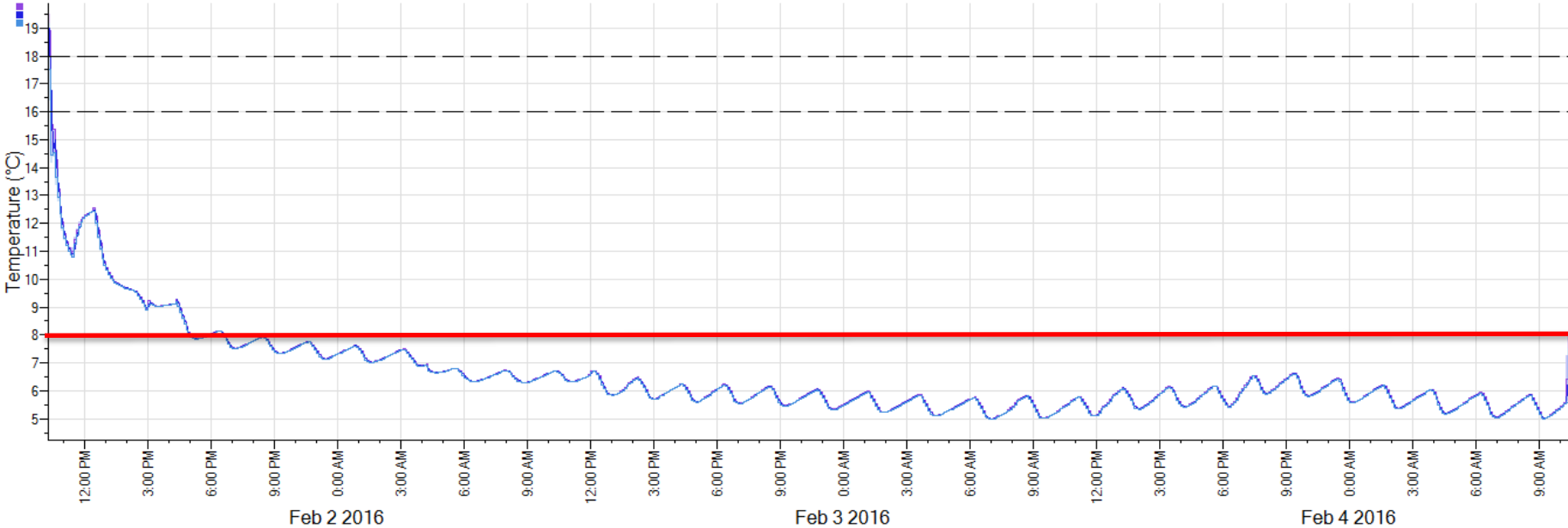


Premise (12)/ 2 day-shelf life

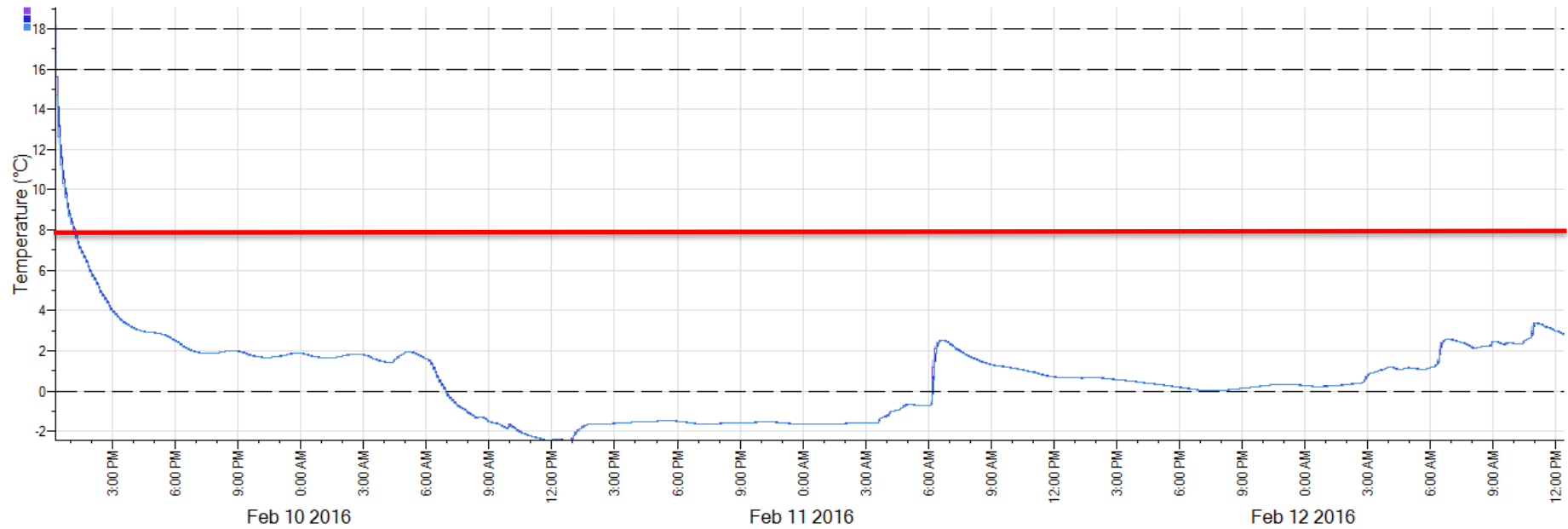




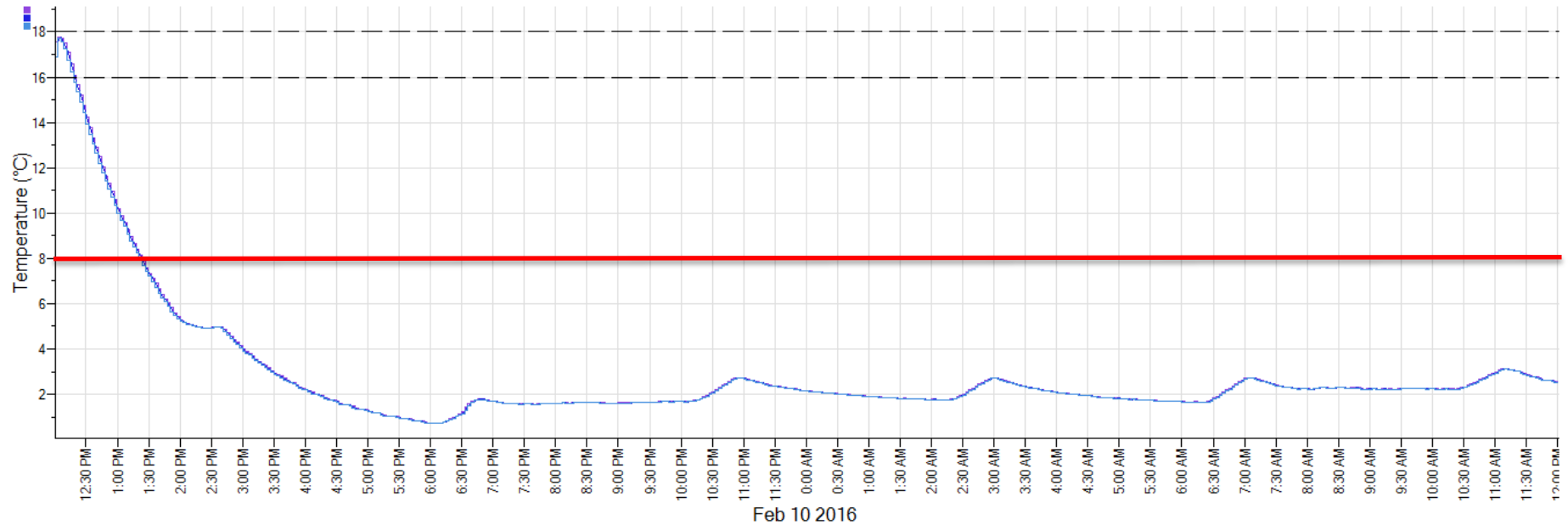
Premise (13)/ 3 days/ Store Fridge



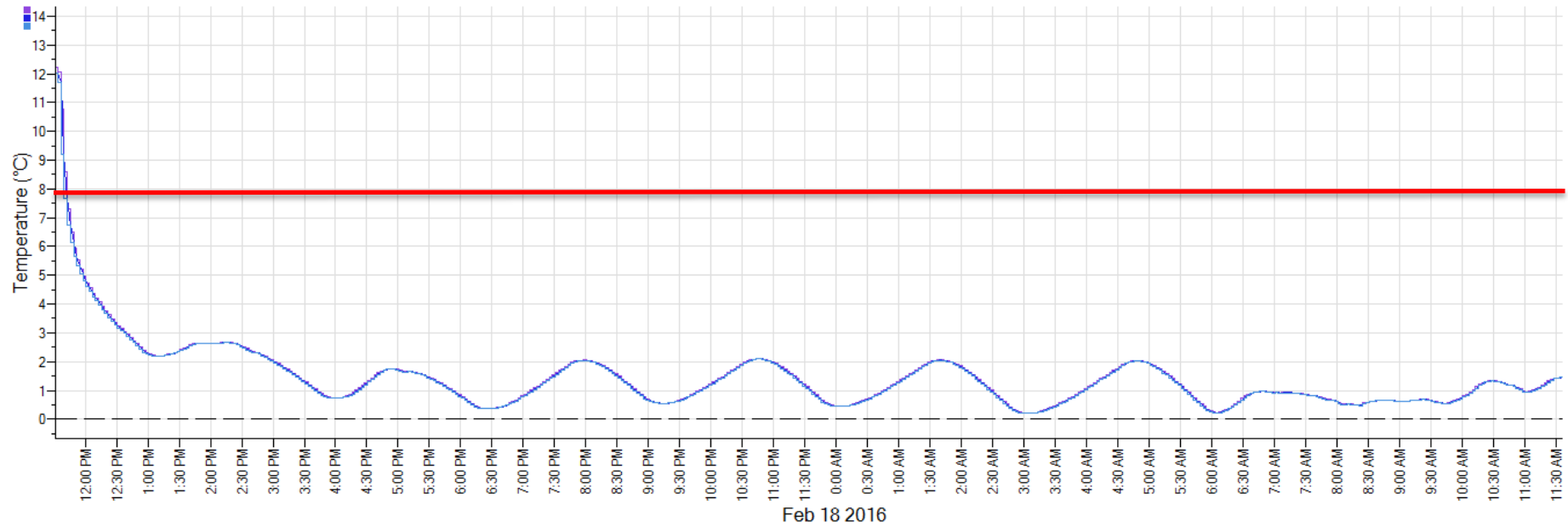
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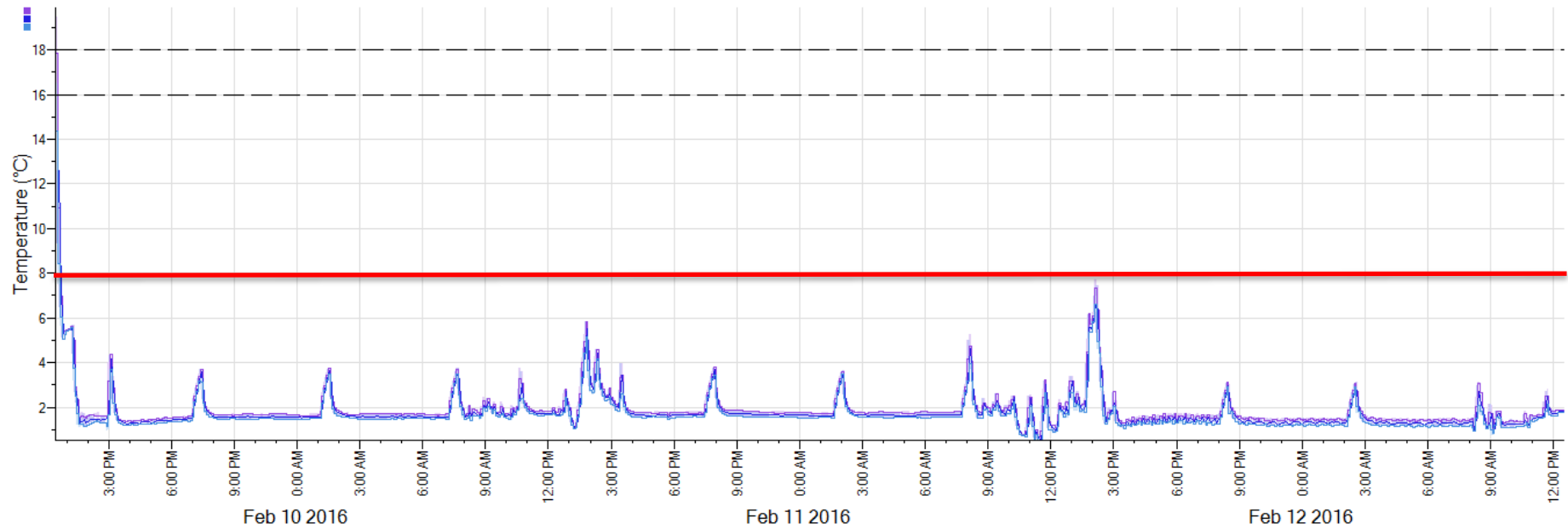
Premise (15)/1 day-shelf life



Premise (16)/ 1 day-shelf life



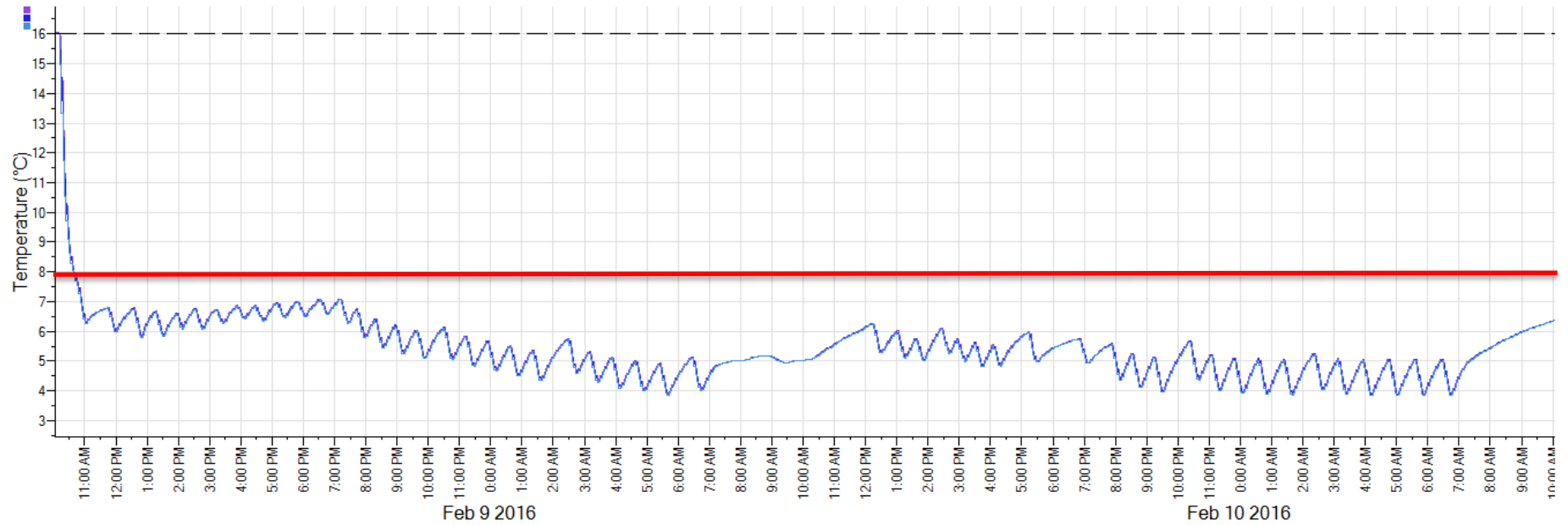
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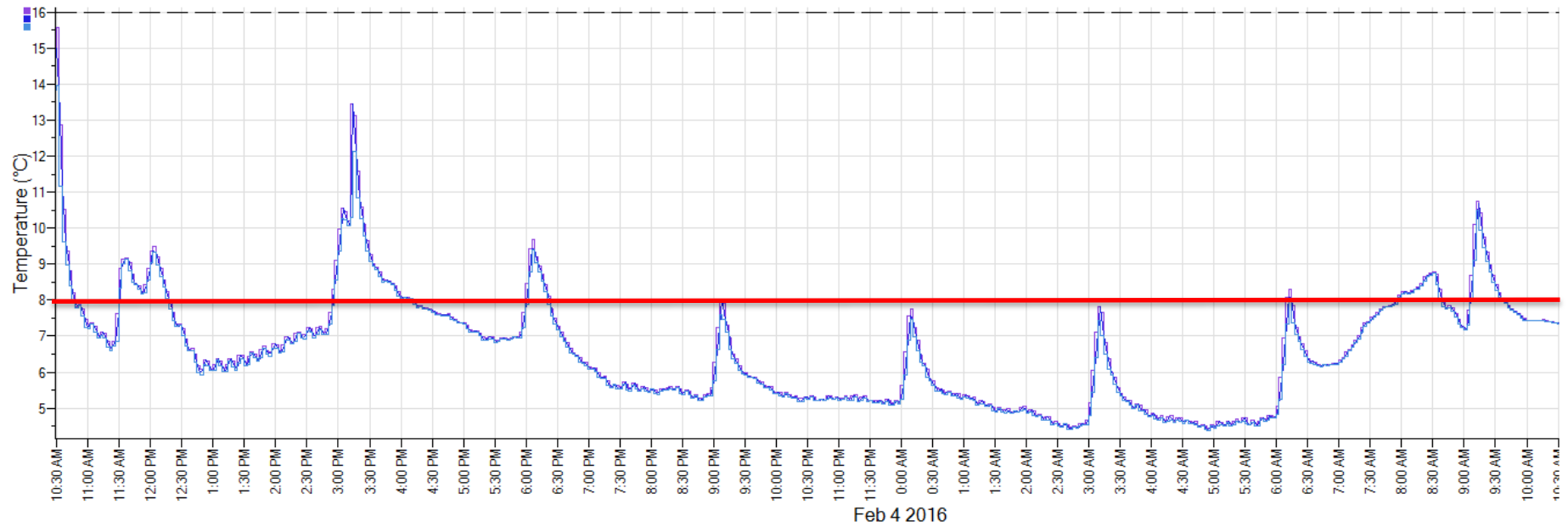




Premise (18)/ 2 day-shelf life



Premise (19)/ 1 day-shelf life/ Display Fridge



## Scoresafe Data

Scoresafe data can only be accessed by authorised persons as it is secure personal data relating to the FBO's own records and stored on google cloud. Each FBO has his/her own secure section. However a sample of the way structure and equipment can be customised is presented below. An example of the temperature recording is in Figure 4.

Equipment
Cooling
Structural Materials
Employees
Supplier
Schedules
Devices

### Structural Materials

Walls	Ceilings	Floors
<input checked="" type="checkbox"/> Tiled wall surfaces	<input type="checkbox"/> Tiled Ceiling	<input type="checkbox"/> Tiled Floor
<input type="checkbox"/> Stainless steel wall cladding	<input type="checkbox"/> Stainless steel cladding Ceiling	<input checked="" type="checkbox"/> Lino Floor
<input type="checkbox"/> Pvc cladding wall	<input type="checkbox"/> Pvc cladding Ceiling	<input type="checkbox"/> Altro type Floor
<input type="checkbox"/> Stone painted wall	<input type="checkbox"/> Stone painted Ceiling	<input type="checkbox"/> Stone painted Floor
<input checked="" type="checkbox"/> Plaster painted wall	<input checked="" type="checkbox"/> Plaster painted Ceiling	
<input type="checkbox"/> Food preparation splash backs wall		

Update

Scoresafe Portal © Scoresafe 2013 to 2014 - Ver. 1.1 Alpha

Equipment
Cooling
Structural Materials
Employees
Supplier
Schedules
Devices

### Equipment

Cooking Equipment	Fixtures Fittings and Furniture
<input type="checkbox"/> Gas hobs	<input checked="" type="checkbox"/> Utensil wash sinks
<input checked="" type="checkbox"/> Electric hobs	<input checked="" type="checkbox"/> Food use sinks
<input type="checkbox"/> Gas/electric ovens	<input checked="" type="checkbox"/> Hand wash Basins
<input type="checkbox"/> Pizza ovens	<input checked="" type="checkbox"/> Hand towel/Roll dispensers
<input type="checkbox"/> Bratt Pans	<input checked="" type="checkbox"/> Hand soap dispensers
<input type="checkbox"/> Steam/combi ovens	<input checked="" type="checkbox"/> Food preparation work surfaces
<input type="checkbox"/> Microwave ovens	<input type="checkbox"/> Work equipment stands
<input type="checkbox"/> Water baths	<input checked="" type="checkbox"/> Storage shelves and surfaces
<input type="checkbox"/> Pasta boilers	<input checked="" type="checkbox"/> General waste bins
<input type="checkbox"/> Rice cookers	<input type="checkbox"/> Extraction hoods and canopies
<input type="checkbox"/> Fryers	<input type="checkbox"/> Extraction filters
<input type="checkbox"/> Barbeque	<input checked="" type="checkbox"/> Waste disposal units
<input type="checkbox"/> Char grills	<input checked="" type="checkbox"/> Fly zappers
<input type="checkbox"/> Grills	<input type="checkbox"/> Fly screening/chains
<input checked="" type="checkbox"/> Contact & Panini Grills	<input checked="" type="checkbox"/> Staff cloakroom storage