Global LEAP Electric Pressure Cooker Test Method

Version 2

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Context

This document includes tests methods for evaluating electric pressure cookers (EPCs) intended for home and small-business use (1-9 litre capacity) for quality, performance, and safety. The test setup, required equipment, and testing constraints are also presented.

The methods were originally developed by CLASP and Colorado State University (CSU) to evaluate the performance and safety of 13 EPCs for the 2020 Global Lighting and Energy Access Partnership (Global LEAP) Awards Electric Pressure Cookers Competition – a program implemented by the Efficiency for Access Coalition. The methods have also been used since the 2020 awards competition to assess additional EPCs for inclusion in the VeraSol Product Database. Where applicable, the procedures draw from existing international standards and technical specifications.

This revision was led by CLASP through VeraSol, a quality assurance program that provides a suite of quality assurance services for the off-grid sector including test methods development, quality standards, appliance testing and certification and test lab capacity building among others, and made in collaboration with Kijani Testing, a testing laboratory in Kisumu, Kenya specializing in testing emerging sustainable technologies in East Africa.

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Contents

Scope

This document defines tests methods for evaluating electric pressure cookers (EPCs) intended for home and small-business use (1-9 litre capacity) for quality, performance, and safety.

The test method consists of the following major components:

- Overall **product quality** inspection, both internal and external, as well as an evaluation of the user manual and company-provided information
- Evaluation of **performance**
- General assessment of various **safety** metrics

Tests can be divided into two categories: (1) non-destructive tests, and (2) destructive or potentially destructive tests. This protocol assumes that two units of each model to be tested are available for testing. One unit will be designated the Non-Destructive Test Unit, and the other will be designated the Destructive Test Unit. The purpose of this designation is to keep one unit fully functional.

Moreover, any destructive or potentially destructive tests should be performed after all non-destructive tests are complete. This allows the Destructive Test Unit to be used as a backup for any non-destructive tests, if necessary.

The following international test procedures and standards have been referenced in the preparation of this document:

- IEC 60350-1:2017 (Household electrical appliances - General safety requirements): Highlights methods for measuring the performance of various household electric cooking appliances such as ovens, steam ovens, and grills. Also provides detailed procedures for evaluating different aspects of performance including energy consumption, cooking times, temperature distribution, and heating efficiency.
- IEC 60350-2 (Household electric cooking appliances - Part 2: Hobs - Methods for measuring performance): Outlines methods for measuring the performance of household electric cooking appliances such as ranges, ovens, steam ovens, and grills. The standard provides guidelines for evaluating various aspects of performance including energy consumption, cooking times, temperature distribution, and heating efficiency.
- GB 39177-2020 (National Standard of the People's Republic of China for Electric Pressure Cookers): Highlights the formula of calculating thermal efficiency of EPCs and the various parameters associated with the calculations.
- IEC 60335-1 2020: This International Standard deals with the safety of electrical appliances for household and similar purposes, their rated voltage being not more than 250 V for single-phase appliances and 480 V for other appliances including direct current (DC) supplied appliances and battery operated appliances.
- IEC 60335-2-15 (Household and Similar electrical appliances - Safety): outlines safety requirements specific to appliances designed for heating liquids in household settings such as kettle, emphasising on potential hazards associated with these appliances such as electric shock, fire, and mechanical hazards.

- BS EN 12778: 2002 (Pressure cookers for domestic use): this standard applies to pressure cookers for residential use, portable, with total capacity up to 25 l, working pressure above 4 kPa and less than 150 kPa, with integrated or separate heating.
- IEC 60529 (Degrees of Production Provided by Enclosures - Ingress Protection code)

Test Conditions

1.1 Test Environment

The test environment shall meet the following conditions:

- Atmospheric pressure: 98kPa~106kPa;
- Ambient temperature: 25°C±2°C, with no air flow in the test room;
- Relative humidity: 45%~75%.

1.2 Power Supply

The test of energy efficiency for electric pressure cookers shall be carried out under the conditions at the rated voltage.

1.3 Measuring Instruments

The measuring instruments shall meet the following requirements:

- Camera
- Ruler
- Power meter: shall not be less than ±0.5%.
- Electric energy meter: can measure energy consumption at a minimum level of 20mW·h.
- Temperature sensors:
    a. Remote temperature sensors, e.g. iButton, are preferred, with a resolution of the measurement is not less than 0.1°C. The accuracy should remain within ±0.85°C in the temperature range of 0°C~100°C. The accuracy should remain within ±1.0°C when temperature exceeds 100°C, for measuring temperature during the pressure-cooking phase.
    b. Self-Adhesive Polyimide Fast Response Surface Thermocouples or Omega Type K Thermocouple can be used for measuring the external surface temperature of the EPC.
- Weighing instrument: when the instrument is at full scale, the relative error does not exceed ±0.1%, and the minimum display (scale) value is 1g
- Timer: the accuracy of the timer should remain within ±2s/h
- Pressure transducer/sensor: within ±0.5psi

1.4 Water

Use tap water for all tests.

1.5 Initial Testing Conditions

Before each test, the difference between the inner pot, heating plate (induction coil), outer shell, and the ambient temperature is within 5°C or the product has not operated for at least 6 hours.

Quality

2.0 Visual Inspection

2.1 Photo Documentation

2.1.1 Record basic product information on the test report **Summary Sheet**:

- Brand name
- Model name
- Manufacturer
- Country of manufacture
- Rated input voltage (V)
- Rated input frequency (Hz)
- Rated input current (A)
- Rated power (W)
- Rated capacity (L)
- Pressure rating (kPa)
- Temperature rating (°C or °F)
- Programmed cooking modes
- Pressure setting options, e.g., high, medium, low pressure), if present

2.1.2 Capture the following pictures of the EPC:

- Packaging – all distinct sides of box
- Packaging – box open but nothing removed
- Packaging – first layer of padding removed, but EPC still in box
- Packaging – pictures of anything broken/off, e.g., broken Styrofoam
- Front/back
- Front control panel – if need additional photograph(s) to improve resolution
- Left/right
- Top exterior
- Top interior – with cooking pot in place
- Top interior – with cooking pot removed
- Lid outside – removed from pot
- Lid inside
- Lid seal (note: the lid seal will be photographed again after performance testing for comparison)

- Safety devices inside
- Safety devices outside
- Photos of all labels
- Bottom
- Bottom with protective cover removed
- Readable photos of all pages of provided user manual and warranty documentation

2.2 Marking and Labelling

2.2.1 Inspect product for presence of the following markings in Table 1. For original equipment manufacturer (OEM) products that did not come in final packaging, mark N/A in the packaging column.[1]

Table 1. Marking and labelling of which to note the presence and resistance to removal

Item #	Description	Is the marking present on the package?	Is the marking present on the product?	Is the information present in the user manual?	Are markings substantially resistant to removal?
1	Manufacturer or distributor	Yes / No	Yes / No	Yes / No	Yes / No
2	Identification of the pressure cooker, e.g., type, model, identification of the series or batch or manufacturing number				
3	Year of manufacture				
4	Working pressure				
5	Maximum allowable pressure				
6	Capacity				
7	Voltage				
8	Frequency				
9	Power				
10	Indication of safety measures to be taken by user				

2.2.2 Rate the presence, clarity, and relevance of the marking and labelling. OEM products may be evaluated based on only the product labelling if the final packaging was not provided:

- *Good* – Labels are present for all of Items #1-10 on package and product. All labels are clear. Markings are resistant to removal.

[1] From BS EN 12778, Section 6 – Table 4

- *Satisfactory* – All labels are on either package or product, but not all labels are on both. All labels are clear. Critical safety markings are present. Markings are resistant to removal.
- *Needs Improvement* – Some labels are missing or unclear, OR labels on product may be easily removed or worn away.
- *Poor* – No labels or markings.

2.2.3 Record any comments.

2.3 Product Packaging and Quality

2.3.1 Rate the quality of packaging and its ability to protect the product:

- *Good* – Product unharmed during transport, and packaging is of a state that it may be reused.
- *Satisfactory* – Packaging may become damaged during transport, but product is unharmed.
- *Needs Improvement* – Packaging leaves product vulnerable to minor damage during transport, but product still functional.
- *Poor* – Packaging does not protect product.

2.3.2 Rate the quality of the product after transportation from visual analysis:

- *Good* – Products appears to be in good condition, all labels are intact, the connections are intact, no scratches, tears, sharp edges, exposed wires, broken parts, or rust observed.
- *Satisfactory* – Product is in good condition, although there are some scratches and cracks due to negligence during transportation.
- *Needs Improvement* – Product indicates moderate visible damage such as dents, scratches, or loose connections that do not pose immediate safety risks but require minor repairs or adjustments.
- *Poor* – Visible exposed wires, cracks, broken parts, sharp edges, or rust that may pose a safety hazard to the user.

2.4 User Manual

2.4.1 Does the user manual or other documentation include guidance for cook times of different dishes? Yes / No

2.4.2 Rate the presence, clarity, and relevance of the user manual:

- *Good* – Operation instructions are clear, and images are unambiguous. All functions are adequately described. Maintenance and cleaning instructions are present and clear.
- *Satisfactory* – Some information is missing or unclear.
- *Needs Improvement* – Significant information is missing or unclear.
- *Poor* – No user manual is provided.

2.4.3 Record any comments.

2.5 Warranty

2.5.1 Rate the presence, clarity, and relevance of the warranty:

- *Good* – Warranty clearly states what is covered, the length of the warranty, and how to access the warranty.
- *Satisfactory* – Warranty states what is covered and the length, but how to access the warranty is missing.
- *Needs improvement* – A warranty is provided, but there is conflicting or lacking information on either what is covered, the length, or how to access it.
- *Poor* – There is no warranty information provided.

2.5.2 State the warranty length.

2.5.3 Record any comments.

2.6 Ingress Protection

The following evaluates how well the electronics are protected from ingress of solids or liquids. It is a simplified version of the IEC 60529 rating system for ingress protection. Solid ingress protection should be evaluated with a tool of the appropriate size. Liquid ingress protection should be evaluated by inspection, and NOT by testing with water, as testing may cause damage to the unit and prevent further testing.

2.6.1 Solid & Liquid Ingress Protection

2.6.1.1 External Solid & Liquid Ingress Protection

The outside of the main body should be evaluated for solid and liquid ingress protection and rated based on Table 2. The goal is to determine whether water can get into the controls (buttons, dials, switches), and whether the electronics on the bottom are protected from solid objects.

Table 2. Solid and liquid ingress protection rating descriptions

Solid Ingress Protection	**Liquid Ingress Protection**
IP00: No protection from solids & liquids IP1X: Protected against access from objects >= 50mm (hand size) IP2X: Protected against access from objects >= 12.5 mm (finger size) IP 3X: Protected against access from objects >= 2.5 mm (screwdriver size)	IP X1: Protected against vertically falling drops of water. Limited ingress permitted IP X2: Protected against vertically falling drops of water with enclosure tilted up to 15 degrees from the vertical. Limited ingress permitted IP X3: Protected against sprays of water up to 60 degrees from the vertical. Limited ingress permitted for three minutes

2.6.1.2 Record any comments.

2.6.2 Interior Spill Protection

- The following is evaluated for the interior of the main body. If water spills inside the EPC, will it be channelled away from any exposed electronics?

- Mark yes / no in the test report.

2.6.3 Boil-over Protection

- Does the design of the cooker protect the electronics if water boils over the edge of the pot? (e.g., is there a channel that will catch any water and direct it away from the electronics?)
- Mark yes / no in the test report.

3.0 Workmanship & Materials Evaluation

3.1 Workmanship Inspection of External and Internal Surfaces

3.1.1 External Inspection – Quality and Maintainability of Materials and Surfaces

3.1.1.1 Rate the overall quality and maintainability of external materials and surfaces, including the ability to be cleaned and maintained:

- *Good* – No workmanship or functionality deficiencies were observed. Materials are clearly sturdy. Very minor scratches OK.
- *Satisfactory* – Small workmanship deficiencies were observed such as scratches, missing screws, or small deformities, but these issues did not affect functionality of the product. Materials are adequate.
- *Needs Improvement* – Many workmanship issues were observed such as scratches, missing screws, or small deformities, which did not affect the overall functionality of the product; OR small functionality issues were observed; OR materials appear flimsy.
- *Poor* – Workmanship issues were observed that affected the overall functionality or safety of the product.

3.1.1.2 Record any comments.

3.1.2 Internal Inspection – Quality and Maintainability of Materials and Surfaces

3.1.2.1 Identify the material of the surface of the inner cooking pot (e.g., non-stick coating, stainless steel). Quality of nonstick coating will be evaluated with a peeling test (Section 3.4, Coating Compliance).

3.1.2.2 Rate the overall quality and maintainability of internal materials and surfaces, including the ability to be cleaned and maintained. Internal surfaces include the cooking pot and the chamber that holds the cooking pot:

- *Good* – No workmanship or functionality deficiencies were observed. Materials are clearly sturdy.
- *Satisfactory* – Small workmanship deficiencies were observed such as scratches, missing screws, or small deformities, but these issues did not affect functionality of the product. Materials are adequate
- *Needs Improvement* – Many workmanship issues were observed such as scratches, missing screws, or small deformities, which did not affect the overall functionality of the product; OR small functionality issues were observed; OR materials are flimsy.
- *Poor* – Workmanship issues were observed that affected the overall functionality or safety of the product.

3.1.2.3 Record any comments.

3.2 Lid Seal Design, Quality, and Durability

3.2.1 Examine and take photograph(s) of the lid's seal prior to testing, and again after all pressurization testing is complete.
3.2.2 Evaluate via visual assessment of design during initial inspection. Does the design of the EPC closing system prevent any jets of steam released from directly hitting the user or the handles? Also perform an "in-practice" assessment when opening the device during performance tests.

- Visual Assessment: Yes / No
- In-practice Assessment: Yes / No

3.2.3 Rate the quality of the lid's seal, including durability and resistance to temperature:

- *Good* – No apparent degradation after performance testing.
- *Satisfactory* – Seal is discoloured but has no other signs of damage.
- *Needs Improvement* – Visual signs of poor durability, such as small cracks in the material, but is functional.
- *Poor* – Seal no longer functions.

3.2.4 Record any comments. Describe the condition of the lid seal after testing. In particular, note any apparent degradation due to temperature, or any signs that indicate low durability.

3.3 Mechanical Functionality of Handles and Lifting Grips

3.3.1 Perform the following assessment:

- Is there a lifting grip on the lid? Yes / No
- Are there lifting grips on the sides of the EPC body? Yes / No
- Are the lifting grips firmly attached? Yes / No
- Are the lifting grips positioned so that they are above the centre of gravity of the EPC with its lid, when filled with water to its capacity? Yes / No
- Does the inner cooking pot have handles? Yes / No

3.3.2 Record any comments.

3.4 Coating Compliance

The following test is used to evaluate whether the internal coating on the EPC will degrade at high (cooking) temperatures. A peeling test is conducted before and after heating the cook pot.

3.4.1 Perform a peeling test before the cook pot is heated in the kiln:

- Make a scratch in the shape of an asterisk in the bottom of the pot (two X's, offset 45 degrees from each other.)
- Stick two pieces of tape to the inside of the pot. One piece should be placed on top of the scratch mark, such that the tape lies parallel with one of the scratch lines. The other should be placed in an unscratched location. Use ASTM D3359-compliant tape, e.g., Elcometer 99 Adhesive ASTM D3359 Cross Hatch Adhesion Test Tape. Use a pencil eraser to press the tape into the surface. Next, wait approximately 60 seconds, then remove the tape.
- If any coating peels off, the EPC fails this test.

3.4.2 Perform a peeling test after the cook pot is heated in the kiln (if pot is integrated with the EPC body, do not perform this step):

- Remove cooking pot from EPC if possible.
- Heat the cook pot inside a kiln for 1 hr at 180°C.
- Allow the pot to cool, then perform a second peeling test.
- If the pot is integrated with the EPC body, perform the second peel test after the sauté cooking test.

3.4.3 Record any comments.

Performance

4.0 Energy Performance and Service Delivery Test

The Energy Performance and Service Delivery Test measures power consumption and temperature of an EPC over time. The purpose is to determine the energy efficiency and effectiveness of the EPC when performing various cooking tasks (heating phase, pressure phase, and sauté phase) and to determine how well the cooker holds heat (cooling tests). External temperature of the EPC will also be evaluated during this section of the test, as part of the safety assessment.

Many pressure cookers incorporate temperature and pressure sensors/switches to regulate the cooking process. When a pressure-cooking program is running, the heating element will turn on until the pressure reaches its set point for cooking. After reaching the set point, the heating element will then turn on and off cyclically to maintain the intended pressure range. The pressure cooker may rely on both temperature and pressure information to determine when to turn the heating element on and off.

The **Pressure-Cooking Performance Test** consists of three phases and uses water to simulate pressure cooking tasks. The three phases are meant to be performed consecutively, with no pause in between phases. Temperature inside the vessel is measured using a thermocouple that is adhered to the outside of the cooking pot.

For Pressure-Cooking Performance Tests, the product is filled with water to 50% of pot capacity, for a total of three tests.

- **Phase 1 – Cold Start Heating Test:** Starting with a room-temperature EPC, water is heated from room temperature until it reaches the set point for high pressure cooking.
- **Phase 2 – Pressure-Cooking Test:** EPC is held at high pressure for 30 minutes. Heating element is cycled on and off to maintain a given pressure range.
- **Phase 3 – Cooling Test:** The pressure cooker is allowed to cool until the water temperature is below 60^0C, while keeping the lid on.

The **External Temperature Test** should be carried out during Phase 2 of the performance test. Temperatures of exterior surfaces will be measured with fast-response thermocouples.

The **Sauté Cooking Test** evaluates the performance of the EPC when used in sauté/fry cooking mode. Oil is heated in the EPC pot for 30 min, while measuring temperature and power

consumption. If the EPC does not have a sauté mode/fry cooking mode, use the pressure-cooking function, but leave the lid off.

4.1 Pre-Test Preparation

Carry out the following steps before beginning the performance test.
4.1.1 Ensure equipment such as scales, temperature devices, and electrical equipment are calibrated.
4.1.2 Install temperature sensor:

- In case of using an iButton remote sensor, make sure it is inside its protective cover.
- Immerse the temperature measuring point in the water surface within the range of 10mm~30mm. Try to fix the temperature measuring point in the cylinder with ϕ50mm in the centre of the inner pot.

4.1.3 Connect electrical equipment.
4.1.4 Set voltage to value at which the EPC is intended to operate, as indicated by the operation manual.
4.1.5 Record the following ambient conditions in the EPC test space and log these on the **Heating Phase** sheet of the test report template:

- Ambient air temperature
- Ambient humidity
- Ambient pressure

4.2 Phase 1: Heating Test – Cold Start

The Heating Test evaluates when the EPC begins heating to when it reaches its designed cooking set point – the pressure and/or temperature at which it is designed to maintain when in pressure-cooking mode. This set point may be controlled by a pressure sensor, temperature sensor, or a combination of the two. Alternatively, it may be controlled mechanically by a weighted valve. The end of the heating phase is signalled by the float valve popping up and sealing the pot. This also signals the beginning of the pressure-cooking phase.

- Record the following data on the **Heating Phase** sheet of the test report template:
    - Test date
    - Cooking mode used for testing
    - Empty EPC mass (including removable pot)
    - Diameter and height of the pot
- Fill pot with water to 50% capacity. Water temperature should be between 15 °C and 25 °C.
- Close EPC lid.
- Weigh the EPC filled with water and record.
- Set the pressure cooker to run on the pressure-cooking setting, and the cook time (not including initial heating time)[2] to 30 minutes. Some pressure cookers may have multiple pressure settings. If this is the case, use the highest-pressure setting.

[2] Generally, EPCs with button-type controls have an internal timer that starts counting down when the cooker has completed the initial heating phase and begins the cooking phase. If this is the case, set the

- Follow instructions in 4.1.2 to install the temperature sensor.
- Power the EPC on. Record start time of the heating phase.
- Use an electric energy meter to start recording the power consumption of the EPC.
- As the EPC is heating, record the time and temperature at which the float valve pops up, if present.
- Allow the EPC to reach its set point[3]. Record the time that the EPC indicates that it has started its pressure-cooking phase (note the pressure status is isochoric).

Record the following performance metrics:

- Time to reach working pressure (°C)
- Average and max power draw when heating element is on (W)
- Initial energy consumption during heating phase (Wh)
- Maximum water temperature (°C)

4.3 Phase 2: Pressure-Cooking Test [4]

The Pressure-Cooking Test Evaluates the 'pressure-cooking phase' of the cooking process. The pressure-cooking phase is defined as the portion of the test after the set point has been reached, where the EPC is in its 'steady state' operation. For many EPCs during this phase, the heating element is turned on and off cyclically so as to maintain the set cooking temperature.

- Allow the EPC to run through the 30-minute pressure-cooking phase. Keep the lid on throughout.
- Add time to the timer if necessary to reach the full 30 minutes of cooking time.
- Record temperature of the EPC lids and body throughout the process with the surface thermocouples.
- When the internal cooking temperature of the tested product reaches 100°C, start to continuously record the temperature value t. Record once every second. After 30min of continuous work, read the power consumption E. Stop recording temperature value t. Calculate the energy consumption value according to formula below

$$\eta = \frac{\lambda \times G(H_i - H_{t_1})}{3.6 \times E} \times 100\% \qquad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (1)$$

timer to 30 min. If the timing mechanism is a dial, the timer starts when the heating phase starts. Therefore, the dial should be set to a time that is sufficient to include both the heating phase and the cooking phase, around 50-60 min total. If necessary, more time can be added to the dial during the cooking phase.

[3] For dial-type EPCs, the product does not necessarily indicate when it has reached its set point. Therefore, for these EPCs, it is necessary to monitor the temperature and record the time that the temperature reaches its first peak as the start time of the cooking phase. Alternatively, if the temperature rises and then stays at a constant value, record the time that it first reaches that constant value. Monitoring power can also help with determining the start time of the cook phase for dial-type cookers. In most cases, the power switches off at the end of the heating phase, which is easily noticeable if monitoring power in real-time. The relay is usually audible when the heating element switches off.

[4] As per GB 39177-2020 standard

In which,

$$H_{\bar{t}} = 9.601\ 2\bar{t} - 539.64\ (100\ ℃ \leqslant t < 140\ ℃) \quad \cdots\cdots (2)$$

$$\bar{t} = \sum_{t=1}^{1\ 800} t / 1\ 800 \quad \cdots\cdots (3)$$

$$H_{t_1} = 4.187\ 5t_1 + 0.143\ 9\ (20\ ℃ \leqslant t < 100\ ℃) \quad \cdots\cdots (4)$$

Where,

- η - Energy efficiency of electric pressure cooker, %;
- λ - Heating method correction factor. For products of which the heating method is electromagnetic induction heating, take 1.15 as λ value; for products of which the heating method is electric heating element heating, take 1.0 as λ value;
- G - Mass of water before test, in kilograms (kg);
- $H_{\bar{t}}$ - When the temperature is higher than 100°C, the enthalpy value corresponding to the arithmetic mean value of the cooking temperature in the cooker for 30min continuous work, in kilojoules per kilogram (kJ/kg), calculated according to formula (2);
- $\bar{t}$ - When the temperature is higher than 100°C, the arithmetic mean value of the cooking temperature in the cooker for 30min continuous work, in Celsius (°C), calculated according to formula (3);
- H_{t1} - Enthalpy value corresponding to the initial water temperature before the test, in kilojoules per kilogram (kJ/kg), calculated according to formula (4); t_1 - Water temperature before test, in Celsius (°C);
- E - Power consumption, total input power of the whole process of determination, in watt hour (W · h);
- t - When the temperature is higher than 100°C, the cooking temperature value in the pot for 30min continuous work, recorded once every second, in Celsius (°C).

The minimum allowable value of energy efficiency for electric pressure cooker is grade 3 index value of the energy efficiency grades in Table 3 below.

Table 3 Energy efficiency grades

Energy efficiency grade	**Energy efficiency value η %**		
	V≥7.5L	3.5L<V<7.5L	V≤3.5L
1	85	79	75
2	79	72	68
3	72	65	60

Record the following performance metrics:

- Minimum, average, maximum temperatures during pressured cooking phase (^{0}C)
- Minimum, average, maximum pressures during pressured cooking phase (kPa)
- Average and max power draw during cooking phase (W)

- Total energy consumption during the entire cooking phase[5] (Wh)
- Calculated energy efficiency value
- Grade the EPC energy efficiency value based on Table 3 above

4.4 Phase 3: Cooling Test

- After the cook phase is finished, turn the power off. Do not open the lid. Record this time as the start time of the Cooling Test.
- Continue recording temperature until the temperature drops below 60^0C.
- Record the Cooling Test end time.
- If the cooker has a float valve (or similar) record the time that the float valve drops.
- Plot graph of temperature drop vs time
- Calculate the heat loss rate using the formular below.

$$Heat\ loss = \frac{m * C * \Delta T}{t}$$

Where,

- η – thermal efficiency of electric pressure cooker (%)
- m – mass of water before test
- C - specific heat of water for heating phase, °C (isobaric)
- ΔT – temperature drop from temperature when pressure phase is turned off to 60^0C
- t- time

- Evaluate insulation efficiency. If time taken for temperature to drop to below 60^0C is less than 100 minutes[6], mark the insulation for the EPC as fail.

Record the following performance metrics:

- Heat loss rate (W)
- Normalized heat loss rate (W/m^2)
- Time taken to drop to below 60^0C
- Insulation efficiency (pass/fail)

4.5 Sauté Cooking Test

The Sauté cooking test has two portions. First, the cooker is operated in sauté mode and the heating element is imaged with a thermal camera to determine temperature distribution across the heating element. Second, the cooker is run on sauté mode with a layer of oil in the pot, and temperature of the oil is monitored for a duration of 30 minutes.

- Record the following data on the **Saute** sheet of the test report template:
    - Test date
    - Cooking mode used for testing

[5] The entire cooking phase includes heating and pressure-cooking phases.
[6] From Kijani's experiment, it took 88 minutes for the temperature in an uninsulated pot to drop to below 6o degrees.

- Start with EPC at room temperature.
- Run the EPC on sauté mode with an empty pot. If the EPC does not have a sauté mode/fry cooking mode, use the pressure-cooking function, but leave the lid off. Use a thermal camera or thermocouples to take images or temperature readings of the bottom of the pot as the element heats up. Images should be taken as the element is heating (e.g. at 1 min, 2 min, and 5 min), and also once the cooker has reached a steady state, e.g. at 10 min.
- Allow the cooker to cool completely before moving on to the next step.
- Fill EPC to a depth of 2 cm with vegetable oil.
- Fix a high temperature thermocouple inside the pot to measure oil temperature. The thermocouple should be located in the centre of the pot. The tip should be immersed in oil but should not touch the surface of the pot.
- Begin logging temperature data and power data.
- Set the EPC to sauté/fry cooking mode. Leave the lid off for the duration of the sauté cooking test. Allow to cook for 30 minutes.
- After 30 minutes, stop data logging, turn off the EPC and allow to cool.

Record the following performance metrics:

- Average sauté power
- Minimum, maximum, and average sauté temperature.
- Sauté time to heat, defined by the time to reach the first temperature peak during the sauté test.
- Sauté temperature stability: percent (%) of time within desired range (140-180°C)

4.6 Low- and High-Voltage Tests

The low and high voltage tests consist of 3 sections:

- Low voltage threshold
- Low-voltage performance: A performance test is run at -30% of the intended operating voltage.
- High-voltage performance test: A performance test is run at +30% of the intended operating voltage

Record the following data on the **Low High Voltage** sheet of the test report template:

- Test date
- Cooking mode used for testing
- Input voltages for testing low and high voltages

4.6.1 Low-Voltage Threshold

Find the low voltage threshold at which the cooker turns on/off. Start with the voltage at 0, and slowly turn the voltage up until the cooker turns on.

4.6.2 Low-Voltage performance

- Set the voltage to 70% of the intended operating voltage (e.g. for a nominal voltage of 230V, the low-voltage performance test should be run at 195.5V).

- Complete Phase 1 (Section 4.2, Heating Test) of the performance test, but using the reduced voltage. Use a water volume of 50% capacity. It is not necessary to perform the cooling phase for this test. Steam may be manually vented to speed up testing.
- Record the following data and any comments:
    - Does the unit pressurize? (Pass/Fail)
    - If the unit pressurizes at low voltage, record the time to pressurize (min)
- Next, perform a sauté test at 70% of the nominal voltage. Use the same procedure as in section Sauté Cooking Test.
- Record the following performance metrics and any comments:
    - Average sauté power in low-voltage conditions (W)
    - Time to heat in low-voltage conditions (min), defined by the time to reach the first temperature peak during the sauté test
    - Minimum, maximum, and average temperatures during low-voltage sauté test
    - Sauté temperature stability: percent (%) of time within desired range (140-180°C)

4.6.3 High-Voltage Test

Use the EPC designated for destructive tests (Destructive Test Unit) for the high-voltage test, as this test may be destructive. This test should be performed after all other non-destructive tests.

- Set the voltage to 130% of the intended operating voltage. (e.g. for a nominal voltage of 230V, the high-voltage performance test should be run at 264.5V)
- Complete Phase 1 (Heating Test) and Phase 2 (Pressure Cooking Test) of the performance test, but using the increased voltage. Use a water volume of 50% capacity. It is not necessary to perform the cooling phase for this test. Steam may be manually vented to speed up testing.
- Record if the product is able to heat and pressurize under high-voltage conditions.
- For products that shut down during the high-voltage test, could the product be powered on and operate at nominal voltage afterwards? Record yes or no.
- Inspect the electronics for damage and record any comments.

Safety

5.0 Exterior Body and Handle Temperature Test

- Conduct the exterior temperature test during Phase 2 of the performance test.
- Use a fast-response thermocouple to measure the temperature of each surface at multiple locations. Record the highest temperatures measured.
- The surface temperature hazard is defined by a comparison of the surface temperature to the ambient temperature. The data reporting template will calculate this automatically. The thresholds are also given in the table below (according to *IEC 60335:1 2020*):

Table 4 Acceptable temperature rise above the ambient air temperature in degrees Celsius for external parts of the EPC, IEC 60335:1

Electric Pressure Cooker External Part	**Temperature Rise above Ambient (**°C)
External enclosure of motor-operated appliances except handles held in normal use: *– of bare metal* *– of coated metal* *– of glass and ceramic* *– of plastic having a thickness exceeding 0,3 mm*	 50 60 65 75
Surfaces of handles, knobs, grips and similar parts which are continuously held in normal use *(e.g. soldering irons):* *– of metal* *– of porcelain or vitreous material* *– of moulded material, rubber or wood*	 30 40 50

- Evaluate the surface temperatures of exterior body, lid handle and the side handles, and any other handles. If temperature rise is within the thresholds listed above, rate product as “good.” If temperature rise is beyond the thresholds listed above, rate product as “needs improvement.”

Report the results on the external temperature test sheet.

- Ambient temperature during this test (°C)
- Handle Material
- Temperature of lid handle (°C) and the temperature rise from ambient temperature (°C)
- Temperature of side handles (°C) and the temperature rise from ambient temperature (°C)
- Ratings of exterior surfaces and handle temperatures Any additional comments and observations

6.0 Tipping Test

Below are the instructions for conducting the stability test as per IEC 60335-1:2020 standard.[7]

The appliance, not connected to the supply mains, is placed in any normal position of use on a plane inclined at an angle of 15° to the horizontal, the **supply cord** resting on the inclined plane in the most unfavourable position. However, if part of an appliance comes into contact with the horizontal supporting surface when the appliance is tilted through an angle of 15°, the appliance is placed on a horizontal support and tilted in the most unfavourable direction through an angle of 15°.

[7] IEC 60335- 1:2020 clause 20

Appliances intended to be filled with liquid by the user in normal use are tested empty or filled with the most unfavourable quantity of water up to the capacity indicated in the instructions.

Appliances that overturn will be marked as fail and ones that do not will be marked as pass. Record the outcome in the report template.

7.0 Control & Safety Device Tests

7.1 Pressure Control Device Functionality

1) Check of direct weight valves and other non-fixed parts

- Turn the pressure cooker lid upside down to check that any loose parts cannot be lost (e.g. locking pin or the weight, if the cooker uses a direct weight valve).
- Are all parts retained? Yes / No
- Record any comments.

2) Check for Incorrect Fitting of Lid

- Is there a possibility of incorrect fitting of the lid? (Look for symmetry vs. asymmetry in the lid design)? Yes / No
- If the lid can be fitted incorrectly, can it create a seal that would allow pressurization? Yes / No
- Describe if yes and add any relevant photographs.
- Test the incorrectly fitted lid with a compressed air pressure test. Use the same compressed air system as in the safety device testing procedure (Section 7.5, Safety Device Testing). Use the procedure given in section 7.5.1, but only increase the pressure up to the working pressure of the device.
- Record any comments.

3) Safety Device Disassembly

- Is disassembly of any control and safety devices required for cleaning? Yes / No
- If so, can control and safety device parts be easily disassembled and reassembled? Yes / No
- Record any comments.
- If parts can be removed while the EPC is under pressure, does this present a hazard for the user? Yes / No
- Record any comments.

4) Control Pressures Check

The control pressures check is used to evaluate how well the pressure cooker maintains a given pressure. The limits for pressure given by BS EN 12778[8] are below:

- Tolerance of +/- 20% of pressure declared by manufacturer, up to max. of +/-20kPa
- Maximum pressure should not be greater than 150 kPa, or less than 4 kPa, when the device is in operation.

[8] from BS EN 12778 – 4.5.2.3

- The highest-pressure level shall be evaluated using data from the performance tests (Heating and Pressure-Cooking phases).
- Does the pressure inside the EPC remain within the tolerances given above? Yes / No
- Record any comments.

7.2 Pressure Indicator Functionality

- Is there a visual and/or acoustic signal indicating that the pressure cooker is operating? Yes / No
- Record any comments.
- Is there a pressure indicator? Yes / No
- Describe the pressure indicator. One example of a pressure indicator would be a float valve that pops up when the cooker is pressurized.
- Does the pressure indicator function properly? Yes / No
- Record any comments.

7.3 Decompression Device Functionality

Some pressure cookers have wobbly valves that may release steam if the pressure cooker is bumped while the pot is pressurized.

- Check the sealing ability of the pressure release valve by bumping the side of the pressure cooker while the pot is pressurized with steam. This can be done at the end of the hot start test or low/high voltage tests (any tests where the cooker is pressurized but a cooling phase is not required).
- Is any steam released? Yes / No
- Does the manual decompression device effectively discharge steam from the pressure cooker? Yes / No
- Does the steam release device to present a hazard to the user? Yes / No
    - (There is an inherent burn hazard in releasing steam from all cookers. This question intends to ask if there is any *additional* hazard due to the direction of the steam jet or other factors).
- Record any comments.

7.4 Safety Device Identification

The goal of this section is to identify the control and safety devices present in the pressure cooker and test their functionality. Safety devices will be tested by using compressed air to pressurize the cooking vessel. Using compressed air enables pressurization without relying on heating water to pressurize the vessel, thereby reducing the hazard of the task. Additionally, this method allows for direct pressure measurement.

Procedure
Mark whether each of the following safety devices are present:
1) Lid

- *Lid position detection*: EPC detects whether lid is closed. This is a mechanism with an electronic component that indicates to the control system of the cooker whether the lid is closed.
- *Lid lock*: Locks the lid in place when the cooker is pressurized. (May also be a float valve)
- *Mechanism to prevent float valve from engaging if the lid is only partway closed.* This is likely the same mechanism as the lid lock.

2) Pressure

- *Pressure Sensor/Switch/Automatic Pressure Control*: Heating element turns off when a given pressure is reached.
- *Pressure Release Valve*: Valve opens if pressure exceeds normal levels
- *Weighted Valve*: The Pressure Release Valve may be a weighted valve.
- *Float Valve*: Metal pin with a rubber stopper. Pin moves upwards and stopper creates a seal to prevent steam from escaping when the cooker is pressurized. The float valve may also serve as a lid lock.
- *Extruding Gasket:* Gasket extrudes/deforms such that the pressure is released. Note, if the cooker has an internally fitted lid, gasket extrusion might not be possible.
- *Moving Inner Pot:* High pressure will cause the pot to move downwards, which creates a gap between the seal and the inner pot, releasing pressure.
- *Leaky Lid Detection:* If there is steam leakage from the lid, the cooker will not pressurize: the cooker monitors the pre-heating time and lowers heat output if the working pressure is not reached within a certain time.
- Other secondary pressure relief

3) Temperature

- *Automatic Temperature Control:* Heating element turns off when the given temperature is reached
- *Thermal Fuse:* Cuts off power when a certain temperature is reached (should be higher than automatic control temperature, but lower than the temperature at dangerous pressure levels).
- *Overheat (burn) Protection:* Heating element turns off when a given temperature is reached to prevent burning.

4) Other

- *Anti-clog cap / Anti-block shield:* Protects the pressure release valve from becoming clogged with food.

7.5 Safety Device Testing

7.5.1 Pressure-Related Safety Device Test Procedure

The safety device test focuses on the pressure-activated safety devices. (Note: the purpose is to test mechanical safety devices rather than any electronic control devices). This test uses compressed air to raise the pressure inside the cooking vessel and activate each safety device in succession.

1) Procedure:

- Modify the EPC: Attach a fitting to the lid of the EPC that will allow the interior of the EPC to be pressurized via compressed air.
- Set up the compressed air system. The system should consist of an on/off valve for the compressed air, a regulator, and a pressure relief system. The regulator/pressure relief system may be either a venting regulator, or regulator plus a downstream manual valve that will allow the pressure to be safely released after the EPC is pressurized.
- Fill the cooking pot with water to the brim and close the lid. **Important:** For safety, the pot should be as full as possible to minimize the volume that will be occupied by compressed air (and therefore minimize the total energy contained inside the vessel).
- Turn the compressed air regulator all the way down, then connect the compressed air line to the EPC.
- Place the EPC inside a safety chamber and close the chamber. The chamber should protect the operator from potential shrapnel and pressurized contents but should also be sufficiently vented to be able to quickly release pressure.
- Start running compressed air into the EPC, by gradually increasing the regulator pressure.
- Slowly increase the pressure until the float valve pops up (if present). Record the pressure at which the float valve popped up.
- Continue gradually increasing the pressure until the primary safety device activates. Record the pressure at which this device activates and note which device it is.
- Continue increasing pressure until the secondary safety device activates. Note the device, and the pressure at which it activated. If the pressure cannot be raised sufficiently to trigger the secondary device, disable/block the primary safety device, then resume pressurization. If necessary, refill the pot with water before pressurizing again.
- If further safety devices are present, continue to increase pressure until all the safety devices have activated, recording the pressure at which each device activates.
- After all safety devices have been activated, close the valve to the compressed air supply and vent any remaining pressure, to ensure the EPC is not pressurized before opening the chamber.

2) Resistance to Deformation

- Verify by inspection that there was no plastic deformation of the vessel during the previous test. Also check concavity of the bottom of the pot. If there was no plastic deformation, continue to the Resistance to Destruction test below.

3) Resistance to Destruction

- Disable/block any safety devices that will prevent the vessel from reaching a pressure of 500 kPa. (Value is subject to change)
- Refill pot with water as in (3), above.

- Reconnect the cooking vessel to compressed air. Gradually increase the pressure to 500 kPa, if possible. Maintain a pressure of 500 kPa for one minute.
- If pressure containment fails before 500 kPa, record the pressure at which containment failed.
- Close the valve to the compressed air supply, then vent any remaining pressure before opening the safety chamber.
- If it was found that the lid may be put on incorrectly, test that the vessel cannot be pressurized now, using the same procedure as in the pressure-testing section.
- Record any comments.

6.5.2 Temperature-Related Safety Devices

This section tests the temperature control devices and identifies details about any thermal fuse present.

- Open the bottom of the pressure cooker. If a thermal fuse is visible, identify and record its location and its temperature rating (if possible).

7.6 Safety Device Functionality

1) Identify and evaluate safety device functionality as a pass or fail.

A “safety device” refers to devices other than those used to control the pressure during normal operation, either electronically (e.g. pressure sensor) or mechanically (e.g. weighted valve).

- For each safety device present, determine whether it is assembled correctly. (From BS EN 12778 5.5.4)
- What is the primary pressure control device? (From BS EN 12778 – 4.5.4.1)
- Is there at least one safety device that is separate from the pressure control device? (E.g. if the pressure is controlled via a weighted valve, is there a separate safety device that will activate if the valve gets clogged. If the cooker is intended to be controlled electronically, is there a mechanical safety device that will activate if the electronics fail?) Yes / No

2) The requirements below are valid only for the safety device that operated first during the Safety Device Test.

- Can the safety device cause a steam jet to hit the lifting grips or the operator of the appliance? Yes / No
- Does operation of the safety device cause the EPC to move significantly? Yes / No
- Is the safety device self-destructing? Yes / No
- If the device is self-destructing, is it replaceable with a new one after each operation? Yes / No
- If the safety device is replaceable, can it be replaced by the user, or does it need to be serviced by a technician? Yes / No
- Is it possible for the device to throw off fragments as it fails that may hit the user? Yes / No

3) The working pressure of the safety device shall be greater than the highest measured control pressure (as per 5.5.2.3) and shall not be greater than the maximum permissible pressure PS.

(From BS EN 12778 4.5.4.2). However, a momentary pressure surge limited to 10% of PS is acceptable, but the pressure of the safety declared device shall not in any case be greater than 300kPa (3.0 bar).

- Are the requirements above met? Yes / No
- Record any comments.
- Can detachable parts of the safety device be wrongly assembled? Yes / No

4) With the safety device incorrectly assembled, inspect for any possibilities of malfunction that could present a hazard to the user, e.g. the part fits more loosely than it should. Record any comments.

5) Detachable parts of the safety device shall be designed in such a way that, if incorrect assembly of the device is possible, the pressure cooker cannot reach a pressure higher than the maximum permissible pressure PS when the device is normally fitted (From BS EN 12778 4.5.4.1). If the safety device has detachable parts that can be wrongly assembled, can the pressure cooker reach a pressure higher than the maximum permissible pressure? Use the procedure below:

- Assemble the safety device incorrectly and set up for a compressed air pressure test. Use the same compressed air system as in the safety device testing procedure (Section 7.5).
- Using the same procedure as in section 5.5, increase the pressure only until the first safety device activates (either the incorrectly assembled safety device or a different device). Note the pressure at which the device activated.
- As long as the pressure does not go above the maximum permissible pressure before a safety device activates, the cooker passes this part of the test – regardless of which device activated first.
- Record any comments.

7.7 Safe Opening System Functionality

- Does the pressure cooker have a device that prevents opening at high pressure? Y/ N
- Describe the components of the safe opening system.
- If so, does it prevent the pressure cooker from being opened if the internal pressure is higher than 4 kPa? Yes / No
- Is there any possibility of wrongly assembling the safe opening system? Yes / No
- If so, test the incorrectly assembled safe opening system using a compressed air pressure test. Use the same compressed air system as in the safety device testing procedure (Section 7.5, Safety Device Testing). Use the procedure given in section 7.5, but only increase the pressure until the lid-locking device operates. Record the pressure at which the device activated.
- If it is possible to incorrectly assemble the safe opening system, is the internal pressure at opening less than or equal to 4 kPa? Yes / No
- Record any comments.

8.0 Circuitry & Wiring Durability Tests

8.1 Quality of Circuitry and Wiring

- Is the wire core stranded? Bend the cable a few times. If the resistance to bending does not change, the wire is stranded. If the cord becomes more difficult to bend, the core is likely solid.
    - Main power cord (external): Yes / No
    - Internal wiring, from main power: Yes / No
- Record the wire gauge, external and internal. (Visual inspection for stamp on the wire).
- Is the power cord attached or detachable?
- Identify the type of connector.
- Can the connector be easily confused with another type of connector? (E.g., can a DC connector be confused with an AC connector?) Yes / No
- If so, is it possible to plug in the connector to the wrong type of socket? Yes / No

8.2 Cord Durability Test

Before operating the EPC, test the durability of the main electrical cord:

- Test the cord attachment:
    - For an attached cord: Pull on the cord with a force of 60 N. Pull at an angle perpendicular to where the cord enters the EPC. Ensure that the strain relief does not fail.
- For a detachable cord, pull on the cord slowly. The cord should remain attached, and subsequently the unit should be dragged across the work surface. Next, pull the cord quickly. When pulled quickly, the plug should separate from the socket.
    - For an attached cord, flex the cord 90 degrees, close to where it enters the strain relief. Repeat for 100 cycles.
- Inspect the cord for signs of failure. Are there any failure signs? Yes / No
- Record any comments.

8.3 Cord Quality Rating

- Inspect the internal circuitry wiring of the EPC.
- Wiggle the wires to see how firm the connections are. Are they connections bolted, or otherwise firmly attached? What type of insulation does the wire have?
    - Good: Wires are firmly attached. No sharp edges. Wire has fibre/cloth insulation.
    - Satisfactory: Some wires do not have cloth insulation but are firmly attached. OR wires wiggle but remain firmly attached.
    - Needs improvement: Some loose wires, or coating on wires is degraded.
    - Poor: Contains sharp edges, loose wires or exposed wires.
    - Record any comments.

8.4 Current Carrying Capacity of Cable

- Determine the current produced in the main power cable during operation.

- Identify the current carrying capacity of the cable (Visual inspection for stamp on the cable). (e.g. Ref. 6)
- Does the operational current exceed the current carrying capacity of the cable? Yes / No
- Record any comments.

8.5 Shock Hazard Test

- When the EPC is plugged in, measure the resistance from the body of the EPC to a known earth ground, e.g., the ground hole in an outlet, or exposed building steel.
- Resistance should be less than 5 ohms. (IEEE 42)
- Record any comments.

8.6 Front Panel and On/Off Switch Quality

- Evaluate the quality of the front control panel and any buttons or dials. (See separate question below for evaluating switches.)
    - Good – Buttons and/or dial do not have any durability problems through the duration of testing.
    - Satisfactory – Buttons and/or dial showing signs of wear after performance testing.
    - Needs Improvement – Buttons and/or dial indicate low durability before any testing.
    - Poor – Buttons fail/break during the course of the laboratory test.
- Record if an on/off switch present? Yes / No
- If possible, identify the current and/or voltage rating of the switch by inspection.
- Determine whether the switch is adequate for the current and voltage requirements of the EPC.
- If an on/off switch is present, describe the quality of the switch:
    - Does the switch fit and hold well?
    - Does the switch perform adequately?
    - Does it appear flimsy?
- Rate the on/off switch according to the following and record:
    - Good – The switch fits well in its housing, feels sturdy when operated, and performs well.
    - Fair – Switch appears flimsy but performs adequately.
    - Poor – Switch does not perform adequately or breaks during the course of the laboratory test.