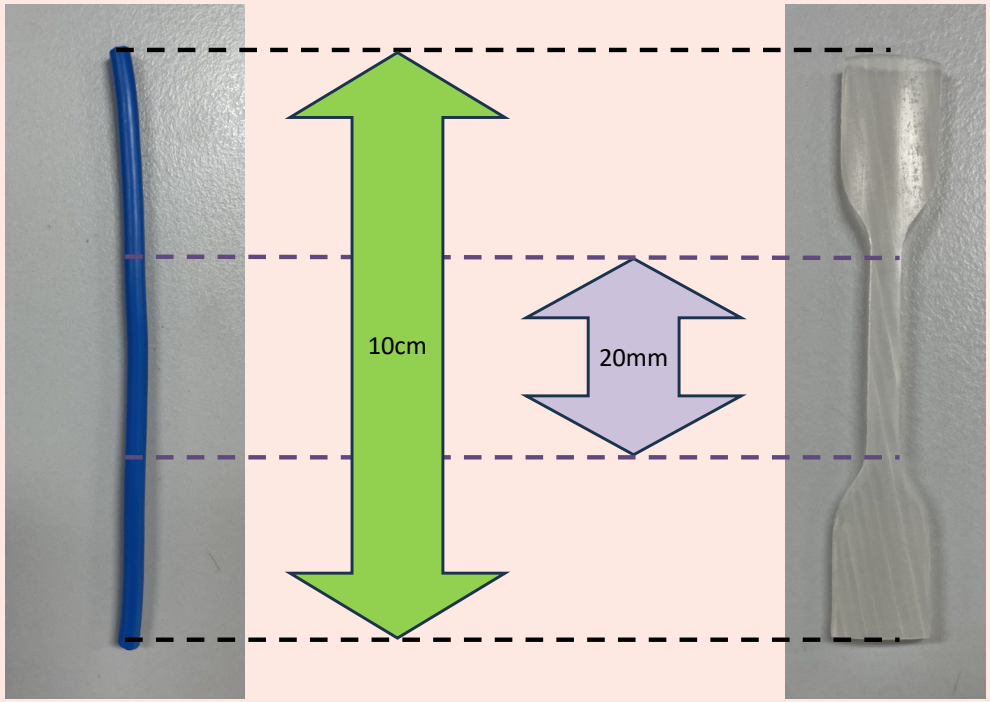
Hot Set Test

Presented by Keystone-cable

2 types of Hot Set Test

Tubular Sample

Dumbbell Sample



1. Know what type of sample you should use to undergo Hot Set experiment (refer to Appendix 1)

- 1.1. Specifically for the dumbbell sample, the thickness must be no less than 0.8 mm and no more than 2.0 mm. We normally aim for a thickness close to 1 mm (refer to Appendix 2 for the grinding procedure)

2. Use a marker to draw a line indicating the 20 mm mark on the tubular sample or dumbbell sample, as shown in the image

2 types of Hot Set Test

Tubular Sample

Dumbbell Sample

Because Hot Set test requires weights to pull on the test material, we must first calculate the required mass. To calculate the amount of mass (in grams) needed for either your Tubular or Dumbbell sample, use the following formula:

We need to take Gram-force (in $\frac{g}{mm^2}$) x area (in mm^2)

= 20.387 $\frac{g}{mm^2}$ x area (in mm^2)

BUT how to find area? Are the area for Tubular and Dumbbell samples the same? Let's find out!

The calculation derivation for 20.387 can be found in Appendix 3, do take a look, they are from step 1 to 4. So the following slides will start from step 5

Tubular Hot Set Test Example

5 Area for Tubular sample = (Mean of outer diameter – Mean of thickness of insulation) x Mean of thickness of insulation x π

For example, Area for Tubular sample = (2.308 mm – 0.642 mm) x 0.642 mm x 3.1416

= 3.360 mm^2

6 Therefore, after we found the Tubular area, we can sub into the mass formula, to calculate the mass (in grams) needed for your Tubular sample:

Mass (in grams) = 20.387 $\frac{g}{mm^2}$ x 3.360 mm^2

= 68.50 g

Later when we discuss the calculation for Dumbbell sample, you will realised that steps 1 to 4 are the same, the only different is their area formula.
The calculation for Tubular area and Dumbbell area are different!!! Therefore, their final mass calculated will be different too.

Tubular Hot Set Test Practice

You are conducting a Hot Set test for an Tubular sample, given that the mean outer diameter of the insulation is 3.111 mm and its thickness is 1.25 mm

1. Calculate the area of the tubular sample using the formula (in mm^2)
2. Using the area calculated, determine the mass (in grams) needed for the tubular sample

Try this question now!

Tubular Hot Set Test Practice Answer

You are conducting a Hot Set test for an Tubular sample, given that the mean outer diameter of the insulation is 3.111 mm and its thickness is 1.25 mm

1. Calculate the area of the tubular sample using the formula (in mm^2)
2. Using the area calculated, determine the mass (in grams) needed for the tubular sample

1

After knowing the values of Mean of outer diameter and Mean of insulation thickness, we can sub into the area formula:

Area of Tubular sample = (Mean of outer diameter – Mean of thickness of insulation) x Mean of thickness of insulation x π

= (3.111 mm – 1.25 mm) x 1.25 mm x 3.1416

= 7.308 mm^2

2

Mass = 20.387 $\frac{g}{mm^2}$ x $area$

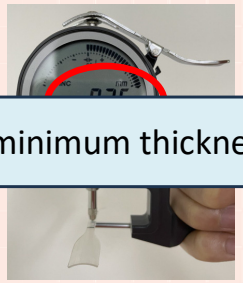
= 20.387 $\frac{g}{mm^2}$ x 7.308 mm^2

= 148.99 g

Dumbbell Hot Set Test Example

5 Area for Dumbbell sample = Fixed width x Minimum thickness

Example: One of the fixed width we use for this experiment is 4.21mm



What is the minimum thickness you measure?

For example, Area for Dumbbell sample

= 4.21 mm x 0.76 mm

= 3.200 mm^2

6 Therefore, after we found the Dumbbell area, we can sub into the mass formula, to calculate the mass (in grams) needed for your Dumbbell sample:

Mass (in grams) = 20.387 $\frac{g}{mm^2}$ x 3.200 mm^2

= 65.24 g

Dumbbell Hot Set Test Practice

You are conducting a Hot Set test for an Dumbbell sample, given that the fixed width is 4.21 mm and its minimum thickness measured is 1.25 mm

1. Calculate the area of the dumbbell sample using the formula (in mm^2)
2. Using the area calculated, determine the mass (in grams) needed for the dumbbell sample

Try this question now!

Dumbbell Hot Set Test Practice Answer

You are conducting a Hot Set test for an Dumbbell sample, given that the fixed width is 4.21 mm and its minimum thickness measured is 1.25 mm

1. Calculate the area of the dumbbell sample using the formula (in mm^2)
2. Using the area calculated, determine the mass (in grams) needed for the dumbbell sample

1

After knowing the values of Fixed width and Minimum thickness, we can sub into the area formula:

Area of Dumbbell sample = Fixed width x Minimum thickness

= 4.21 mm x 1.25 mm

= 5.263 mm^2

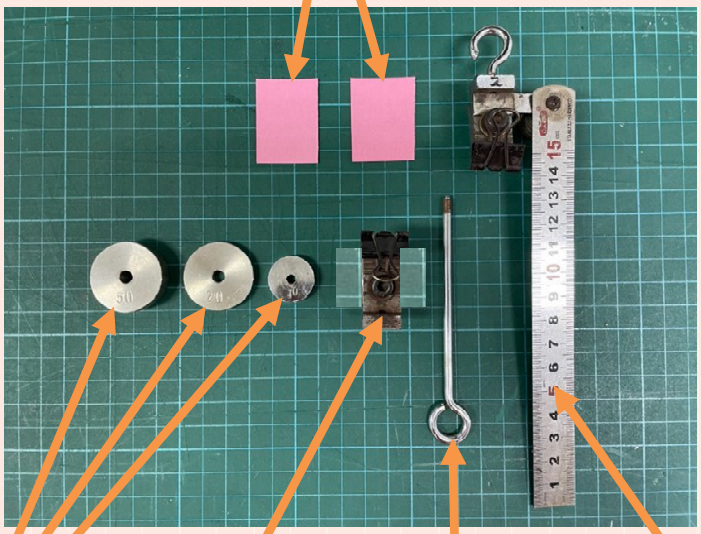
2

Mass = 20.387 $\frac{g}{mm^2} x\ area$

= 20.387 $\frac{g}{mm^2}\ x\ 5.263\ mm^2$

= 107.30 g

Preparation of Apparatus



Apparatus needed

Take note: the upper clip with ruler do not contribute to your calculated mass, so we do not weight them

Choose the suitable mass balance to weigh the sample based on your calculated mass

Preparation of Apparatus

After you weight the mass that you have calculated, now we start to assemble them

Before assembly
(Mass shown on balance is just an example)

After assembly
(We are ready for the next step which is oven procedures)

Oven Procedures – Preparation and Safety

Before starting the experiment:

Pre-heat the oven to a temperature of 200°C ± 3°C, as pre-heating takes time!

During the experiment:

1. Safety first - Wear gloves before touching any part of the oven
2. Ensure that the temperature of the oven is stable at approximately 200°C before you open the oven door to put in your test material

Oven Procedures - Proper Sample Positioning

Placing of test materials

3. The temperature will definitely drop when the oven door is opened, so do place your test materials as quickly as possible but in a safe manner

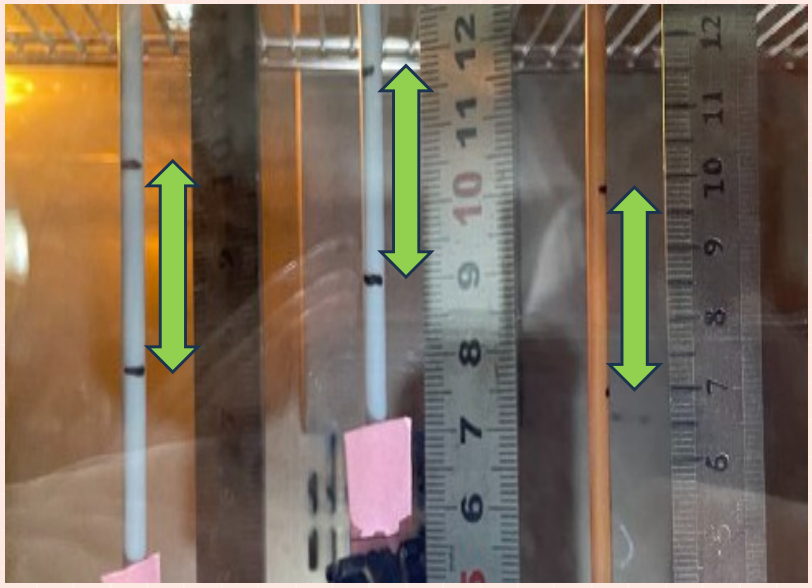
4. Position the test materials in the area visible through the glass part of the oven door, ensuring they are suitably spaced apart, not “squeezing” each other

Adjust properly!
Ruler not visible to the operator

Good to continue!
Suitably spaced apart, rulers are visible to the operator

Oven Procedures - Elongation Measurement

5. Close the oven door and wait until the temperature reaches 197°C (within the 200°C ± 3°C range) before starting the 10 mins timer

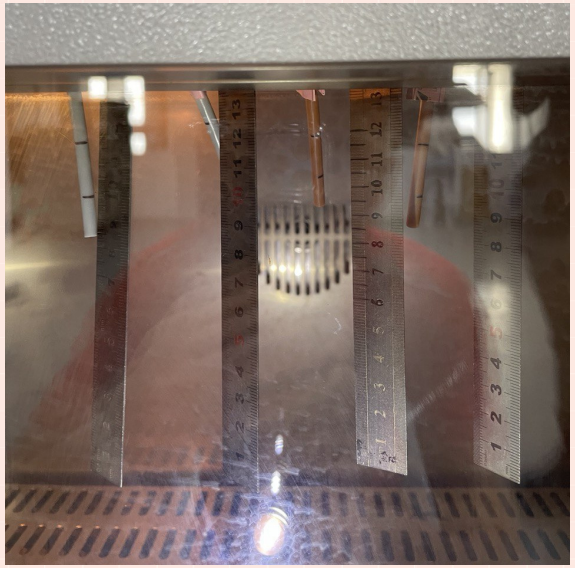


6. At about 9 mins mark, start taking the readings of the elongation (if you cannot see clearly, do use a torch light)

Oven Procedures – At The 10 Mins Mark

7. At the 10 mins mark, we have to remove the weights by opening the oven door. Use one hand to hold and gently lift the weights, while using the other hand to cut the test material below the second marked line with general scissors. Place the hot weights on the designated steel area and close back the oven door for an additional 5 mins

Oven Procedures – At The 15 Mins Mark

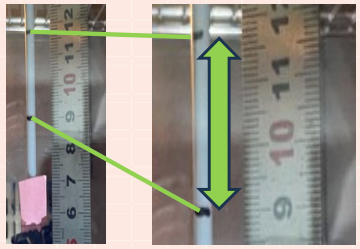


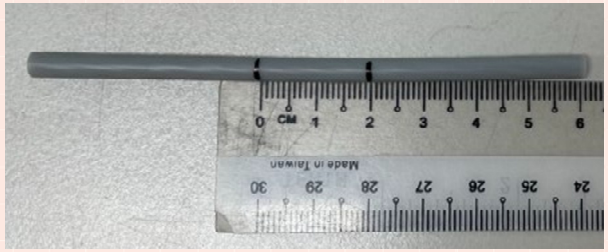
8. At the 15 mins mark, remove all the apparatus from the oven and place them on the designated steel area to cool down. Only after the test materials have cooled to room temperature, then you can start your calculations for final recording

9. **Housekeeping** – To turn off the oven, press and hold onto the “start/stop” button, eventually after the temperature has cooled down, you can switch oven off. Additionally, do turn off all the lights and fans before leaving the test location

Calculations for Final Recording Example

1 At the 10 minutes mark:

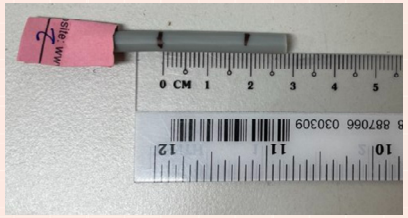


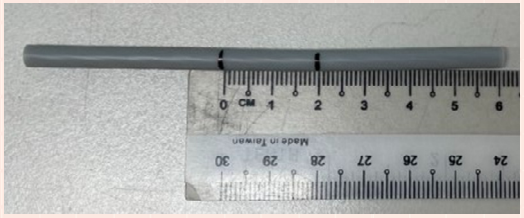


For example: $\frac{(118-90)\ mm - 20\ mm}{20\ mm}$ x 100% = 35%

Elongation under load percentage = $\frac{Elongated\ length - Original\ length}{Original\ length}$ x 100%

2 After an additional 5 minutes and cooling down:





For example: $\frac{19\ mm - 20\ mm}{20\ mm}$ x 100% = -5%

Permanent elongation after cooling percentage = $\frac{Length\ after\ test - Original\ length}{Original\ length}$ x 100%

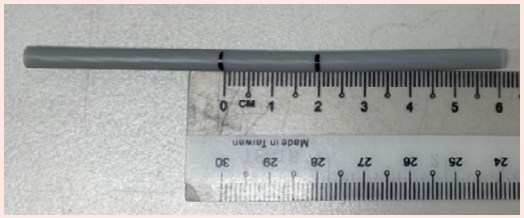
Calculations for Final Recording Practice

After you finished your Hot Set test, you know that you have to calculate the Elongation under load percentage and Permanent elongation after cooling percentage! So given that the values at shown in the pictures below:

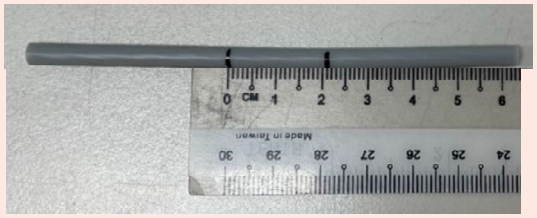
Calculate the Elongation under load percentage and Permanent elongation after cooling percentage

Elongation length at 10 mins

Try this question now!



Original length you measured is 20 mm



Length after test and cooling down

Calculations for Final Recording Practice Answer

After you finished your Hot Set test, you know that you have to calculate the Elongation under load percentage and Permanent elongation after cooling percentage! So given that the pictures show:

- The elongation length at 10 mins is 30 mm
- The length after test and cooling down is 21 mm
- The original length you measured is 20 mm

Calculate the Elongation under load percentage and Permanent elongation after cooling percentage

1 we can sub all required values into the Elongation under load percentage formula:

$$\text{Elongation under load percentage} = \frac{Elongated\ length - Original\ length}{Original\ length} \times 100\%$$

$$= \frac{(120-90)\ mm - 20\ mm}{20\ mm} \times 100\%$$

$$= 50\%$$

Calculations for Final Recording Practice Answer

After you finished your Hot Set test, you know that you have to calculate the Elongation under load percentage and Permanent elongation after cooling percentage! So given that:

- The elongation length at 10 mins is 30 mm
- The length after test and cooling down is 21 mm
- The original length you measured is 20 mm

Calculate the Elongation under load percentage and Permanent elongation after cooling percentage

2 we can sub all required values into the Permanent elongation after cooling percentage formula:

$$\text{Permanent elongation after cooling percentage} = \frac{Length\ after\ test - Original\ length}{Original\ length} \times 100\%$$

$$= \frac{21\ mm - 20\ mm}{20\ mm} \times 100\%$$

$$= 5\%$$

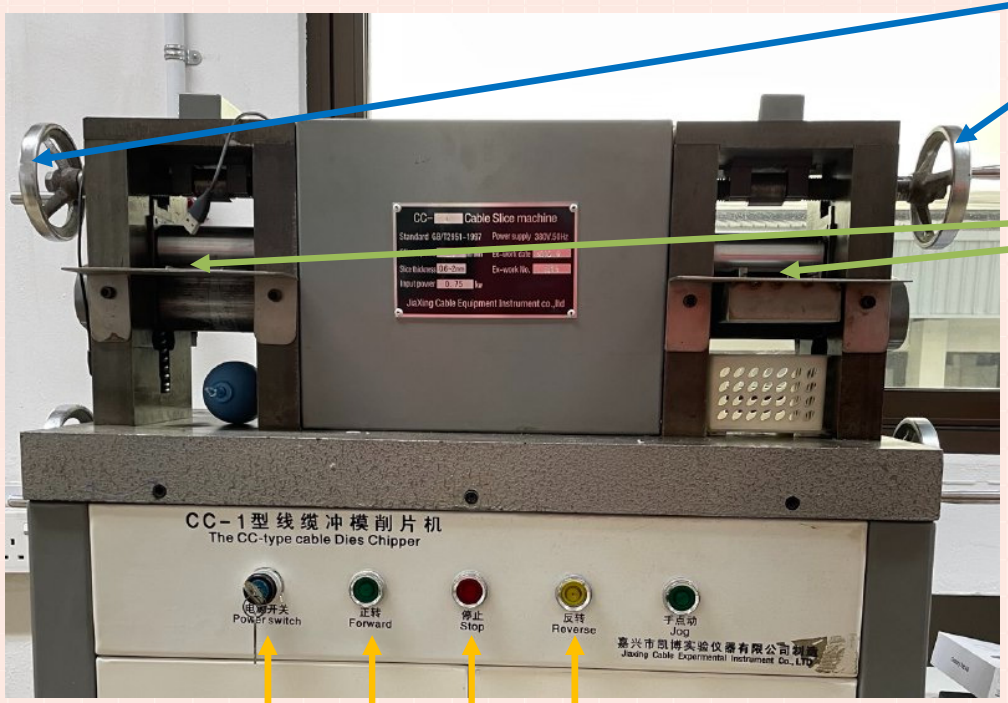
THANK YOU

Appendix 1 – How to Know When to Use Tubular or Dumbbell Sample for Hot Set Test?

In this case, cannot go for Dumbbell sample

Ideally, we always opt for using the dumbbell sample for Hot Set test, unless the width cannot fit the fixed-width molding apparatus as a whole. In such cases, we use the tubular sample.

Appendix 2 – Grinding Procedure for Dumbbell Sample



Tightening and Loosing wheel

Sample input/output

1. Switch on the “Turn on/off key”
2. Adjust the “Tightening and loosening wheel”
3. Allow your test sample to be grinded until to the desired thickness
4. Switch off the machine after use by reversing step 1

Appendix 3 - Tubular/Dumbbell Gram-force calculation (steps 1 to 4)

1. Knowing that Tensile force = 20 $\frac{N}{cm^2}$ and 1 kg = 9.81 N

Using the relationship of 9.81 N = 1 kg
Therefore, 1 N = $\frac{1}{9.81}$ kg

Then

Since 1 kg = 1000g
Therefore, multiply by 1000

2. Gram-force (in $\frac{g}{cm^2}$) = 20 $\frac{N}{cm^2}$ x $\frac{1\ kg}{9.81\ N}$ x $\frac{1000\ g}{1\ kg}$

= 20387 $\frac{g}{cm^2}$

1 cm = 10 mm
So $(1\ cm)^2 = (10\ mm)^2$
$1\ cm^2 = 100\ mm^2$

3. Gram-force (in $\frac{g}{mm^2}$) = 20387 $\frac{g}{cm^2}$ x $\frac{1\ cm^2}{100\ mm^2}$

= 20.387 $\frac{g}{mm^2}$

4. Finally, to calculate the amount of mass (in grams) needed for your Tubular sample:

We need to take Gram-force (in $\frac{g}{mm^2}$) x area (in mm^2)

= 20.387 $\frac{g}{mm^2}$ x area (in mm^2)

So now, let learn how to calculate area for Tubular/Dumbbell sample, to complete this mass formula