X. Determining Hold Stage Parameters

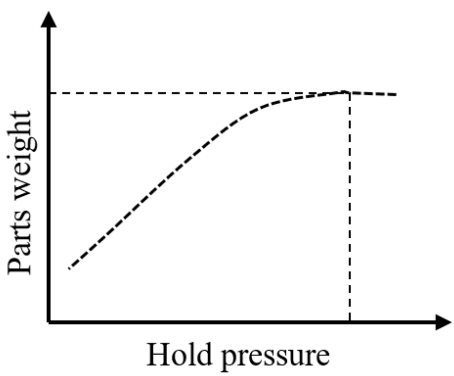
- **Laboratory I - Determining Hold Pressure**
- **Laboratory II - Determining Hold Time**
- **Hold Stage for Molds with Hot Runners and Gate Valves**

Again, remember that before continuing with these ***Universal Molding***^{TM} labs:

- Auxiliary equipment should be properly installed and correctly operating.
- Temperatures should already be reached.
- Barrel adjustments should have been programmed.
- The required clamping force should have been set.
- The press openings, their movement, speeds, and mold protection should have been carefully and precisely adjusted.
- Extended cooling time should have been set, in order to prevent it from interfering in the determination of other parameters.
- The ideal injection speed should have been determined, adjusted and should be filling about 95% of the required fill for the mold.
- The injection pressure limit should have been determined and adjusted.
- The hold stage should stay off.
- The fill balance should have been verified and adjusted.

Important -- only qualified personnel who have read the operational manuals of the equipment and understand the functionality of the equipment should operate them and/or make adjustments.

The hold pressure is determined, increasing the hydraulic or melt hold pressure, until the cavities are completely full or have reached the desired weight.



X-1. Graph of the effect of hold pressure on the weight of the parts

Notes:
In this laboratory, only the pieces without runners are weighed.

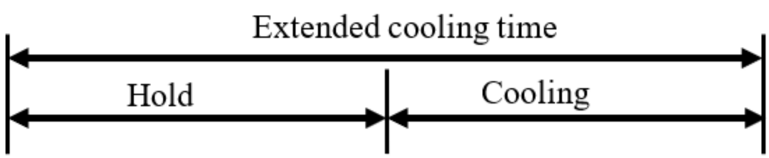
There exists parts that cannot be weighed, such as overmolded terminals with long cables and parts that must be demolded together with the runner. If it is not possible to weigh the parts, consider the following:

- Some dimension, such as the thickness of a wall in one or multiple cavities: If the pack pressure increases, the thickness of that wall will also increase.
- Cushion position or minimum screw position after holding: If the holding pressure increases, the cushion will decrease.

Laboratory I - Determining Hold Pressure

1. Set the hold time to a value greater than required. For example, consider half the extended cooling time that was used in previous labs. The goal is to ensure gate freeze; hold time will be optimized later.

2. Write down a cooling time equal to the difference between extended cooling time and hold time. Note that the sum between hold time and cooling time will be equal to extended cooling time.



X-2. Extended cooling time

For example, in a laboratory where the extended cooling time is equal to 12 seconds, half of the extended cooling time was used in order to guarantee gate freeze. The results are the following:

Hold time = 6 seconds
Cooling time = 6 seconds

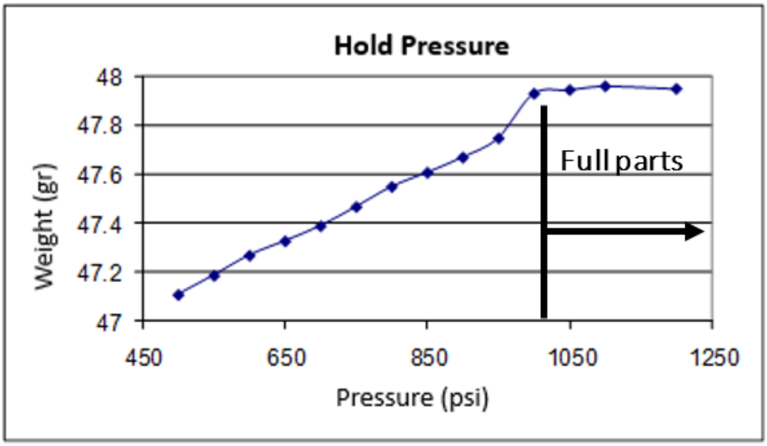
Important, always guarantee that cooling time is longer than recovery time. It was explained in previous chapters that, when cooling time expires, permission to open the mold will only be allowed if recovery has finished. In other words, the mold will be closed until the recovery is complete, regardless of whether cooling time has finished. Consequently, cooling time will be extended and, depending on the machine, you may not realize this is happening.

3. Perform a weight study of the parts at different hold pressures. Start the experiment with a lower pressure than required. For example, start with 10% of the injection pressure acquired at the time of transfer; then increase the pressure until you get completely full parts or the desired weight. Take two or three samples per pressure and calculate the average of the weight of the parts. Tabulate the data and plot the weight of parts against hold pressure. Weigh only the molded parts; do not include the runner.

Pressure (psi)	**Average weight (gr)**
500	47.11
550	47.19
600	47.27
650	47.33
700	47.39
750	47.47
800	47.55
850	47.61
900	47.67
950	47.75
1000	47.93
1050	47.95
1100	47.96
1200	47.95

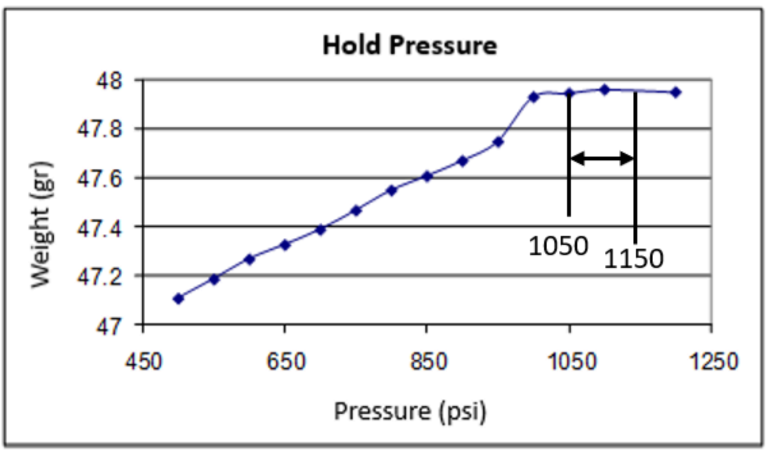
X-3. Table of the effect of hold pressure on the weight of the parts

In the graph below, we see that the pressure stopped contributing to the weight of the parts after 1000 psi of hold pressure.



X-4. Graph of the effect of hold pressure on the weight of the parts

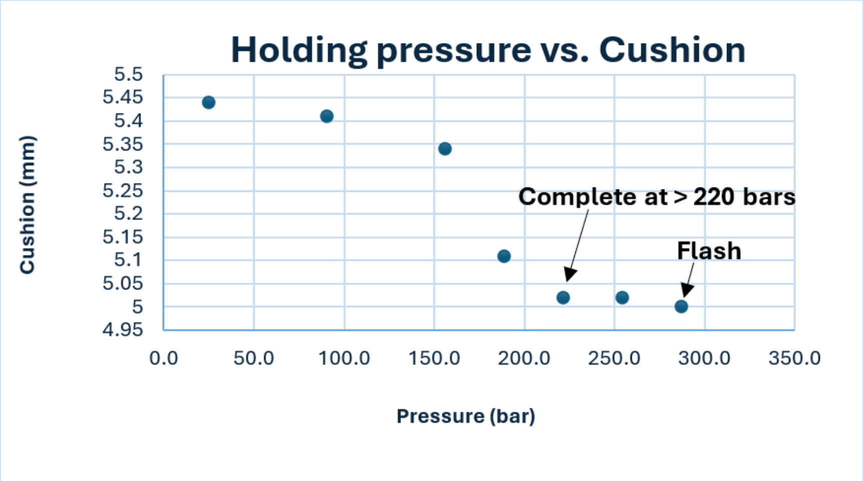
4. Select a pressure where the weight is relatively constant. This example used a minimum hold pressure of 1050 hydraulic psi, a machine parameter. The norm would be to select a pressure range, for example from 1050 to 1150 psi.



X-5. Graph indicating hold pressure range

5. Once you select your hold pressure range, convert to ***Universal*** parameters.

Example:



In a process of overmolding, where the pieces could not be weighed, it was decided to use the effect of hold pressure on the cushion position (See the graph below). The graph reveals that the cushion stopped contributing to the fill with a pack pressure greater than 220 bars and also showed that pressures greater than 260 bars created flash.

X-6. Determination of hold pressure with the cushion's position

6. After selecting the hold pressure, it is essential to verify the percentage of volume injected during the injection stage, based on position. Although the weight-based percentage should have been verified during the determination of the ideal injection time, it is recommended to confirm it using a second method: by position. This is a simple and effective verification method that all injection processors should utilize.

Verification of injected volume percentage based on the screw's position

The formula to calculate this percentage is as follows:

$$\% \text{ volume at injection stage} = \frac{recovery\ position - transfer\ position}{recovery\ position - cushion\ position} * 100\%$$

If you are using a control system with ***Universal*** parameters and working with volume instead of position, apply this formula:

$$\% \text{ volume at injection stage} = \frac{recovery\ volume - transfer\ volume}{recovery\ volume - cushion\ volume} * 100\%$$

Example:
Determine the fill percentage during the hold stage in a process where the recovery position is PP = 32mm, the transfer position is PT = 6mm, and the cushion position is PC = 4mm.

$$\% \text{ volume at hold stage} = \frac{(PT-PC)x100\%}{(PP-PC)} = \frac{(6mm-4mm)x100\%}{(32mm-4mm)} = 7\%$$

This equation can be stated more simply:

$$\% \text{ volume at hold stage} = 100\% - \% \text{ volume at injection stage}$$

Subsequently, if necessary, make adjustments by incrementally increasing or decreasing the recovery position. Keep in mind that modifying this position will likely impact both injection time and maximum injection pressure. If the adjustment is significant, modify the injection speed to coincide with the previously determined ideal injection time and adjust the injection pressure limit to be 5% to 10% above the new maximum injection pressure.

Finally, update your technical documentation with the new recovery and cushion positions, the new maximum injection pressure and injection limit pressure, and the adjusted ideal injection speed.

In this example the injection unit used had an intensification ratio (R_i) of 12.2, and its corresponding ***Universal*** parameters are:

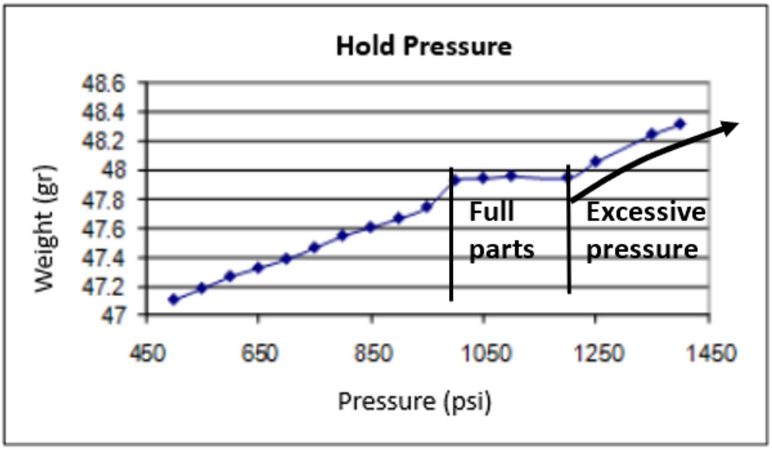
Universal hold pressure = Hydraulic pressure x R_i
Minimum pressure = 1050 psi x 12.2 = **12810 psi**
Maximum pressure = 1150 psi x 12.2 = **14030 psi**
Average pressure = 1100 psi x 12.2 = **13420 psi**

Notes:

- Although the objective is dimensions and not weight, for now you must work with the weight of the parts. After unmolding, the parts will undergo multiple changes in dimensions due to shrinkage.

- Only weigh the molded parts, not the runner.

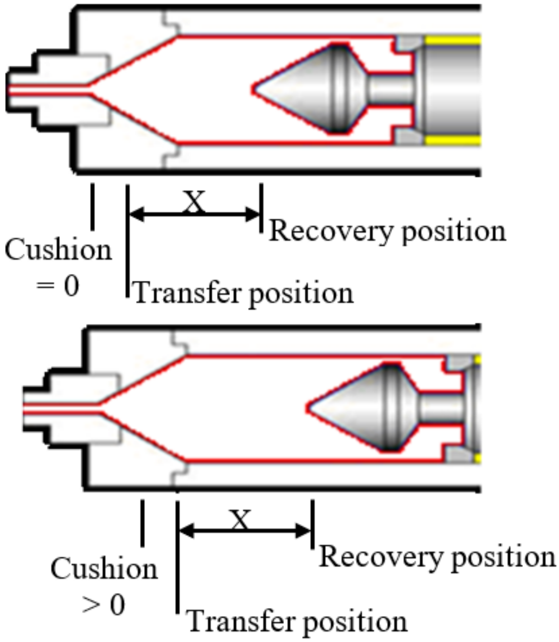
- Avoid opening the mold or forcing melt to sneak into unwanted spaces as a result of excessive pressure. An easy way to find out if the pressure is excessive is by looking at the graph of pressure versus weight of the parts.



X-7. Graph indicating excessive hold pressure

In the graph, after 1200 psi a new tendency was started, indicating that the cavities are opening, or plastic is oozing.

- The cushion must be greater than zero. If it reaches zero, injection volume will have to be increased. This could have happened as a result of a filling volume well below 95% during the injection stage. Assuming there are no defects in the injection unit, such as a leaky check ring, increase the recovery position and transfer position by the same amount until the final position (after hold) is greater than zero. If you want to make this adjustment without stopping the process, first increase the cushion position and then the recovery position. Otherwise, you could end up with excess material, which might damage some molds.



X-8. Correction when cushion is zero

If the cushion becomes zero as a result of a defective injection unit, such as a leaky check ring, talk to the maintenance department to have the defect repaired.

Notes:
The final cushion position is always greater than zero and less than the transfer position.

If the cushion position ends up being greater than the transfer position, there are two possible scenarios:

1. Low hold pressures: In some machines, when hold pressures are programmed too low, the cushion position can move above the transfer position. This situation is resolved by programming the appropriate hold pressure.
2. Excessive volume during injection stage: Another common reason is when positions are programmed that result in a filling volume

exceeding 95% during the injection stage. The solution is to reduce that filling percentage during that stage.

These position adjustments will impact both injection pressure and injection time. Make the necessary adjustments.

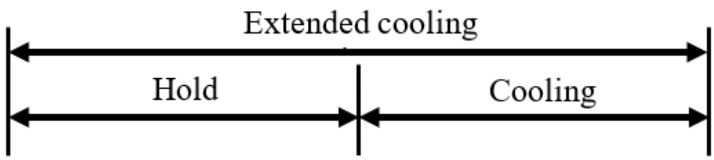
Laboratory II - Determining Hold Time

Hold time is determined by the gate freeze test. While the gates are liquid, hold pressure keeps the melt in the cavity. Once the gates freeze, the melt cannot escape even when hold pressure is removed.

1. Adjust to the previously determined hold pressure.

2. Without changing the hold pressure found, decrease the hold time in intervals until the weight of the parts begins to decrease due to soft gates, which are unable to keep the compressed melt inside the cavities.

In order to maintain a constant total cycle, the sum of cooling time and hold time must be kept constant. For each interval that is subtracted from hold time, the same amount should be added to cooling time.



X-9. Extended cooling time

3. Tabulate the times with their corresponding total weights of the parts and make a chart of the weight of the parts against hold time.

Hold time (s)	Average weight (gr)	Cooling time (s)
5.00	47.949	23.00
4.75	47.949	23.25
4.50	47.949	23.50
4.25	47.947	23.75
4.00	47.945	24.00
3.75	47.940	24.25
3.50	47.935	24.50
3.25	47.931	24.75
3.00	47.927	25.00
2.75	47.901	25.25
2.50	47.875	25.50
2.25	47.845	25.75
2.00	47.815	26.00
1.75	23.908	26.25

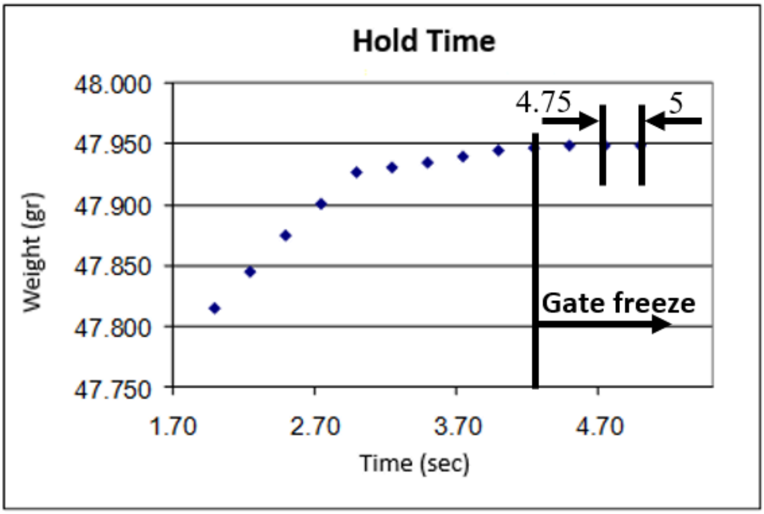
X-10. Table of the weight of the parts and their respective hold and cooling times

Although the cooling time column is not graphed, include it. It will help you when entering the times during the experiment.

Notes:

- For each hold time setting, take two to three samples and average the total weight of the parts.
- Only take the weight of the molded parts without the runner.
- Always ensure that the cooling time is longer than the recovery time.

4. On the graph, find the time where the weight of the parts begins to decrease. It is clearly shown that hold times longer than 4.5 seconds will be required to ensure gate freeze.



X-11. Graph of the effect of hold time on the weight of the parts

The hold time range selected in this example is 4.75 to 5 seconds.

Summary of parameters
Once the hold parameter determination is complete, summarize them:

- determined hold time and its operational range
- determined hold pressure (***Universal*** and machine parameter) and its operational range
- remaining extended cooling time
- volume position or recovery position
- cushion or final position of the screw after hold and its operational range.

Finally, verify that the machine control has been programmed with the determined hold parameters.

Hold Stage for Molds with Hot Runners and Gate Valves

With molds that include hot runners, the procedure is similar; we will have to guarantee gate freeze.

Now, if the mold also includes gate valves, those will do the function of gate freeze. These are programmed so that valve closure occurs when the adjusted hold time is met. In addition to creating a good finish at the injection site, these valves reduce hold time, since you don't have to wait for gate freeze.

Notes:

- If the valves close prematurely you will probably end up with incomplete parts.
- If the valves close too late, they may encounter hardened material in the valve seat, which could damage the gates in the cavities. Consequently, this defect would be reflected at the injection point of the parts.

During the hold stage, we guarantee measurements that are a function of mass. Do not attempt to correct thermal measurements in the hold laboratory.

Amorphous	**Semi-crystalline**
Problems with over-packing due to low shrinkage	Problems of incomplete pack due to high shrinkage
Problems with flash	Sink marks
Breaks during demolding	Easy demolding
The transition from softened melt to solid is gradual	The transition from liquid melt to solid is sudden

X-12. Mechanical characteristics of materials which should be considered during hold

Questions

1) Increasing hold pressure increases the weight of the parts. Assuming the mold does not open, eventually a pressure will be reached where the weight of the parts will stop increasing.
    a. True
    b. False

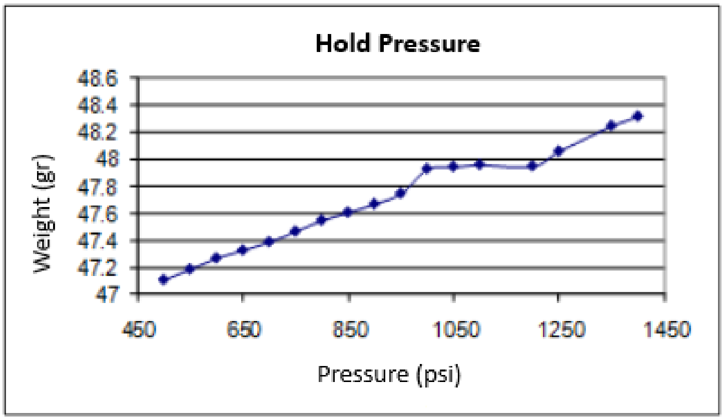
2) A hold pressure graph is created by using hold pressures and the total weights of the parts with runners.
    a. True, the weight of the parts and runners is used.
    b. False, only the weight of the parts without the runners is used.

3) The dimensions that are the effect of shrinkage are evaluated when determining hold pressure.
    a. True, during hold we consider the mass dimensions.
    b. False, during hold we only consider the mass dimensions and not the shrinkage.

4) The hold time is used to
    a. determine thermal dimensions.
    b. improve the operating cycle.
    c. determine gate freeze.

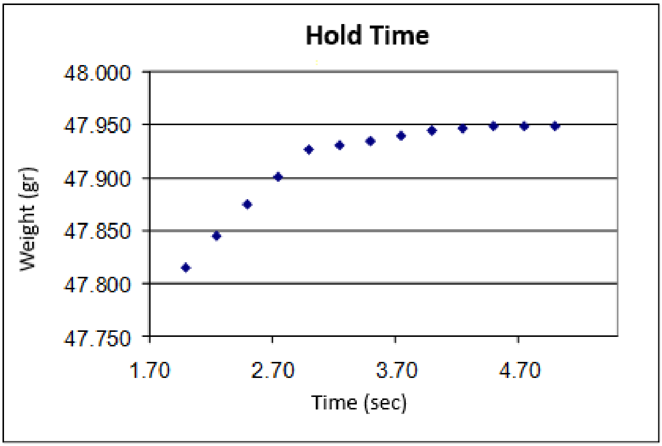
5) In one process a hold time of 6 seconds was found. The corresponding ***Universal*** hold time would be
    a. 6 seconds.
    b. 6 seconds ÷ intensification ratio.
    c. 6 seconds x intensification ratio.

6) Using the graph below, select all the correct statements.



a. In the graph, after 1200 psi a new tendency begins, indicating that the mold is opening, or plastic is oozing as a result of excessive pressure.
b. In the graph, using a hold pressure of 850 psi will give us complete parts.
c. In the graph, a selection of 1050 psi is an adequate hold pressure.

7) Using the illustrated graph, select the correct statement.



a. We get gate freeze with a hold time of 2 seconds.

b. We can see that we will need hold times greater than 4.5 seconds in order to guarantee gate freeze.

8) Determine the fill percentage during the hold stage in a process where the recovery position is *PP*, the transfer position is *PT*, and the cushion position is *PC*.

a) $\% \; volume \; at \; the \; hold \; stage = \frac{(PT-PC)x100\%}{(PP-PC)}$

b $\% \; volume \; at \; the \; hold \; stage = \frac{(PP-PC)x100\%}{(PP-PC)}$

c) $\% \; volume \; at \; the \; hold \; stage = \frac{(PP-PT)x100\%}{(PP-PC)}$

9) Determine the fill percentage during the injection and hold stages in a process where the recovery position is *PP*, the transfer position is *PT*, and the cushion position is *PC*.

a) $\% \; volume \; at \; the \; injection \; stage = \frac{(PP-PC)x100\%}{(PP-PT)},$

$\% \; volume \; at \; the \; hold \; stage = 100\% - \% \; volume \; at \; the \; injection \; stage$

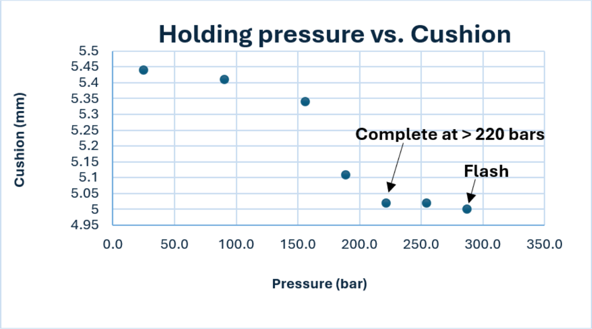
b) $\% \; volume \; at \; the \; injection \; stage = \frac{(PT-PC)x100\%}{(PP-PC)}$

$\% \; volume \; at \; the \; hold \; stage = 100\% - \% \; volume \; at \; the \; injection \; sta$

c) $\% \; volume \; at \; the \; injection \; stage = \frac{(PP-PT)x100\%}{(PP-PC)}$

$\% \; volume \; at \; the \; hold \; stage = 100\% - \% \; volume \; at \; the \; injection \; stage$

10) At what hold pressure will we get full cavities?



a) between 220 y 250 bars
b) 200 bars
c) 300 bars