

OVERVIEW

This module on Standard Operating Procedures (SOP) for the Formech™ 660 vacuum forming machine located at AT 141 Ball State University focuses on providing learners with the necessary knowledge and skills to operate the machine safely and effectively. The objectives of the module include practicing safe procedures, creating suitable models, selecting appropriate materials, performing vacuum forming, and carrying out post-processing of vacuum-formed parts.

The module covers various topics such as safety precautions, model preparation, material considerations, heating and forming processes, and post-processing steps. By the end of this lesson, learners will be equipped with the understanding and abilities required to utilize the Formech 660 vacuum forming machine efficiently and follow the established SOPs.

Using a Formech™ 660 vacuum forming machine.

Located in AT 141 Ball State University.

Objectives.

By the end of this lesson. You should be able to.:

1. Identify and practise safe procedures when using a Formech 600 vacuum forming machine.
2. Create or obtain a model suitable for vacuum forming.
3. Select materials suitable for vacuum forming.
4. Vacuum form using a Formech 660.
5. Post-process a vacuum-formed part.



Introduction.

Vacuum forming is a process that typically involves heating or plasticizing a sheet of material, and then putting it contacts with a model evacuating much of the air from between the two. Atmospheric pressure then presses the material to the model where it is cooled and hardens, retaining the shape. As needed, refer to the Vacuum Forming Guide from Formic. Typically placed in a blackboard area for students. And available directly from Formic by Registering at, [HTTPS://formechnic.wordpress.com/2012/08/29/vacuumformingguide/](https://formechnic.wordpress.com/2012/08/29/vacuumformingguide/)



A Safety

A1. Make sure you have received instruction on the use of this vacuum former before beginning. If you have any questions, consult the references, and ask an instructor.

A2. Treat the heating surfaces as if they are hurt. Avoid burns.

A3. Clean dust and foreign matter from the vacuum former before turning it on.

A4. Be sure to wear safety glasses and proper lab attire (no loose clothing or hair, only closed-toed shoes.)



A5. Do not place anything on the top of the vacuum former.

A6. When moving the heating unit forward and back, it is possible for it to jump off its tracks as shown. Avoid doing this by moving it only forward or back with no lateral pressure. Move it carefully. It is best to use two hands. If it jumps the track, ask the lab supervisor for assistance in getting it back on track (as shown). Do not get burned.

A7. Do not touch hot plastic with your skin.

A8. Do not place anything under the heating elements that can catch fire from them during normal use.

A9. In the event of an emergency or accident, identify the lab supervisor or instructor immediately.

B. Create or obtain a vacuum forming model.

B1. Read up on models for vacuum forming. Watch videos on this process, such as the one at <https://www.youtube.com/watch?v=ficoGsmRK98>

B2. Consider that vacuum forming models generally should not have undercuts, and that the vertical sides should typically slope at an angle to provide the draft needed to remove the model from the sheet of formed material (about 50 draft is recommended, maybe more for some models and materials. Hard materials that are not impacted by the heat involved may provide better and wear.



Note

If you use plaster of Paris to make a model, here are some recommendations.

- Mix it so it is the consistency of a very thick soup, and so there are no chunks.
- Try to get as much air out of the mixture as you can be gently rapping it.
- Pour it onto the cavity where you want it to set.
- Again, try to get trapped air bubbles out.
- Plaster does not shrink as it sets, but instead sets by a chemical reaction. You will need to get it out of the cavity, possibly by breaking the mold. If you are using plaster as the Mold, you can try to add a thick solution of soapy water to aid in removal.
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- Realize that rock gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) is mined and crushed, then it is heated (calcined) to drive out $\frac{3}{4}$ of the water and produce plaster of Paris. When you add water to plaster, the plaster sets by hydrosetting, or chemically combining with water, in an exothermic reaction that can create quite a bit of heat. This heat could even soften thin thermoplastic containers.
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- Do not allow any plaster, plaster dust, or water with plaster in to go down a drain. Again, plaster is hydrosetting, and it is common for it to clog a U-bend in a sinks or toilet's drain. It can set under water. Instead, place waste into a waste receptacle.



B3. After you find or make a model, check with the instructor to see if there are any problems with it. Make sure it is clean and dry, and that you will be able to remove it from the vacuum formed plastic. Delicate, materials used as molds may break during vacuum forming, so don't use anything as a vacuum forming Mold that is likely to break, or that is precious.

B4. Consider that some models have additional bases through the vacuum-formed, material around those bases is later excised. This additional height is referred to as standoff.

B5. You might want to keep a camera handy so you can take pictures to document what you are about to do.



C. Obtain and prepare the material.

C1. You need flat thermoplastic sheet stock of sizes. Try to obtain a few more than you need to allow for errors.

Properties of the material

- It must be rigid when cool, soften when heated to allow forming, and then become rigid again in a new shape when it is cooled.
- It must not give off toxic vapours when heated.
- It must be of the right thickness, not exceeding the maximum listed.
- It must be cut to the right length and width to match one of the material sizes listed in the Appendix.
- It should be free from scratches, coating, and foreign matter.



C2. Identify the material and read about it. Ideally you would locate a recommended thermoforming temperature. A manual from Formech provides the following recommended forming temperatures.

As thickness increases, the required heating time would increase. Note that no times are listed here, as these should be experimentally determined by your material.

Special Note about PVC: When polyvinyl chloride is heated to the point of combustion, it can emit hydrogen chloride, which is toxic and can damage even metal parts. That is why we do not laser machine PVC. However, heating it to the point of softening it for vacuum forming does not liberate the same quantity of hazardous materials, and is permitted as long as it does not get too hot. Old records played in record players were typically made from PVC.

C3. Cut the material to size. If you have not received instruction on using our lab equipment for this, please see the instructor.

C4. Fill out a new line in the material log sheet. If you make additional runs with different settings, models, or material, use a new line for each.



D. Vacuum form.

Position the model and the material.

D1. With all the dust removed from the working surfaces of the vacuum former, carefully install both halves of the reducing window that fits your model and material.

D2. Raise the table using the drape table lever on the right.

D3. Select the two-piece window of the appropriate size for your Mold and place it into the vacuum former. After both halves are installed, you might need to move the bottom piece, so the opening exactly aligns with the opening in the top half of the window.

D4. Place your model on the platform so that it is well-positioned with regard to the window and lower the table.

D5. Place the clean material between the two halves of the reducing window or material area so that it entirely covers the cushioning gaskets surrounding the opening.

D6. Adjust the left and right clamps as necessary for your material thickness to lock them into place. The nuts should be adjusted finger-tight only to allow the clamp to securely lock the material, as shown to the right. Make sure the specialized washers are properly oriented. Please note that clamps must squeeze the windows together tightly, and in the locked position the orange handles should be squeezed tighter-than horizontal to lock.

The image at the right, shows a clamp that is loose. Adjust it so that it fits as pictured.



Power and Pre-heating the heating elements

D7. Check to make sure there is nothing on top of the heating area.

D8. With safety glasses on, plug in the power cord for the vacuum former.

D9. With the heater away from you, turn on the heating zones corresponding to your sheet size. You might want to have a slightly cooler setting on the centre (Zone 1) since the heat will naturally tend to be greater in the centre. Record what settings you use.

Note: In production work, we would generally use a non-contact thermometer to determine the temperature of the material with different heater settings, aiming for a temperature that has been elsewhere determined ideal for this material and thickness. We could then experimentally determine which heating settings were optimal.

D10. Be patient. The pre-heating period will likely last ten minutes. You will know it is over when all of the heating zones you have turned on begin to cycle off and on. During this time, you are not pre-heating your plastic, but just getting the heating elements up to temperature.

Heat and form the material.



Note: Experimentally Determining Heating Times

You will likely make more than one run. In order to determine what heating time will work, it is recommended that you start heating your plastic for a known number of seconds, then quickly push the heater away from you and use a non-contact thermometer to record the temperature in the centre of the plastic. If this is not the recommended forming temperature, then you will have to heat it for some additional seconds before forming it using the steps outlined below. During the next run with another cold sheet of plastic, you would then increase the initial heating time and again measure the temperature. Measuring the temperature allows it to cool, so again it will likely require a bit more heating prior to forming. But you should soon be able to determine for how many seconds you must heat a cold sheet to reach the recommended forming temperature.

D11. There is a timer on the front of the Vacuum Former, though you may want to use your own watch or smartphone so that you know the time between moving the heater over the material and when you move it away.

D12. After preheating the heating elements for about fifteen minutes, move the heating unit toward the operator to the full extent of its travel. Do not allow it to jump off its rails or for electrical cords to impede its travel.

D13. Begin timing how long the plastic sheet heats.



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D14. If you do not know a recommended forming temperature, then carefully watch the material through your safety glasses. Look for when it sags and then draws drum tight. For material that is relative thin (about 1 mm) you might want to try just a few additional seconds after the material draws drum tight. For thicker materials, it might take a little longer.



D15. When you determine the heating stage should end, note the time.

Note:

If there is a partner, then it is recommended that the person on the left has the responsibility for moving the heater back and taking the temperature while the person on the right has the responsibility for raising the model and pressing the Mould button.



D16. Immediately move the heater away from you all the way without it running off its track.



D17. Immediately pull the drape table lever toward you to raise the model.

D18. Immediately press the green mould/Vacuum button to engage the vacuum.



D19. Look at your watch again so you can time how long you are drawing the vacuum. For these materials, this might be as short as 5 seconds, but for thicker materials it might be 1 minute. You can turn on the overhead cooling fan by engaging the black Auxiliary switch, and this should shorten the cooling period.

D20. When you determine that the material has cooled long enough, disengage the vacuum switch by pressing the stop button.

D21. Press and hold the release button for several seconds to send air up between your model and the plastic to aid in separation.

D22. Press the stop button and turn off the auxiliary fan.

E. Post-process

E1. Carefully remove your formed plastic sheet. If the model is stuck inside it, you might need to wiggle it out. In some cases, a poorly chosen model with insufficient drafts or with undercuts will not be able to be removed without cutting the sheet away. Do not damage the model when you do that.

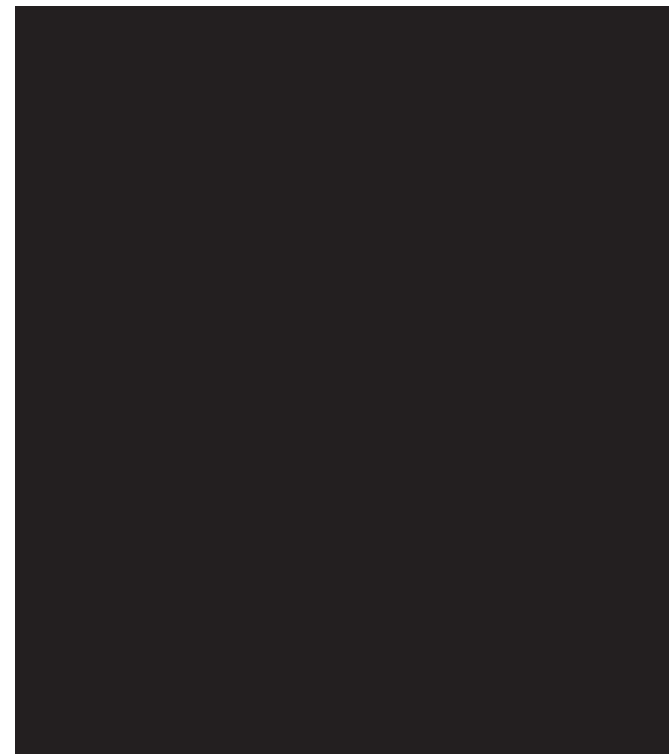
E2. Turn off all heaters on the vacuum former.

E3. Unplug the vacuum former.

E4. Trim your vacuum formed product, as needed.

E5. Clean up any mess you've made, getting rid of waste, and putting any materials, tools, and vacuum former accessories back where they belong.

E6. Update the log sheet for the machine and make sure the information from your job is complete.



Notes

If you were to repeat this process, you would not have to again pre-heat the heater if it is already at temperature.

If you were to repeat this process, you could use the built in timer to automatically indicate when the time you input in seconds had elapsed. This is handy for determining heating time, however, realize that the first few products of a production run are often not at the full temperatures of later products in that run.

Appendix A: Formech 660 specifications from the User manual with derived values.

Appendix B: Instructions and notes for Laboratory staff

S1. Make sure that the operator does not leave the vacuum former unattended.

S2. Check the model to make sure it won't likely crush or break.

S3. Do not allow the user to place unfired clay onto the drape table, where it might clog the grid.

S4. Check the model to see if it has sufficient draft. Let the operator know if there are likely problems with the model.

S5. Make sure that the plastic sheet completely covers the white gasket surrounding the window hole.

S6. Make sure the operator and others are wearing eye safety.

S7. The operator is to fill out the machine log.

S8. Make sure the vacuum former is unplugged when the operator has finished.

S9. Make sure the area is clean and the thermometer is in its holder at the end of a job.

