Arrow Springs

MANUAL

Annealers and Fusers

Your new Arrow Springs oven was designed so that it could be used on the worktable next to you while doing one or more of the following: making beads, fusing, enameling, silver clay, ceramics, jewelry wax burnout or just about any use up to 1900º F (1035º C), depending upon model. The smaller models, such as the popular AF99, can do everything listed above quite easily running on 100 or 120 volts. Larger ovens, such as the AF1313, can also perform all of these duties when run with 240 volts, however, when run on 100 or 120 volts, have a practical temperature limit of 1200º F (650º C), and at that can be slow to arrive to temperature.

SET UP

Before setting the oven on the table, or any work surface, be sure the surface can withstand the heat that radiates from it. Expect any surface to feel very warm to the touch if you are using it for annealing. The table surface can become very hot at fusing temperatures and above. Placement of the oven should be at least 12" (30 cm) from any wall for the same reason as well as to facilitate movement of the lid.

Important! Remove all protective plastic which may be covering any part of the oven or its accessories.

Place the steel stand on the worktable. This is the piece that looks like and sits like a table and stands 3" (75 mm) tall.

If the oven model you have has its lid attached by hinges to the section that forms the firing chamber, and the section that forms the bottom of the oven is not attached, follow these instructions for setup. Place the oven’s bottom section onto the metal stand with the side of the bottom section where the metal band joins together towards the back. Next place the firing chamber, with its attached lid, onto the bottom section. If the oven is a fusing only model, designated by the model’s name having an ”F” before numbers, as in F66 or F99, center the firing chamber from left to right and from front to back, over the bottom section. However, if the oven is a combination annealing and fusing model, designated by the model’s name having an ”AF” before numbers, as in AF66 or AF99, center the firing chamber from left to right and make the front of the firing chamber flush evenly to the front of the bottom section. If you are using an optional extension ring, it is positioned between the bottom section and the firing chamber.

If the oven model you have has its bottom section attached to the firing chamber section, place the whole oven onto the metal stand and center it as described above.

Optional Rod Rest

If you have an annealing model and ordered the optional Adjustable Rod Rest, now is the time to install it. The rod rest assembly is made up of four pieces: the rod rest, the rod rest holder and two holding clips. Start by fastening the holder to the front of the oven. The holder is the L-shaped piece that measures 4½" (11.5 cm) wide and has two legs each measuring 5¼" (13.3 cm) long, each with a ¾" (1.9 cm) flange on them. Insert one of the flanges between the 2" (5 cm) wide metal band that wraps around the bottom floor bricks and those bricks. Insert it from the top of the band. The holder should now look like a small table or platform at the front opening of the oven. Place the rod rest on top of the holder. The rod rest is 4½" wide by 7" (17.75 cm) with flanges at each end that are notched. Match up the 4½" width of the rod rest with the 4½" width of the holder and secure them with the two clips. The notches are what hold the glass rods and should point upward.

The rod rest is adjustable so that it will accommodate various lengths of rods. The rods rest in the notches and their ends insert into the open doorway to preheat them. This preheating will greatly speed up the time it takes to melt the glass in the flame and can eliminate popping and cracking. The further the rods are inserted into the opening of the oven, the hotter they get. The holder can be adjusted either left or right by sliding it. The rod rest can be adjusted closer or further from the oven by sliding it forward or backward. The rod rest does not work when an optional extension ring is installed. See picture at the end of this manual.

Bead and Mandrel Rest

A Bead and Mandrel rest comes with annealing oven models. It is 6” (15.2 cm) wide and 2” (5 cm) from front to back. It is made of perforated stainless steel bent to have three sides. The middle side is the widest side and sits flat on the floor of the inside of the oven. The shortest side faces the front of the oven and points up. The third side faces the back of the oven and also points up. Place the Bead and Mandrel Rest inside the oven anywhere you find it suitable, but towards the back of the firing chamber. This part is not mandatory or even necessary to use. Its use though, insures that if you put a bead into the oven that is a little too hot, it will not stick to other beads or dent from the brick bottom. To use, simply rest the mandrel holding the hot bead into the notches. The rack suspends the beads by their mandrels. Start by first filling the lower row by staggering the beads on either side of the notches and then fill the taller row. See picture at the end of this manual.

Using a Pyrometer

If the oven is to be run using an infinite control switch and not a temperature controller, you will need to install a pyrometer. A pyrometer is like a thermometer. It lets you know the temperature inside the oven. The pyrometer is shipped loose and needs to be installed.

If you chose a simple analog pyrometer (needle points to printed numbers on a dial), it will come with a bracket that needs to be attached to the electrical junction box. The electrical junction box is what houses the connections between the power cord, the infinite control switch and the heating coil. It is located on the right side of the oven, when viewed from the front. Not all ovens have an infinite control switch.

The electrical junction box is assembled and fastened to the oven with eight screws. Locate the two screws that are furthest forward and furthest to the right With a screw driver, remove the two screws, place the pyrometer's bracket to the screw hole locations and reattach the two screws so that the bracket will now be connected to the oven. See picture at the end of this manual.

If you chose a digital pyrometer (electronic readout), it will not come with a bracket. It either sits on your worktable or can be hung on the wall.

The next step is to insert the thermocouple into the hole provided for it in the back of the oven. The thermocouple is the temperature sensor that a pyrometer or temperature controller uses to read temperature. It is the tip of the thermocouple that senses the temperature and it is **extremely important** that the tip is inserted well within the oven. A close look at the thermocouple will reveal that it is made up of five, 1" (2.5 cm) porcelain segments. The four segments closest to the end of the thermocouple are narrower than the fifth segment. Place the wire loop of the thermocouple's tip to the small hole at the back of the oven and push it all the way through the brick and beyond. The thermocouple should be pushed into the brick until the largest of the five porcelain segments is touching the brick or is close to it. You will notice that the wire loop is larger than the hole in the brick. Without too much effort the wire loop will make a "keyway" in the brick as it is pushed through. This is done so that the thermocouple will not come out easily should it be accidentally bumped. Some oven models may have more than one thermocouple hole. They can be located in the back wall or in the lid. This is to give you options for various types of firings. The holes are small and unused holes do not need to be plugged. If in doubt of which hole to use, the default hole is in the back and is the lower one.

Finally, if the oven has an infinite control switch, be sure it is set to its off position and then plug the oven into the appropriate electrical outlet. If the oven has no infinite control switch, plug it into a temperature controlling device. Be sure it is turned off first.

Using a Temperature Controller

If you are installing your own pyrometer or temperature controlling device, use the same hole described above and install the thermocouple is a similar manner. You may need to modify the brick hole to accommodate your thermocouple. If your oven has an infinite control switch and you want to use it with a temperature controller, simply set the switch to high and then plug the oven into the controller. With the switch set to high, it will not do any controlling at all and will let the temperature controller have total control of the oven.

ATTENTION

Before turning on the oven, close the top opening lid. Do not let it drop. Dusting inside the chamber and damage may occur. Always keep the lid down except when necessary to be open. Always use proper safety procedures and protective clothing and eyewear when inserting or removing hot or cold items to or from the oven while it is hot. Never touch the heating coil when the oven is plugged in or hot. In addition to the heating coil possibly being hot enough to burn you, it conducts electricity. Sever injury or even death may occur from electrical shock.

Arrow Springs ovens are manufactured from hand selected insulation bricks that are more durable than industry standard. By their nature, insulation bricks are delicate and easily damaged. Care should be taken to not gouge or impact them. Crushing and chipping at edges and non-gapping cracks are common occurrences that can happen during everyday use and should be expected during the life of any oven, even with upgraded bricks, and do not affect performance. Insulation bricks commonly contain small cosmetic imperfections, such as small voids and surface lines, as well as patches, these also do not affect oven performance.

USING YOUR OVEN AS AN ANNEALER

By placing glass items into a hot annealer, while the item is still hot from the flame, will prevent thermal shock and excessive stress from building up within the item prior to annealing. Depending upon which oven you have, your glass items that are to be annealed may be able to be inserted into the oven from the top, however, you will find that the front opening is usually the easiest, safest and most convenient to use. Depending upon which model oven you have, the front opening will have a single, double or triple fiber blanket “Flip Door” attached, by a hinge, at the top of opening. The flexible fiber on the door is designed to close over bead mandrels and thin punties that have been inserted part way into the oven’s front opening, thereby creating a heat seal that will result in an evenly heated and properly annealed glass item. **The Flip Door opens freely to 90º, then with a little resistance, will snap up further and stay open.** To use the Adjustable Rod Rest properly, leave the Flip Door in the up position until you are done adding items in the oven. When you are ready to anneal, remove all glass rods from the Adjustable Rod Rest and make sure that the top part of the Adjustable Rod Rest is clear of the Flip Door as it is lowered. The Flip Door can close over any standard bead mandrels and small diameter glass rods and tubing that may be sticking out of the opening. It is recommended that you use 12” (30 cm) mandrels or longer. The longer mandrels will stick out of the front opening further than the shorter mandrels, thereby keeping your hands further away from the heat.

Any oven that is an “AF” model will also come with either one or two unattached brick doors. Brick doors are intended to be used for higher temperature applications, such as fusing, but can also be used for annealing if nothing is sticking out of the front opening. To use a brick door, flip up a Flip Door and insert a brick door into the front opening.

Operation

To operate your Arrow Springs oven:

- Turn it on with the flip door closed.
- If the annealer has an infinite control switch, turn it on to a setting less than high.
- Watch the pyrometer to see what temperature the annealer goes to.
- Make adjustments to its setting until the annealer stabilizes at or near to the desired temperature.
- Make a small mark on the infinite control switch dial for future reference.
- Repeat this procedure with the front opening open so that you can operate the oven for long periods of time with the front opening open.
- If the annealer is in a drafty area and the door is left open, the temperature will fluctuate and you will need to monitor it and make manual adjustments.
- If you are using a temperature controller, you can set it to the desired temperature, and it will make any and all adjustments automatically under any conditions.

If you heat up the annealer with the Flip Door closed, the oven will heat faster. The oven's Flip Door can be continuously left open until you actually start the annealing process. If your oven has more than one Flip Door, they can all be opened for access momentarily, but only leave one open for extended periods of time. Once the annealer has reached its set temperature, or come close, it is ready to receive your finished glass items. It is very important to properly flame anneal all glass items before putting them into the annealer, because they could still break before the annealer has a chance to anneal them. If you are making beads on mandrels, insert the hot bead, still on the mandrel, into the annealer through the front door opening and place it on the annealer floor or set it onto any available notch on the Bead and Mandrel Rest. Be certain not to let the bead touch any other beads if it might be hot enough to be sticky. If the Bead and Mandrel Rest is filled, any bead that has been on the rack for ten minutes will be at a temperature that will not stick or distort and can be moved off and located elsewhere in the annealer to make room for new beads.

When you have finished making beads for the day, close the Flip Door. This will allow the annealer to achieve a uniform temperature throughout the firing chamber. If necessary, push the Flip Door's fiber around the mandrels to make a better seal. This is usually not necessary, as a little gap between the mandrels and the fiber will not affect annealing. Closing the door, especially if it has been left open for an extended length of time, may cause the temperature to immediately increase, since the annealer is no longer losing heat through the front opening. Do not be alarmed. The temperature you see is of the thermocouple itself, which heats up faster than the beads. For manual operation, set the dial of the infinite control switch to the proper setting, as described above. Monitor the temperature. An infinite control switch's setting can wander, especially after long periods of time. If you are using a temperature controller, it will automatically make all necessary adjustments throughout the entire time.

There may be times when you find it necessary to anneal glass items that have already cooled to room temperature. It is very important to heat them to the annealing temperature slowly in order to prevent thermal shock and breakage. To successfully accomplish this, start by place them into a cold annealer. If you are using an infinite control switch, set the dial it to its lowest setting and then adjusting it gradually higher until you finally reach the annealing temperature. If you are using a temperature controller, follow its instructions to accomplish the same thing. We recommend heating small glass items to annealing temperature slowly and evenly over at least a one hour period. Allowing up to two hours is even better, especially if the item is large.

WHAT IS ANNEALING , WHY IS IT IMPORTANT AND HOW TO DO IT

Annealing is the process of making the entire glass item uniformly hot and holding that temperature steady long enough to remove all stress caused from the manufacturing process. The annealing cycle also includes cooling down slow enough so as to not allow too much stress to build back up.

When glass is held at a steady temperature over a length of time, it is called soaking. Soaking the glass at a higher temperature has the advantage of requiring a shorter soaking time for the stress to dissipate, but also runs the danger of being so hot that it may distort under its own weight or of sticking to something. The glass will also need to cool down through a longer temperature range, and this will take longer than if it were annealed at a lower temperature. Soaking the glass at a lower temperature has the advantage of a shorter cooling time, but requires a longer soaking time to remove the stress, and, if soaked at too low a temperature, will not even remove the stress no matter how long soaked.

After the glass has soaked for the proper length of time, all of the manufacturing stress will dissipate, but stress will reappear during cooling. The faster the glass is cooled, the more the amount of stress the glass will acquire.

The annealing temperature for any glass is actually a range. The higher end of the range is a temperature set to be safely below any possible chance of distortion. The lower end of the range is a temperature high enough for heat soaking to be effective within a reasonable amount of time. The commonly used temperatures for any particular glass is actually just a temperature chosen as a compromise between the higher and lower ends of the range. In other words, a temperature in about the middle of the range. An exact temperature is not what is important. What is important is that you keep the temperature steady for a period of time before slowly cooling the glass to room temperature.

The annealing temperature we recommend for Effetre (Moretti), Bullseye and Lauscha glasses, is around 960º F (515º C). Use around 1050º F (565º C) for borosilicate glass. Around 890º F (475º C) for Satake. Using a temperature controller can maintain the temperature to within a couple of degrees. Manual control using an infinite control switch can not hold as tight a tolerance, but is adequate. This is one of the reasons we use annealing temperatures near the middle of the range.

As the glass cools, the outside will always cool faster than the inside. As glass cools it contracts. If the outside of the glass cools much faster than the inside, the outside glass contracts faster than the inside glass. This variance in contraction causes stress in glass. Too much stress and the glass breaks. The slower the glass is cooled, the less the amount of temperature variance throughout the glass and less the amount of stress that will develop.

The cooling of glass is most important between the annealing temperature and the strain point. As explained, glass will develop stress in itself through the cooling process. The strain point is a point in temperature at which any stress that develops below that temperature in the glass through the cooling process is only temporary. Stress that develops in the glass above the strain point is permanent. Once the glass has stabilized to room temperature, temporary stresses will disappear. Because of this fact, you can accelerate the cooling time below the strain point temperature and not worry about this strain causing the glass to break at some time in the future. However, cooling at too fast a cooling rate can still break the glass from thermal shock while still in the annealer. The strain point for glass varies between manufacturers and even between different colors from the same manufacturer. If you use a temperature well below the strain point, for all the glasses you use, to cool slowly down to, before then increasing the cooling rate, you will not need to know the exact strain point temperature of each individual glass. For simplicity, use 750º F (400º C) for Satake and 800º F (425º C) for every thing else.

The process to anneal glass once it is at the annealing temperature is as follows:

- First soak it for a period long enough to remove its stress. For a small bead, this can be as little as twenty minutes. For large beads, one hour. For a large paperweight, it can take half a day. Very large glass castings can take days.
- After soaking, cool the glass down past the strain point temperature slow enough so as not to allow too much harmful stress to develop. For a small bead, this can be as fast as 600º F (315º C) per hour (10º F/5.25º C per minute). For large beads, one half or one third that rate. A large paperweight, may require a rate as slow as 50º F (28º C per hour (less than 1º F/.5º C per minute).
- Once the glass temperature has past below the strain point temperature, the cooling rate can be increased without causing permanent stress in the glass. However, cooling the glass too fast below the strain point temperature can still cause the glass to break during cooling due to thermal shock.

The above described procedure is very easily accomplished using a temperature controller that is programmed properly. To do it manually using an infinite control switch and a pyrometer, you first soak the glass as already described above. After the soak time has elapsed, there are several options, depending upon the size of the glass being annealed. For very small glass items, such as small beads, simply turn the infinite control switch to Off. Since the annealer has been on for a while, the brick walls will have absorbed a lot of heat. This stored heat keeps the firing chamber from cooling very fast. For medium to large beads, or small hollow sculptures, instead turn the infinite control switch to Low. This setting will make it so that the temperature loss is slowed down. After about fifteen minutes the oven temperature will have dropped to below the strain point temperature. Because as the temperature in an oven gets lower, its heat loss slows, and the glass temperature is below the strain point temperature, you can turn off the oven and let it cool to room temperature for the size of the items described here. You should slowly cool to a lower temperature before turning off the oven for large items. To cool even slower, put the infinite control switch to a setting of 2, then after the temperature drops a to about half way to the strain point temperature, set it to Low.

When soaking and cooling different sizes of glass, use the rate that is best for the larger pieces. You cannot over soak or cool too slowly for the smaller items.

You can anneal together borosilicate, Effetre (Moretti), Bullseye and Lauscha glasses. The recommended temperature to use is 1000º F (535º C). It is a little high for all but the borosilicate, but at least 30º F (17º C) below what any of the non borosilicate glasses should distort at. It is a little low for the borosilicate glass, but you can compensate for that by increasing the soaking time.

To find out more about specific soak times and cooling rates and how it relates primarily to glass thickness, consult one of the many excellent books available that cover the subject. Two very good books are: More Than You Ever Wanted To Know About Glass Beadmaking by James Kervin and Contemporary Lampworking - A Practical Guide to Shaping Glass in the Flame by Bandhu Scott Dunham.

USING YOUR OVEN AS A FUSER

Always use a kiln shelf, especially when taking glass to its melting temperature. Molten glass dissolves insulation brick, the bricks from which the oven is made. Given enough time and temperature, the molten glass will go completely through the oven and find its way to the floor creating an extreme safety and fire hazard. Be sure to use a good quality shelf wash, also known as shelf primer or shelf release, to prevent glass from sticking to the shelf, thereby destroying the shelf and the project. A shelf wash designed for glass fusing will usually give the best results with less sticking and a smoother finish. For best results, always clean the shelf and re-wash it after each firing. The shelf must be completely dry before using. You can expedite the drying time by placing the shelf in the oven and heating it to about 500°F (260º C) for 10 minutes. To allow the moisture to easily escape, prop the lid up with about a 1" (2.5 cm) kiln post. To prevent damaging the brick, only place the 1” kiln post under the lid near the front of the oven. When dry, turn off the oven, open the lid and allow to cool before handling. If you get air bubbles between the shelf and your fused glass project, your self was not adequately dried. The shelf may have gotten so wet that water soaked deep into it. The water escaped as moisture during fusing. A longer and hotter drying time may be necessary.

Generally, large kiln shelves are not placed directly onto the oven bottom. Use short kiln posts under the shelf to raise it up. This gives more even heating to the shelf and glass and less chance of the glass breaking during heat up from thermal shock. Arrow Springs ovens that are 18” by 13” or smaller can usually be used without the use of kiln posts. Also, small glass projects such as jewelry are not as susceptible to breaking, regardless of shelf size.

There are several ways to load your glass project into the oven. You can place the shelf in the oven and center it, then place your project onto the shelf. Or, on models that have the bottom section that is not attached to the firing chamber, you can lift off the firing chamber to load the shelf. Or, you can load the shelf on the worktable then carefully move it to the oven. The third method allows you to prepare several shelves ahead of time but, it is hard to move the shelf without disturbing the glass. In all cases, be sure the oven is turned off or even unplugged.

When fusing glass it is important not to heat it up too fast. Too fast causes thermal shock resulting in broken glass. Very small pieces are the exception. If your oven has an infinite control switch, turn on the oven by selecting the lowest setting on the switch. The temperature in the oven will rise slowly. You can continue to increase the temperature slowly by changing the setting on the infinite control switch. Once the temperature inside the oven has reached about 1000º F (535º C), you can turn the switch to high without fear of thermal shocking, for all but very large pieces of glass. If your oven is controlled by a temperature controller, follow the instructions for the particular controller you have to accomplish the same thing.

Very small glass items, such as small earrings, can usually be heated up at a rate as fast as the oven will go. Glass the size and thickness of typical jewelry pendants do well when heated to 1000º F (535º C) over a 30 minute period. Larger and thicker items may require one, two or more hours of slow heat up to a higher temperature to prevent breakage from thermal shock.

Most art glasses used for fusing will start to bend in a mold at about 1200º F (650º C). The edges will begin to round and different pieces of glass will start to tack together at about 1300º F (700º C). At about 1450º F (785º C) the glass will fully fuse together with a raised look and will flatten out at about 1550º F (845º C). These are generalized temperatures. Changes in glass happen faster as its temperature is increased and changes continue to happen if its temperature is held steady. For example, your project will fuse flat at 1450º F (785º C) if held at that temperature long enough. In addition, different colors and brands of glass react to heat differently. You can, and should, look at the glass to check its stage, during the firing.

Always wear proper heat resistant gloves and clothing and proper eye wear when opening a hot oven and be mindful of the heat on your face, hands and arms that will escape when either the lid is lifted or the door is opened.

The thermocouple of a pyrometer or temperature controller measures the temperature of itself, not the actual glass. The metals that make up a thermocouple absorb heat much faster than glass does. If you heat the oven at a very fast rate, the real temperature of the glass can be substantially lower than the thermocouple reads. A slower rate allows the glass to catch up. At a very fast firing, you may not see the glass melt until the indicated temperature is several hundred degrees past the temperature you expected it to have melted at. This is one of the reasons that you should look at the glass during the fusing process to determine that it has melted the desired amount.

There are two very important factors in fusing that determine how the outcome will be. They are time and temperature. A fast firing at a high temperature will have a similar effect on the glass as a slow firing at a lower temperature. If you peek at the glass often while heating it to fusing temperatures, heat will escape every time a lid or door is opened. Excessive peeking may cause uneven heating and will extend the length of time it takes to reach temperature. If you repeat a project often you will eventually learn what the glass will do at a certain time and at a certain temperature without looking at it.

Once you are satisfied with the look of the glass, turn the power off. Open the lid and allow the temperature to come down to about 1000º F (535º C). Then close the lid onto a short kiln post placed under the lid near the front of the oven. The temperature will increase when the lid is closed onto the kiln post, but will quickly drop again. When the temperature again drops to about 1000º F (535º C), remove the kiln post and fully close the lid. As before, the temperature will again go up. When the temperature stabilizes around the annealing temperature, anneal the glass as described before.

Cooling the glass quickly down from the fusing temperature to about 1000º F (535º C), often referred to as crashing, accomplishes two things. First, it stops the glass from melting further, and secondly, it prevents the glass from devitrifying. 1000º F (535º C) is above the annealing temperature and high enough to not allow the glass to break, but below the devitrification range. Devitrification is when the glass becomes dull and matted looking on the surface. It happens when glass stays too long between 1300º F (700º C) and 1450º F (785º C).

Techniques for fusing are as varied as there are people that do fusing. For more detailed information on fusing techniques, refer to one of the many excellent books on the subject. A very good book, by one of the founders of the modern fusing movement, is <u>Kiln Firing Glass</u> by Boyce Lundstrom.

Pictured below is the Bead and Mandrel Rest. To see pictures of all of the models of Annealers and Fusers, please visit **ArrowSprings.com**