

Chapter 9

AGE OVENS

The Ageing Process



Figure 9-1: Typical age oven

Approximately 60-70% of the extrusions sold in the US and perhaps worldwide are from the alloy family 6063/6060/6061/6005A. These alloys are heat treatable, meaning that it is possible to retain the magnesium silicide in a solid solution with a suitable quenching mechanism at the press and then precipitate the magnesium silicide in a controlled fashion in an ageing oven at an elevated temperature. This mechanism is referred to as age hardening and it is a necessary step to achieve desired mechanical properties such as ultimate and yield strengths and elongation.¹

The ageing process requires maintaining the profiles at a precise temperature for a specific time, according to standard Time-Temperature-Transformation curves for each alloy and temper. Instead of measuring and controlling actual profile temperature, under proper conditions the age oven may be controlled from air temperature if the location for measuring the air temperature is chosen correctly. It is also necessary to know the relationship between the air and profile temperatures, as well as how temperatures vary throughout the oven.

1. Ramanan, Ram, "How to Obtain the Most from Your Ageing Ovens," Proceedings of 6th International Aluminum Extrusion Technology Seminar, (1996).

If the profile temperature is not uniform within the oven, profile quality will be unpredictable -- perhaps some under-aged or over-aged, or both conditions occurring within the same load.

Heat Treated - "T" Tempers:

	Press quenched: T1 naturally aged T5 artificially aged
	Furnace Solution Treated* T4 naturally aged T6 artificially aged

Temperature Surveys

To insure temperature consistency and predictability, it is important to conduct periodic surveys. Methods vary: extruders producing high performance alloys, for example for Military applications, are required to survey at least weekly in order to certify the heat treatment used. Many others, however, never conduct surveys and have no idea of the actual ageing "recipe" being followed; for these, quality is left to chance.

Keep in mind that readings of Webster hardness are at best a very poor indicator of age oven operation. Instead, quarterly temperature surveys are recommended to control quality performance.

Procedure for Oven Surveys. A multi-point temperature device is required, typically with 24 or more recording points. A multi-point temperature recorder with strip chart is commonly used; another option is to use a notebook computer fitted with a thermocouple interface device. Mr. Ram Ramanan³ used "a Toshiba personal computer (with) Multiple I-O plexer interface." Data gathered via PC is more easily collected, analyzed, and stored.

2. Fourmann, Jerome, presentation to AEC Press Maintenance Workshop, April 17, 2018.

3. Ramanan, Ram, IBID

Next prepare a map of the oven, selecting and numbering the locations to be measured. The goal is to find and measure the hottest and coldest profile temperatures at various points in the oven. The coldest ones tend to be downstream of the load, and/or isolated from the air flow, for example near the center of the load. The hottest points will be upstream, and directly exposed to the incoming air flow, for example at the exterior of the load.

Attach the thermocouples to the profiles using heat resistant tape. See notes on thermocouples on Page xix at the front of this Manual.

ASTM B221 requirements – do you comply?⁴

B221 states that “Aging processes and equipment shall meet the practice and requirements of **B918 Standard for Heat Treatment**”. Therefore, to meet B221 extruders need to perform aging oven surveys.

- **Uniformity** within the age oven should be better than $\pm 10^{\circ}\text{F}$.
- All ovens need to be **calibrated and surveyed**.
- **Weekly checks** are required to show the temp. measuring system and control **thermocouples agree within $\pm 2^{\circ}\text{F}$** .
- **Surveys** need to be carried out using 40 thermocouples (one at each corner and one in center a must). Once equilibrium has been reached, temperatures should be measured at 5 minute intervals for 30 minutes to demonstrate uniformity of $\pm 10^{\circ}\text{F}$.
- **Surveys have to be done monthly** for 6 months followed by every 6 month intervals.
- Contact pyrometers shall be **calibrated** once per Quarter.
- Non contact sensors (infrared) shall be verified with contact pyrometers on weekly intervals.

4. Fourmann, Jerome, IBID

Loading the oven

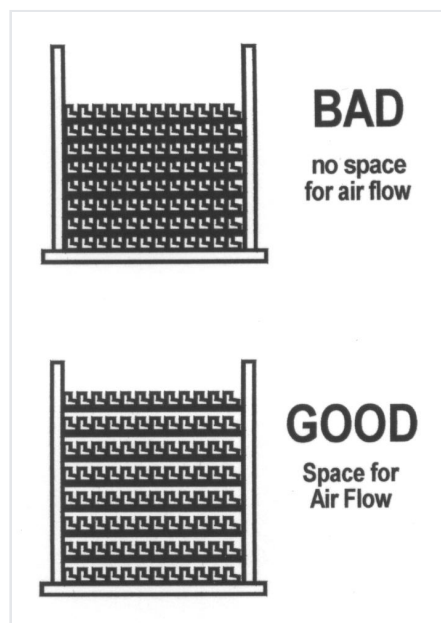


Figure 9-2: Profile Loading in Age Ovens

If air by-passes the load to any degree, heat transfer will be reduced, cycle time will be longer, and there will be a decrease in fuel efficiency and temperature uniformity. Therefore the first goal in loading the oven is to minimize hot air by-pass and to maximize the air flow through the load. If possible, horizontal spacers should allow space between layers to promote flow through the load (**Figure 9-2**); this is especially critical with cross-flow age ovens.

Excess space on the sides, top and bottom of the load should be reduced to the minimum required for clearance when loading and unloading the oven. Baffles constructed of sheet steel may be installed for this purpose; they may be temporary or permanent.

Partially-loaded containers of profiles may also allow by-passing. If full loads are not possible, a system of temporary baffle plates may be needed, to block the by-passing and force the air through the load.

Finally, the heaviest profiles in a given load should be located upstream so that they contact the hottest air. The heavy profiles require longer to heat up, so this manner of loading will tend to even out the profile temperature.

Basic Age Oven Configurations

Age ovens are built in various designs, according to performance requirements and individual preferences. However, most age ovens have the following basic design; for multi-zone ovens, each zone has the same elements.

Work Chamber. The section of the age oven where the profiles are loaded to be aged. Some means for loading and unloading containers of profiles is usually included, for example a work cart, conveyors, or tracks located on the floor. Age oven floors are sometimes insulated but often are not.

Air Distribution Ducts or Plenum. Ductwork to distribute the heated air to one end or one side of the load and return it to the circulation blower and combustion chamber; designed for even distribution of the air.

Air Circulation Blower. This high-temperature blower recirculates the heated air and, in the case of direct fired ovens, mixes it with the products of combustion. It is usually selected to provide high air velocity in order to enhance convective heat transfer to the work load.

Combustion Chamber or Plenum. This chamber usually contains the combustion system and circulation blower, separated by baffles which direct the combustion products to the inlet of the circulation blower. The blower is normally installed downstream of the burner to insure complete mixture of the air and combustion products.

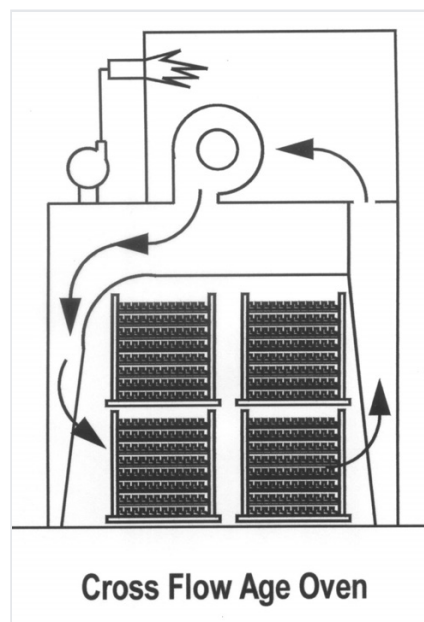


Figure 9-3: Cross-Flow Age Oven

Burner System and Controls. Commonly a package burner system, it is usually flange-mounted to the wall of the combustion chamber. (If electric power is used for heat, resistance elements will typically be located in the circulation plenum.)

Alternative Age Oven Designs

Direct Fired vs. Indirect. Age ovens are most commonly direct fired, that is, the products of combustion are mixed with the circulated hot air. In applications where metallurgical or finishing requirements prohibit contact between the profiles and combustion products (principally water), the burner(s) fire through a radiant tube and then exhaust to the outside; circulating air passes over the outside of the tube and is heated by radiation and convection. Unless properly designed, indirect firing may result in high temperature exhaust and lower energy efficiency; and greater firing capacity may be required for the oven.

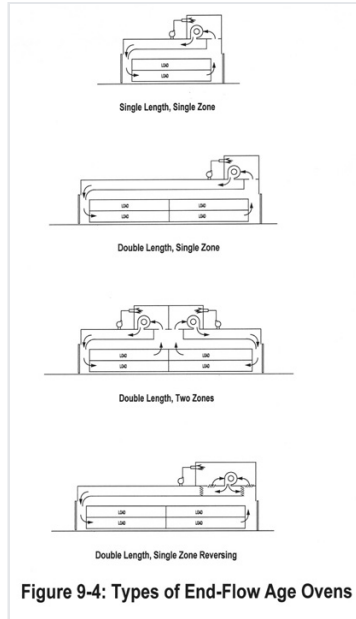
End-Flow vs. Cross Flow. The majority of age ovens are end flow, with the circulating hot air passing lengthwise over the profiles. In theory, cross-flow ovens offer improved temperature uniformity but slightly lower energy efficiency. However, uniformity may be better or worse with cross flow, depending on the nature of the load and how it is stacked in the oven. Heat transfer predominately occurs by means of convection, so an important objective is to have maximum contact between the profile surface and the circulated air. If profiles are stacked so that cross flow of air through the load is effectively blocked, or so that only the edges of the profiles are touched by the air stream, heat transfer will be poor for all but the first profile in each row. With end flow ovens, profiles must also be stacked in a way that permits good air flow through the load.

Oven Length: Efficiency vs. Uniformity. In theory, thermal efficiency increases with greater length of the load along the path of air flow. Unfortunately, temperature uniformity also decreases with load length. Therefore, each oven design is something of a trade-off of these factors. Because of the layout of most extrusion plants, age ovens are commonly built to hold 2 to 4 containers of profiles end-to-end. Where space and capacity requirements dictate a longer oven, multi-zone construction is preferred (see below). Otherwise, regular temperature surveys become even more important.

Multi-zone vs. Single Zone. To improve temperature uniformity, longer ovens may be built with two or more zones of circulation and control. Older single zone ovens may also be converted to multi-zone. Each control zone will have its own combustion, air circulation, and temperature control systems. Modern end-flow ovens should ideally have one control zone for every length of profiles placed end-to-end.

For additional information on age oven design, see "Building a Better Age Oven."⁵

5. Marinelli, M., "Building a Better Age Oven," Proceedings of 7th International Aluminum Extrusion Technology Seminar, (2000).



Combustion Systems



Figure 9-5: Single zone end-flow age oven (Photo courtesy of Belco)



Figure 9-6: Dual zone end-flow age oven (Photo courtesy of Granco Clark)



Figure 9-7: Semicontinuous age oven (Photo courtesy of OMAV)

Among the different types of industrial heating equipment, age ovens are a relatively low-temperature application and so may be heated with various types of combustion systems. One common type is the **package** or **integral burner** system, which incorporates the burner, air blower, air control damper, air filter, pilot, spark igniter, flame rod, and other features in a single unit. The package unit may be flange-mounted directly into the hot air recirculation chamber or plenum. The burner may be either **nozzle mix** or **premix**; the fuel-air ratio controls used with each one are described below, along with maintenance procedures and recommendations.

Main Gas Train. The main gas train which feeds the burner system for each zone of the oven is equipped with safety shut-down devices as dictated by fire (NFPA) and insurance (FM or IRI) codes, typically:

- main gas shut-off valve
- main gas pressure regulator
- high gas pressure safety switch
- low gas pressure safety switch
- manual reset blocking valve (main safety valve)
- safety vent valve (discharge piped through the building roof)
- second blocking valve (auto-reset)
- test cocks and/or pressure gauges

In every case, safety devices, interlocks, purge cycles, and flame detectors must be maintained in proper working condition. Never allow a safety device or system to be defeated or by-passed, and check often to insure that all such devices and systems are in good condition and working properly.

Special Alert: Possible Malfunction of Safety Vent Valves. NFPA, FM, and IRI regulations require that a vent located between the blocking valves of the main gas train be opened automatically when the main safety valve closes for any reason. The purpose is to safely vent away any fuel gas which may leak through the main safety valve when it is closed. However, the solenoid vent valves are prone to sticking in the open position --- many furnaces have valves which are specified for horizontal installation only, incorrectly mounted in a vertical position. As a result, when the furnace is turned on, these valves often remain open, venting expensive (and dangerous) fuel gas through the roof. To control this problem, we recommend several steps:

- Make sure the vent solenoid valve is installed properly.
- Use gas meter readings to detect any sudden increase in gas usage.
- Install a test cock after the valve to permit testing for leaks; connect a rubber hose and put the other end into a glass of water to test for gas discharge.
- Install a visible sight flow indicator after the vent valve.

Adjustment of the Combustion System

Values for combustion settings for each zone, both before and after adjustment, should be recorded in a permanent log. The sequence of adjustments for each type of burner system is as follows:

Nozzle-Mix Burners. Nozzle mix burners receive both combustion air and gas into separate intake ports of the burner, in the correct fuel-air ratio, and mix them just before combustion. For each burner, fuel gas is supplied through a “cross-connected” ratio regulator, which adjusts the gas flow in proportion to changes in the flow rate of combustion air (see illustration in Figure 9-7). An impulse line is connected from the combustion air supply pipe to the diaphragm chamber of the ratio regulator. As the flow of combustion air is varied by the motorized air damper on signal from the temperature controller, the changing air pressure causes the diaphragm to open or close the gas regulator’s valve, keeping the gas flow more or less in proportion to air flow. Because this ratio adjustment is somewhat imprecise over the range of air flows, it is adjusted for accuracy primarily on low fire; a more precise ratio adjustment on high fire is made by means of a limiting orifice valve located in the gas line after the regulator.

Adjustment of Nozzle Mix Burners. The following procedures are based on recommendations from North American Mfg. Co., reprinted here in part with their permission. Similar principles may apply to systems supplied by other manufacturers, but the original maintenance and safety instructions for your equipment must take precedence.

1. Adjust the Combustion Air Pressure. High- and low-fire settings are established by adjusting the combustion air control damper’s linkage as indicated on North American Mfg. Co. Instructions Bulletin 1230, reprinted in Chapter 7, on page 7-13.

Note: set combustion air according to your manufacturer’s recommendations. Typical values at blower outlet:

16 ounces/sqin. High fire

0.5 ounce/sqin. Low fire

2. Adjust the Fuel Gas Supply Pressure. With the air blower off, set the main gas supply regulator to deliver the correct pressure (at least 2 ounces/sqin greater than the maximum combustion air pressure) to the inlet of the cross-connected ratio regulator.

3. Start the System. Start the blower, purge as required by code (typically a minimum of 4 to 6 air changes), and ignite the pilots.

4. Adjust the Pilot Flame. Set the outlet pressure of the main pilot regulator at 11 inches WC. Set the combustion air inlet to the pilots at 14 ounces/sqin. Ignite the pilots and adjust by sight: the flame should be sharp and forceful, with a well-defined light blue inner cone and a deeper blue outer envelope. A long, bushy green, yellow or orange flame indicates a rich ratio. A short, pale blue or violet flame indicates a lean ratio. Rich or lean flames may cause a failure to satisfy the flame rod or UV detector, or failure to ignite the burners.

Note: see the North American Mfg. recommendations for **pilot adjustment** reprinted in Chapter 7, on page 7-19.

5. Light the Main Burners. Set the air control valve on low fire position, then open the main gas safety shut-off valve. Open the gas adjustment of the ratio regulator just enough to maintain a flame. If the burners do not light, close the gas shut-off valve, open the ratio regulator one more turn and repeat the purge and lighting sequence. Continue to repeat this sequence until the burners light. (See North American Mfg. recommendations in Figure 9-9).

6. Adjust the High Fire Setting. Turn the control setting to High Fire. With a screwdriver, adjust the limiting orifice valve for the desired air-gas ratio.

7. Adjust the Low Fire Setting. Turn the control setting to Low Fire. With a screwdriver, adjust the spring of the ratio regulator to get the desired low fire ratio.

8. Recheck Settings. Turn back to high fire and verify that the adjustment to low fire did not disturb the high fire setting. Alternate between the high and low settings until both are correct.

Desired Flame Characteristics: While it is difficult to describe what a flame should look like, in general a natural gas flame should be primarily blue with flecks of yellow. See recommendations on **judging flames**, from North American Mfg., in Chapter 7 on page 7-23. Flue gas analysis is also an excellent way to adjust flames; combustion analysis kits are available from suppliers of combustion equipment, or from McMaster-Carr Supply Co., www.mcmaster.com, PO Box 4355, Chicago IL 60680-4355, Telephone 630-833-0300, Fax 630-834-9427.

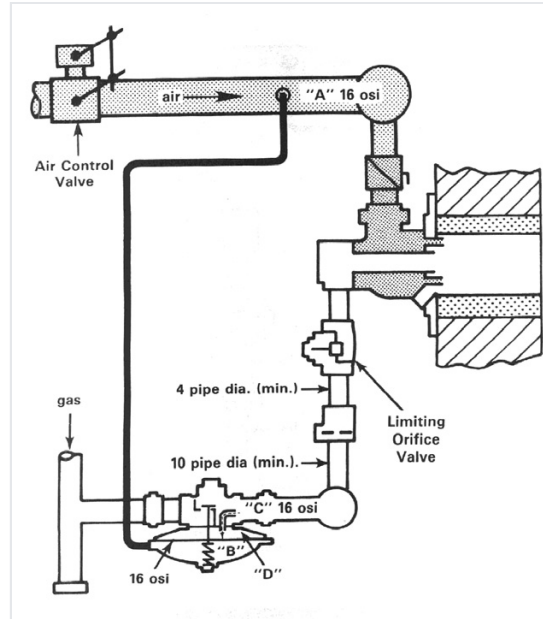


Figure 9-8

OPERATION OF A CROSS-CONNECTED

AIR/GAS RATIO REGULATOR

The pressure at "A" goes through the impulse line to chamber "B." The regulator opens until the outlet pressure at "C" passing through balancing tube to chamber "D" equals the pressure at "B."

From "Practical Pointers - Industrial Burner Control Systems." page 19, used with permission of North American Mfg. Co.

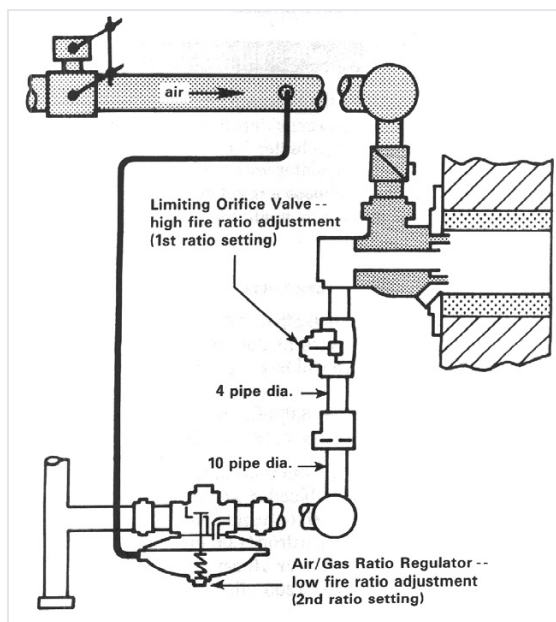


Figure 9-9

SUMMARY -- PRACTICAL AIR/FUEL RATIO ADJUSTMENT

- Set the linkage on the air control valve for the desired high and low air pressures.
- Light the fire at low air pressure with enough gas to maintain flame.
- Turn to high fire, adjusting the high fire ratio adjustment to keep the flame burning.
- Set the high fire ratio adjustment for the desired air/gas ratio, using a screwdriver on the limiting orifice valve.
- Turn to low fire position, and, if needed, adjust the low fire ratio by removing the gas diaphragm cover plug and using a screwdriver to turn the spring adjusting plug.
- If a major adjustment was necessary on low fire, return to high fire and correct the ratio again with the limiting orifice valve.
- Recheck the low fire ratio and correct it if needed using the regulator spring adjusting plug.
- Replace caps on the limiting orifice valve and the regulator.

From "Practical Pointers - Industrial Burner Control Systems." page 23, used with permission of North American Mfg. Co.

Premix Burners. Premix systems are commonly used for gas-fired log/billet heaters and are described in detail in Chapter 7. Premix systems use a single ratio control regulator for each control zone. For each zone, fuel gas is supplied through an atmospheric or "zero pressure" regulator, which maintains the gas supply at zero pressure to a mixer unit, as described in the illustrations on pages 7-14 and 7-15. Combustion air is also supplied to the mixer, and "aspirates" or draws a flow of the fuel gas in direct proportion to the amount of

air flowing. Air flow to the mixer is varied by a motorized damper on a signal from the temperature controller. The air-gas mixture is delivered to the different burners of each zone, pre-mixed in the correct ratio for combustion. Fuel-air ratio adjustment for low fire is made by means of a gas adjustment valve on the mixer, and a limiting orifice in the gas line before the mixer is used to regulate the fuel-air ratio at high fire.

Adjustment of Premix Burners. The following procedures are based on recommendations from North American Mfg. Co., reprinted here in part with their permission. Similar principles may apply to systems supplied by other manufacturers, but the original maintenance and safety instructions for your equipment must take precedence.

1. Adjust the Combustion Air Pressure. High- and low-fire settings are established by adjusting the combustion air control damper's linkage as indicated on North American Mfg. Co. Instructions Bulletin 1230, reprinted in Chapter 7, on page 7-13.

Note: set combustion air according to your manufacturer's recommendations. Typical values at mixer inlet:

8 ounces/sqin. High fire

1 ounce/sqin. Low fire

2. Adjust the Fuel Gas Supply Pressure. With the air blower off, set the main gas supply regulator to deliver the correct pressure (11 inches WC for North American Mfg. systems) to the inlet of the atmospheric regulator.

3. Pre-adjust the Atmospheric Regulator. Adjust the spring of the atmospheric regulator as needed to achieve 0 inches WC at the outlet. See North American Mfg. recommendations concerning typical settings, reprinted in Chapter 7, on page 7-14.

4. Start the System. Start the blower, purge as required by code (typically a minimum of 4 to 6 air changes), and ignite the pilots.

5. Adjust the Pilot Flame. Set the outlet pressure of the main pilot regulator at 11 inches WC. Set the combustion air inlet to the pilots at 14 ounces/sqin. Ignite the pilots and adjust by sight: the flame should be sharp and forceful, with a well-defined light blue inner cone and a deeper blue outer envelope. A long, bushy green, yellow or orange flame indicates a rich ratio. A short, pale blue or violet flame indicates a lean ratio. Rich or lean flames may cause a failure to satisfy the flame rod or UV detector, or failure to ignite the burners.

Note: see the North American Mfg. recommendations for **pilot adjustment** reprinted in Chapter 7, on page 7-19.

6. Light the Main Burners. Set the air control valve on low fire position. Open the gas adjustment of the aspirator mixer valve 3 or 4 turns. Then open the main gas safety shut-off valve. If the burners do not light, close the gas shut-off valve, open the aspirator mixer valve one more turn and repeat the purge and lighting sequence. Continue to repeat this sequence until the burners light. (See North American Mfg. recommendations reprinted in Chapter 7, on page 7-20).

7. Check the Flame Characteristics. The furnace should be powered on according to established procedures and one zone ignited, with the controller set on manual or thermocouples manually shorted out to keep the system on **high fire**. Flame adjustment may be made by visual judgment: while observing the flame through the sight glass, adjust the limiting orifice (on the inlet of the atmospheric regulator) as needed to obtain good flame characteristics. While it is difficult to describe what a flame should look like, in general a natural gas flame should be primarily blue with flecks of yellow. See recommendations on **judging flames**, from North American Mfg., in Chapter 7 on page 7-23. Flue gas analysis is also an excellent way to adjust flames; combustion analysis kits are available from suppliers of combustion equipment, or from McMaster-Carr Supply Co., www.mcmaster.com, PO Box 4355, Chicago IL 60680-4355, Telephone 630-833-0300, Fax 630-834-9427.

Next adjust the **low-fire** characteristics. Set the controller for the low position and observe the flame: it should be burning only to the face of the burner tile. If too high, reduce the gas setting with the adjusting screw of the atmospheric regulator. If the flame goes out or is unstable, increase gas with the same adjusting screw. (Clockwise to increase gas, counter-clockwise to decrease.)

Finally, return to high fire and re-check the setting. Some fine tuning may be required to settings. Continue until all zones have been set.

For further information on combustion systems, refer to **Chapter 7 – Billet and Log Feed Systems**, especially the recommendation to maintain a log of all combustion settings, **pages 7-24 to 7-27**.



Figure 9-12: Maxon Ovenpak burner complete with gas train piping.



Figure 9-10: Maxon Ovenpak burner



Figure 9-11: Maxon Ovenpak burner (front view)

In addition to North American Mfg. Co., many age ovens in the and are equipped with Maxon burner systems. The illustrations in Figures 9-9 through 9-11, along with Installation and Start-Up Instructions on the following pages, are taken from the Maxon web site at www.maxoncorp.com.

Maxon "400" OVENPAK® Gas Burners

Installation Instructions

General Instructions

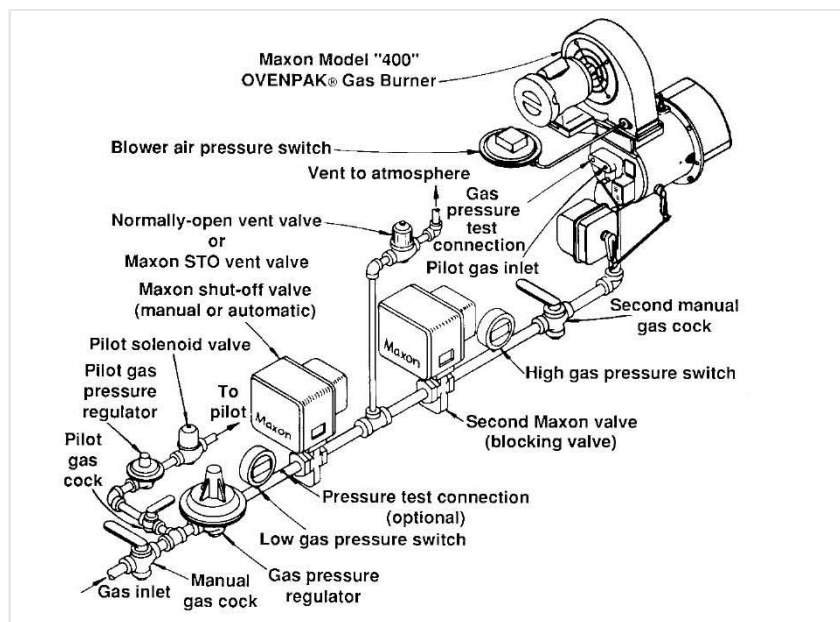
Important: Do not discard packing material until all loose items are accounted for.

To prevent damage in transit, the spark ignitor, discharge sleeve, mounting gaskets, flame rod and connecting linkage components may be packed separately and shipped loose with your new Maxon OVENPAK® Burner.

The burner itself is normally only a part of your complete combustion system. Additional pipe train accessories and control components will be required for a complete system installation. The sketch below shows a typical gas train as might be used with OVENPAK® gas fired burners.

Piping Layout as sometimes required by insurance and standards groups

Block and Bleed gas train arrangement illustrated with Model "400" OVENPAK® Burner



Model "400" OVENPAK® Burners provide the air supply (except for EB versions, which require a separate combustion air blower). They also serve as a fuel flow control and fuel/air mixing device. Model "200" OVENPAK® Burners serve as a mixing device and usually have an externally-mounted gas control valve.

Burner should not be exposed to direct radiant heat or positioned where it might draw in inert gases. If such conditions exist consider filters, relocation, and/or use of the EB version and external air supply.

Electrical service must match the voltage, phase and cycle of all electrical system components and be compatible with burner nameplate ratings. Insure that all normal control safeguards are satisfied. Combustion air blower should continue to run after shutdown to allow burner to cool.

Gas supply piping must be large enough to maintain the required fuel pressures cataloged for the particular burner size used with burner operating at full rated capacity.

Anything more than minimal distance or piping turns may necessitate over-sizing piping runs to keep pressure drops within acceptable ranges.

Inlet pipe leading to any burner should be at least four pipe diameters in length. If multiple burners are fed from a single gas train, care should be taken to minimize pressure drop and give maximum uniformity.

Clean fuel lines are essential to prevent blockage of pipe train components or burner gas ports.

Main Shut-Off Cock should be upstream of both the main gas regulator and pilot line take-off. Use it to shut off fuel to both pilot and main burner during shut-down periods of more than a few hours.

The fuel throttling valve contained within a Maxon burner is not intended for tight shut-off.

Main gas regulator is essential to maintain a uniform system supply pressure. If one pipe train supplies multiple burners, provide a separate regulator in the branch leading to each burner system.

Size the regulator for full system capacity at the required pressure, carefully considering pipe train losses. Follow the instructions attached to the regulator during installation and be sure to remove any shipping pin or block.

Pilot take-off should be upstream of the main gas regulator, but downstream of the main gas cock. It should normally include its own pilot gas regulator, a solenoid valve and shut-off cock. A pilot adjustable orifice at the pilot inlet simplifies adjustment.

Pilot piping must be large enough to provide for the full flow and pressures shown in the catalog for your particular burner size.

Fuel Shut-Off Valves (when properly connected to a control system) shut the fuel supply off when a hazardous operating condition is sensed. Manual reset valves require operator attendance each time the system is started up (or restarted after a trip-out). Motorized shut-off valves permit automatic start-restart when used with an appropriate control system.

Test connections are essential for burner adjustment. They should be provided immediately downstream of the regulator and are included in the burner itself. **Test connections must be plugged except when readings are being taken.**

Horizontal mounting is preferred, but burner may be mounted in any position suitable for automatic control motor and UV scanner (if used).

OVENPAK® Burners will typically be installed through an oven wall or insulated air duct. Cut opening approximately 1" larger in diameter than discharge sleeve to allow for thermal expansion of sleeve.

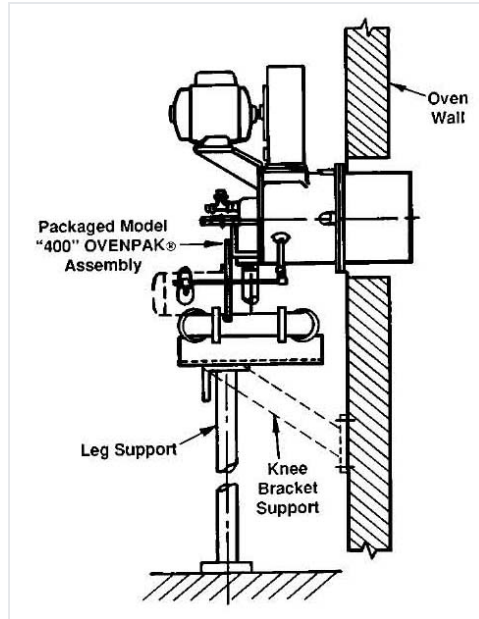
Burner mounting requires four studs and a flat mounting surface perfectly centered on the discharge sleeve.

After placing burner in position over studs, add lock washers and nuts, then draw up hand-tight only. Check that burner is seated evenly all around the flange, filling any gaps to prevent air leakage, then tighten all nuts firmly.

For proper performance of any burner, air inlet and motor should be surrounded by clean, fresh, cool air.

Burner and pipe manifold support will be required to support weight of the burner and connected pipe train components. Air control motors, in particular, require additional support. Maxon connecting base and linkage assemblies are designed to position the control motors to work with the burner, not to support their weight.

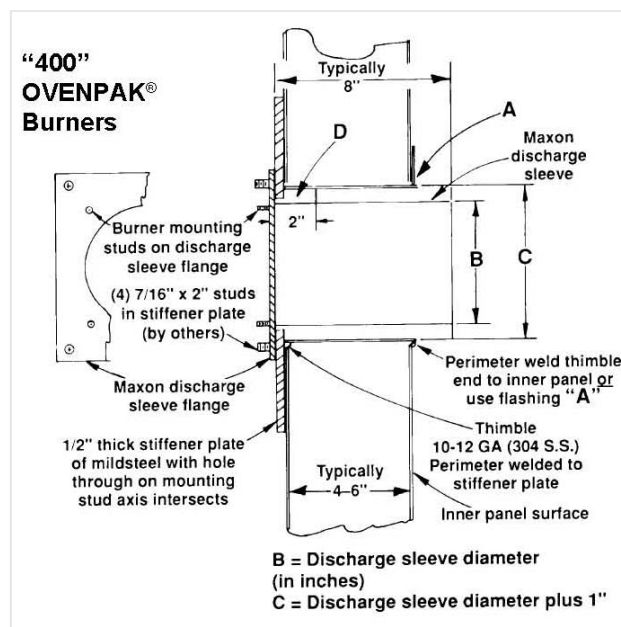
The Packaged Model "400" OVENPAK® Burner requires external auxiliary support provided by the user. The support configuration may be similar to the leg support or knee bracket support illustrated below.



Suggested supporting arrangements for Packaged Model "400" OVENPAK® Burners:

Additional burner support may be required in conjunction with a stiffener plate when mounting OVENPAK® Burner (weighing 100-350 pounds) through typical thin wall of heater/oven panels.

For push-through systems, use Maxon special back pressure gasket between stiffener plate and discharge sleeve flange and use (2) ring gaskets between discharge sleeve flange and burner casting to prevent back flow of high temperature air. Fill area **D** (see sketch below) with **no more than 2"** of high temperature packing (too little will overheat mounting; too much will overheat sleeve).



Typical discharge sleeve mounting recommendations

For pull-through systems, spacers may be installed on stud bolts and area **D** left empty to admit cooling air past the sleeve.

WARNING: Welding of burner flange to stiffener plate may cause warping of burner flange and require additional seal material to prevent leakage.

Four lock screws permit centering of mixing cone within burner body and sleeve.

For "400" OVENPAK® Burners: Lock screws should be drawn up hand-tight, then backed out one-half turn to allow for cone expansion. **They must be re-checked after start-up**, and loosened if necessary to prevent deformation of cone. See start-up instructions for details. **Over-tightening lock screws can lead to cone distortion and greatly reduce cone and discharge sleeve life.**

Discharge sleeve must be flush with, or extend beyond, interior wall. Maxon can supply a special 12" long discharge sleeve, but higher noise levels may result, particularly when firing on propane.

An external viewing port should be provided for flame observation, preferably in such a position that burner pilot and main flame can both be seen.

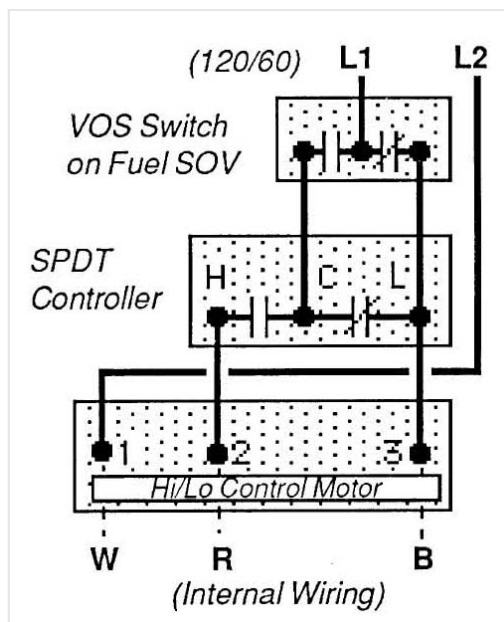
Flame sensing can be accomplished by either flame rod or UV scanner. When UV scanner is used, it should be kept as close to burner as feasible. Heat block, if used, may affect signal strength with some brands of scanners.

For "400" OVENPAK® Burners, field conversion from a flame rod version to a UV scanner version and vice versa may require additional parts in the burner. Contact Maxon for requirements.

Alternate fuels may require correction of supply pressures.

If OVENPAK® Burner is equipped with Maxon Hi/Lo Control Motor, low-fire start wiring can be accomplished as shown in the sketch below.

Maxon assumes no responsibility for the use or misuse of the layouts shown. Specific piping and wiring diagrams should always be submitted to the appropriate agencies for approval on each application.



Multi-burner installations require special considerations if supplied by a common pipe train and/or air supply. **Air and Gas Balancing Valves** should be used for improved heating uniformity; **Gas Swing-Check Valves** should be installed as close as possible to each burner inlet for dependable lightoff (gas manifold may otherwise act as a reservoir, preventing lightoff during trial-for-ignition period).

Control system's circuitry must not allow main Fuel Shut-Off Valve to be opened unless combustion air is on, and must de-energize valve upon loss of combustion air pressure, along with the other usual system interlocks. Motor starter is to be interlocked with valve, whether or not a combustion air pressure switch is used.

Maxon "400" OVENPAK® Gas Burners

START-UP INSTRUCTIONS

Read complete instructions before proceeding, and familiarize yourself with all the system's equipment components. Verify that your equipment has been installed in accordance with the original manufacturer's current instructions.

CAUTION: Initial adjustment and light-off should be undertaken only by trained and experienced personnel familiar with combustion systems, with control/safety circuitry, and with knowledge of the overall installation. Instructions provided by the company and/or individuals responsible for the manufacture and/or overall installation of complete system incorporating Maxon burners take precedence over these provided by Maxon. If Maxon instructions conflict with any codes or regulations, contact Maxon Corporation before attempting start-up.

For initial OVENPAK® Burner start-up:

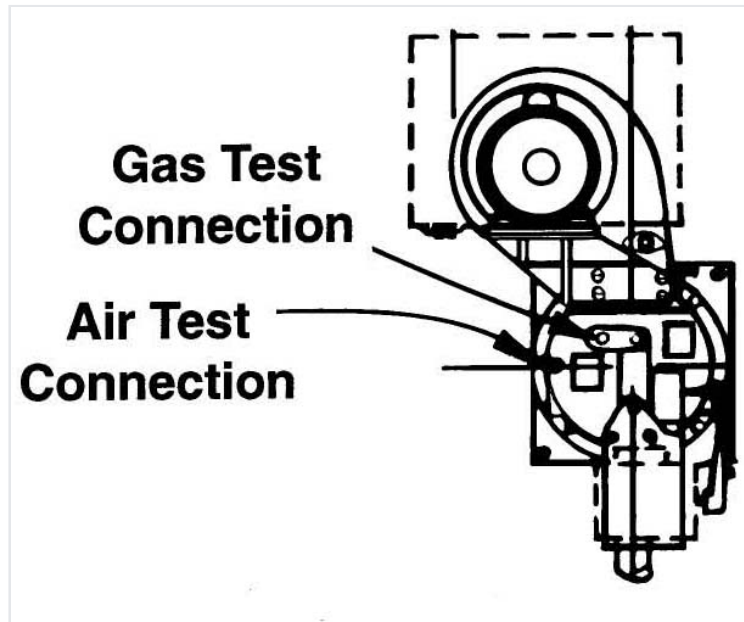
- **Close all burner fuel valves and cocks.** Make preliminary adjustments to fuel gas regulators. Remove pilot and main gas regulator's adjusting screw covers. Turn adjusting screw down (clockwise) to approximately mid-position. Close pilot gas adjustable orifice screw by turning in clockwise until it stops. (Do not over-tighten.) Then back out the adjustable orifice (counter-clockwise) approximately 2-3 turns.
- **Check all electric circuitry.** Verify that all control devices and interlocks are operable and functioning within their respective settings/ranges. Be sure all air and gas manifolds are tight and that test ports are plugged if not being used.
- **Check that all duct and chamber dampers are properly positioned** and locked into operating positions.
- **Disconnect the automatic control motor's linkage** from the "400" OVENPAK® Burner's operating crank arm by loosening the control motor's connecting rod from the burner's toggle linkage.

For Model EB-MRV and Model "200" OVENPAK® Burners, the connecting linkage on the separate control valve must be similarly loosened and disconnected. Refer to specific adjusting procedures relating to control valve adjustment in Maxon catalog.

Initial start-up adjustment should only be accomplished during a manual burner control mode.

- **Start all system-related fans and blowers.** Check for proper motor rotation and impeller direction. Verify that all control interlocks are working. Allow air handling equipment to run for adequate purge of your manifolds and combustion chamber plenums. With main gas shut off, manually advance burner to high fire position so that air only flows through burner and combustion chamber.

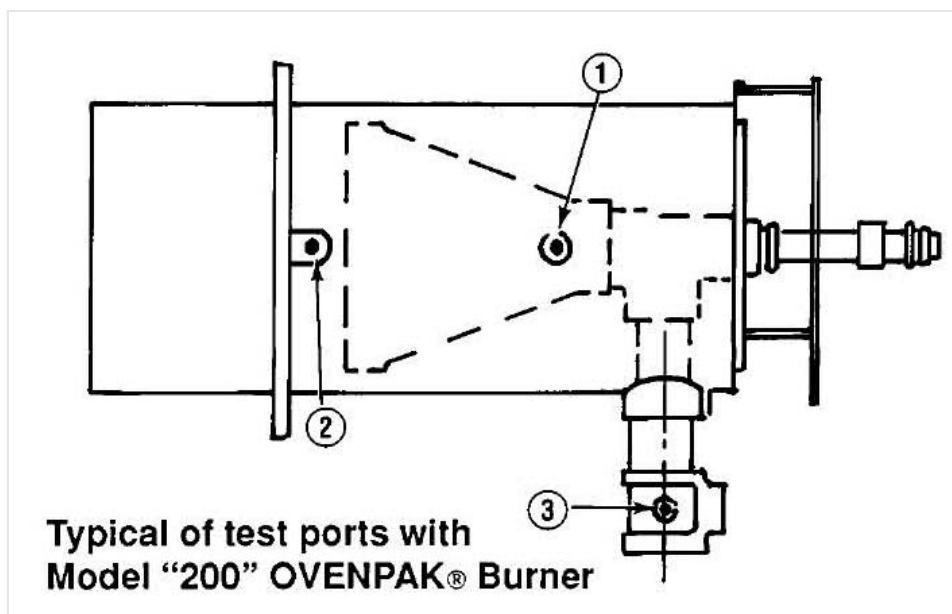
CAUTION: Do not by-pass control panel timers typically controlling sequential operations.

For EB OVENPAK® Burners only (step 6)

- **Verify differential air pressure.** With combustion air blower on, all volume air fans operating, and burner at high fire position, connect a manometer between the air test connection on backplate of OVENPAK® Burner and your combustion chamber static pressure test connection. This will give a **direct** differential air pressure reading.

Determine your differential air pressure reading by taking an additional reading with manometer connected between the burner's air pressure test port and atmosphere with the burner at high fire position, fuel valves closed, and all air handling systems running. Subtract the combustion chamber static pressure obtained above from this air pressure reading to give you **differential air pressure reading**.

For Model "200" OVENPAK® Burner only (steps 6A-6C)



6A. Cross-connect manometer to upstream (1) and downstream (2) air pressure test connections on Model "200" OVENPAK® Burner's main housing.

6B. Start air handling system and adjust louvers, dampers, etc. to desired setting to establish cold suction design conditions.

6C. Transfer manometer connection from upstream air pressure test (1) to gas pressure test connection (3). This is the differential air pressure reading for a Model "200" OVENPAK® Burner.

For "400" OVENPAK® Burners: The differential air pressure setting determines the burner's capacity and performance capabilities. Model EB and MA manual air OVENPAK® Burners, with their external air control valve(s), provide for the manual setting of this differential air pressure to the burner. Refer to specific adjusting procedures relating to MICRO-RATIO® and control valve adjustment in Maxon product line catalog. MA OVENPAK® Burners have an external locknut adjustment on the end of the air butterfly control valve. This lets you limit and set the differential pressure to the OVENPAK® Burner. Refer to Maxon specification tables in the catalog for the differential air settings required for your specific OVENPAK® Burner capacity.

- **Determine the required differential gas pressure** using this differential air pressure reading obtained from step 6. If your combustion chamber does not have a static pressure test connection, then you must measure combustion chamber static pressure by connecting a manometer between the **gas** pressure test port on the burner's backplate and to atmosphere with the burner at low fire position, fuel valves closed, and all air handling systems running. High fire pressures are provided in Maxon product line catalog literature and/or read data stamped into burner nameplate.

- **Verify that spark ignitor is properly positioned** and lines up with the appropriate dimensions required for your specific burner. (Refer to appropriate Maxon catalog specification table.) Check that spark ignitor arcs at the end of your properly positioned ignitor.
- **Return burner control valve (or crank) to low fire position** when purge of system is complete.
- **Open main and pilot gas cocks**, then attempt spark ignition to light pilot while slowly turning pilot gas regulator spring clockwise and/or adjustable orifice screw counter-clockwise to increase fuel flow. Repeat procedure as necessary until pilot ignites as air might have to be bled out of fuel supply lines before reliable pilot flame is established. Pilot gas regulator should normally be set for as low a pressure as possible, using fuller opening of pilot gas adjustable orifice (if used).
- **After ignition, adjust pilot flame** for good stable flame shape. A rule of thumb is that any pilot over a tennis ball size is probably too large. This assumes you have visual access to the pilot flame. If this is not possible, then adjust pilot to give the strongest and most stable flame signal through your flame safety circuit. This signal strength can be read with a micro-amp meter. The signal strength (or range) will be determined by the specific type of flame safeguard instrument you have with your burner system.
- **Re-check pilot ignition** by closing pilot gas cock or otherwise causing pilot outage. Re-light and refine pilot gas adjustment as necessary to get ignition within a second or two. The flame safeguard relays should now power your main fuel Shut-Off Valve(s).

CAUTION: After completing steps above, re-check all interlocking safety components and circuitry to prove that they are properly installed, correctly set, and fully operational. If in doubt, shut the system down, close pilot cock and contact responsible individual before proceeding further.

- **Establish main flame.** With burner at low fire position, back out main gas pressure regulator adjusting screw (counter-clockwise) to get lowest outlet pressure possible. Open all manual fuel shut-off valves (automatic fuel shut-off valve should already be open) so gas flows to burner inlet. There should be little, if any, change in flame appearance. Turn main regulator adjusting screw in (clockwise) to obtain outlet pressure of about 4"-6" wc higher than combustion chamber pressure (2"-4" wc for propane, considerably higher for some EB versions). Main flame should now appear larger than pilot-only flame.
- **Establish high fire setting** by slowly moving burner toward high fire position while observing gas pressure at burner gas test connection. Refine main gas regulator adjustment as necessary to provide correct differential pressure (gauge to combustion chamber, see step 7) at high fire. If pressure cannot be adjusted low enough, a different regulator or regulator spring may be necessary, or a limiting orifice valve (such as Maxon's Series "BV") should be added. Do not, however, exceed 4" wc pressure drop between regulator outlet and burner inlet.

CAUTION: If burner(s) go out, close shut-off valve or shut main gas cock at once. Return to minimum setting, re-light pilots if necessary, then turn main gas on again. Check carefully that every burner is lit before proceeding.

Cycle burner from minimum to maximum and refine adjustment, if necessary.

For operation with interrupted pilot (as recommended), shut off pilots and cycle burner from minimum to maximum and back several times to verify the flame is maintained.

- When burner performance is satisfactory and stable throughout the firing range, reconnect control motor.

For "400" OVENPAK® Burners: Reconnect linkage to control motor. Control linkage travel must be such that burner crank is moved throughout its complete travel, or cataloged capacities and turndowns will not be achieved. If less than full-rated burner capacity is required, linkage can be adjusted to limit maximum output.

With interrupted pilot, it may be necessary to set control for somewhat higher than minimum burner setting to permit hold-in of flame detection system without pilot.

CAUTION: Internal drive mechanism within the control motor may be damaged if linkage is adjusted so as to cause binding with burner in high or low fire position.

- **Re-check differential gas pressure** with unit at operating temperature. Refine high fire setting if necessary, considering differential pressure, flame length, and appearance. Natural gas flame should normally be predominantly clear blue but possibly with semi-luminous tips. Dust or contaminants in the air stream may affect flame appearance.
- **For "400" OVENPAK® Burners: Check for contact between mixing cone and top-most centering screw** after system has reached maximum operating temperature. If set screw touches cone, back off an additional 1/8 turn on top and both side set screws.
- **Plug all test connections not in use to avoid dangerous fuel leakage.** Replace equipment cover caps and tighten linkage screws.
- **Check out overall system operation** by cycling through light-off at minimum, interrupting pilot, and allowing temperature control system to cycle burner from minimum to maximum and return. Recheck all safety system interlocks for proper setting and operation.

NOTE: Typical gas firing control sequence for Maxon burner is provided **only as a guide**. Instructions provided by complete system manufacturer incorporating Maxon burners take precedence.

For gas firing Model "400" OVENPAK® Burner

Light-off:

1. Close cocks, shut-off valve(s)
2. Verify burner at low fire
3. Start recirculating/exhaust fans
4. Start burner blower

5. Purge at least 4 air changes
6. Open pilot & main gas cocks

Shut-down:

- Close main & pilot gas cocks

2. Keep combustion air blower running after shut-down long enough to allow burner to cool.

WARNING: Test every UV installation for dangerous spark excitation from ignitors and other possible sources of direct or reflected UV radiation. Use only gas-tight scanner connections.

- **Before system is placed into full service, instruct operator personnel** on proper start-up operation with shut-down of system, establishing written instructions for their future reference.

Routine Combustion System Maintenance. On a weekly basis, check the pilot flames for proper operation, and inspect the flame safety detectors (UV sensors or flame rods) to see that they are clean and functioning properly.

The following “tune up” procedures for the combustion system are recommended as indicated, or at least annually, unless experience dictates a different frequency:

- Clean or replace inlet air filter of combustion blower and lubricate the bearings (monthly).
- Remove and clean pilot air strainers (monthly).
- Perform a leak test of the safety shut-off and vent valves (monthly).
- Check linkages on air damper control motor (monthly).
- Remove and clean or replace spark plugs (monthly).
- Clean and inspect flame detectors (monthly).
- Check the proper functioning of the purge cycle timer (monthly).
- Remove and clean the metering rods from the atmospheric regulators (premix systems only).
- Clean the inside body of the atmospheric or ratio regulators.
- Clean and inspect combustion blower impeller and housing.

11. Check the burner tiles for damage (monthly); badly cracked or broken tiles must be replaced. Check that burner nozzles are clean.

Electric Heating System. With an electric oven, check the heating elements daily, making sure that the elements are free from any obstructions. Make sure no metal is in contact with the elements. A monthly check should be made for any burned out elements; it is recommended to also check amperage on all elements. At the same time check the elements’ electrical terminals to insure that the connections are tight. Electrical contactors should also be checked on a monthly basis.

Hot Air Circulation Fan or Blower. Hot air recirculation requires a high temperature blower, typically designed for service at 600oF (315oC). Depending on the location of the fan bearings with regard to the hot air plenum, high temperature lubricants are normally required. In general, bearings should be lubricated monthly, unless dictated otherwise by past experience (less often for one shift per day operation). Lubricate the bearings only when the fan is operating, and do not over-lubricate.

Drive belts for the blower should also be inspected monthly for wear, tension, and alignment; when replacing belts, only matched sets should be used. Manually turn the shaft to check for dragging or contact between the blower wheel and housing.

Belt tensioning: Check belt tension with a tensioning gage and adjust using the motor slide base. Insufficient tension shortens belt life, can reduce fan performance and may cause vibration. Excess tension shortens bearing life. The lowest allowable tension is that which prevents slippage under full load. Belts may slip during startup, but slipping should stop as soon as the fan reaches full speed. For more precise tensioning methods, consult the drive manufacturer's literature.⁶

For maximum fan and bearing life, the hot air fan should not be shut down unless the oven temperature is below 250oF (120oC).

If fan vibration occurs, the likely causes are:

- loose mounting of the fan or motor
- mis-alignment of the belt sheaves or poor condition of the sheaves
- drive belts worn, improperly tensioned, or not a matched set
- improper bearing lubrication (lubricate only when fan is running)
- bent fan shaft

Check the fan wheel annually for wear or corrosion and for any build up of material which may cause unbalance or loss of performance. Clean or replace the wheel as required. Check all fan bolts and setscrews for tightness.

6. From "Installation, Maintenance, Operating Instructions," The New York Blower Company, 7660 Quincy Street, Willowbrook IL 60521-5596, USA.



Figure 9-13: "Tadpole" type door gasket with wire mesh.

Exhaust. Air balance within the oven is maintained by exhausting a quantity of air to offset the volume of combustion products. Some ovens use an induced-draft fan with volume established by fan speed or control damper. Other ovens use a chimney and damper located after the circulating blower; exhaust is controlled by a counterweighted or power-actuated damper arm. In either case, it is important to maintain a slightly positive pressure within the oven, to eliminate temperature variations and energy loss. Check monthly for proper adjustment or control of the damper by testing around the oven doors for leakage in or out (with smoke or tissue paper).

Doors and Door Seals. Proper sealing at the doors is required for temperature uniformity and good energy efficiency. Steel door frames may become warped in time; remove and place on a flat surface for straightening (cut and re-weld if necessary). Check door seals monthly and replace when worn. "Tadpole" door gaskets usually consist of ceramic ropes wrapped in high-temperature ceramic cloth; cloth inserted with Monel wires may be used for longer seal life. More recently, seals are available which consist of stainless steel wire mesh wrapped in Monel wire inserted cloth.

Doors may be hinged, or opened vertically. Hinged doors require monthly lubrication for the hinges and typical maintenance of the door actuators (air cylinders, for example), if used. Hoist systems require regular lubrication and checks of the hoist mechanism, cables, and door limit switches. Each month, check that doors hang evenly and seal properly; adjust cable length as needed. Check limit switches for loose mountings, loose wires, loose arms, etc.; check limit switches for proper tripping. Check the hoist gearbox oil level annually, and check operation of the motor and brake.

Temperature Controls. Temperature controllers should be checked at least monthly for calibration, to verify that temperatures are controlled at the set points. Maintenance and calibration of temperature control instruments is difficult and is usually best contracted to firms which specialize in instrument repair and maintenance.

A separate high limit temperature controller is recommended for each zone, to guard against over heating in the event of failure of the primary controller. A temperature recorder is also recommended in order to provide production records of the actual time-temperature curve of each cycle.

As detailed above (page 9-3), temperature surveys of the oven are recommended at least quarterly.

Oven Structure and Insulation. Age ovens are typically constructed as a structural steel framework, enclosed with insulated sidewall and roof panels. The insulated panels contain 4" to 6" of block or ceramic blanket insulation, sandwiched between steel sheets. Panels interlock with the other panels on either side, and all joints are gasketed or caulked for sealing. Air distribution ductwork and/or baffles are installed inside to direct the air supply and return, often using adjustable discharge openings.

Maintenance of the age oven structure requires mainly detection and repair of any hot spots, caused by settling or deterioration of the wall insulation; extreme local temperatures lose energy and may eventually result in structural cracks. In this case, have a sheet metal worker open the shell and re-insulate the affected areas. Likewise, check and repair any damage to the internal dampers, baffles and plenum, usually caused by careless loading of the oven.

Assembly Bolts and Foundation. Check and tighten all bolts annually, that may become loose due to possible vibration or impact loads. Check the condition of the concrete floor.

Profile loading and Conveyors. Routine maintenance depends on the type of container used and the method of loading:

Tracks for guiding cart wheels should be cleaned by sweeping or compressed air and then checked for straightness (monthly).

Wheels or **casters** for basket transport should be checked for alignment or wear, and re-lubricated with high-temperature grease (monthly) unless fitted with lubricated-for-life bushings.

Load cars or **carts** require a monthly check and lubrication of the drive mechanism (gearbox and chain drive) and wheels; clean and check the tracks.

Powered or idle **roller conveyors** also require a monthly lubrication and check of the rollers and drives (where installed); clean and remove any debris in the rollers.

Improving Age Oven Energy Efficiency

When hot air by-passes the oven load, cycle time is increased and energy efficiency is reduced. Therefore, installing interior baffles to reduce by-passing will pay off in energy savings and overall oven capacity, as well as in more uniform temperature and better product quality.

A minimum exhaust from the oven is required by safety codes, especially during the purge cycle. However, any excess exhaust is very costly in terms of energy consumption. To minimize any excess exhaust, be sure that the exhaust damper and/or blower are properly maintained and functioning properly. In case of exhaust by powered blower, contact the oven manufacturer for the minimum exhaust level permitted by codes, and adjust blower speed accordingly.

Also recommended is installation of a main gas meter for measuring the gas consumption of the age oven. The meter should be equipped with pressure-compensation for accuracy. Read the meter weekly and record the total consumption as well as the BTU/pound (or Kcal/Kg). A running plot of these values will provide a good indication of any malfunction of age oven controls or incorrect adjustment of the combustion system.

Another major cause of energy loss is malfunction of the safety vent valve. See recommendations on page 9-8.

The following paper was presented to the 2014 IMEDAL Conference in Puerto Vallarta, Mexico

The Ageing Process for Extruded Aluminum Profiles

by Al Kennedy

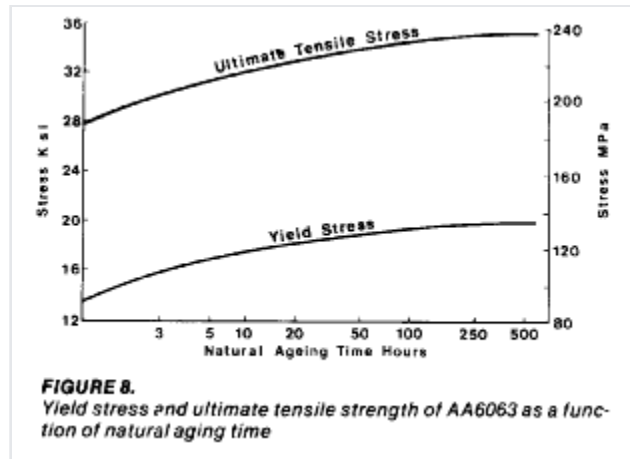
Abstract

Extruded aluminum profiles in the Al-Mg-Si family are typically "aged" in order to improve the mechanical properties of the alloys. Ageing will occur naturally with time, but artificial ageing by heat treatment is preferred because it is not possible to store the production on the floor for long periods. In this paper we review why this process is performed; what equipment is used and how it should be operated and maintained; and what quality tests are used to verify the results of the process.

While this process is often referred to as "age hardening," the desired properties are higher ultimate tensile strength and yield stress. Hardness is a side effect that is discussed because it is more easily measured.

Natural Ageing

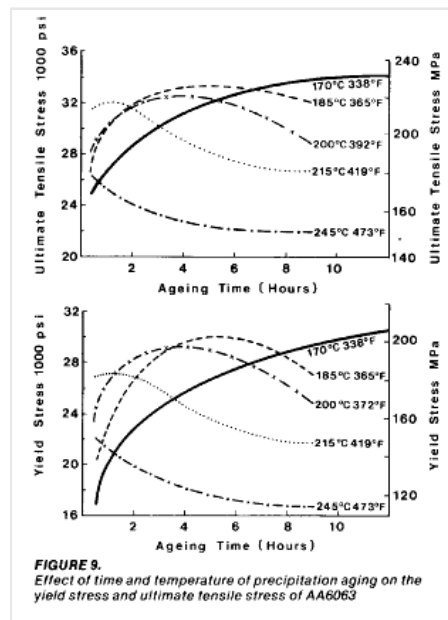
The precipitation process is quite complex and involves the solubility of inter-metallic clusters that precipitate within the alloy. Left at room temperature, the Al-Mg-Si alloys commonly used in extrusions will gain in strength over a period of 100 to 500 hours (illustration⁷).



However, this process of "natural ageing" is not practical due to the logistics problems and time delay. The floor space required for storage for 4 days' production is not practical, and the demand for fast deliveries also will not allow for natural ageing.

Artificial Ageing

Precipitation ageing is accomplished much faster at higher temperatures:



These charts from the paper Precipitation Aging by R.W. Hains show that maximum properties are achieved quickly under controlled temperatures and time. A common process for ageing alloy 6063 is at 185°C for 4 to 5 hours.

7. "Precipitation Aging, R.W. Hains," Extrusion Technology Seminar, Atlanta, 1977.

The Process Cycle and Parameters

From these and similar references it is not difficult to define the ideal process parameters of time and temperature for ageing extruded profiles. Most problems that occur are caused by non-uniformity of temperatures throughout the oven and throughout the load.

Most ageing is done in batch-type ovens with hot air circulation to provide heat transfer by convection. Uniform heat transfer requires that the heated air is in contact with all of the load, and that the air temperature is uniform. These simple rules are often ignored; following are some extreme examples of bad practices.

Loading the Oven



This extruder is ageing bundles of heavy profiles with no space for hot air to pass through the profiles. Note the center bars in each bundle --- how can heat reach these pieces, and how can they reach the same temperature as the pieces on the outside?



All of the heated air passes over the load, not through the load. It will take a very long time for this load to reach temperature.

Notice how these extrusions are spaced to allow room for the heating air to pass through the load to transfer heat. The extrusions are also stacked to the top of the oven, so there is no air by-passing the load over the top of the load.



The baskets have "fingers" to allow separation of the extrusions between layers, which protects the profiles and allows better ageing.

The Cycle: Heat-Up and Soak

The standard procedure specifies a soak time, which begins after the entire load has reached the required temperature. A common specification for the load is to reach temperature within one hour, with an accuracy of ± 3 Co.

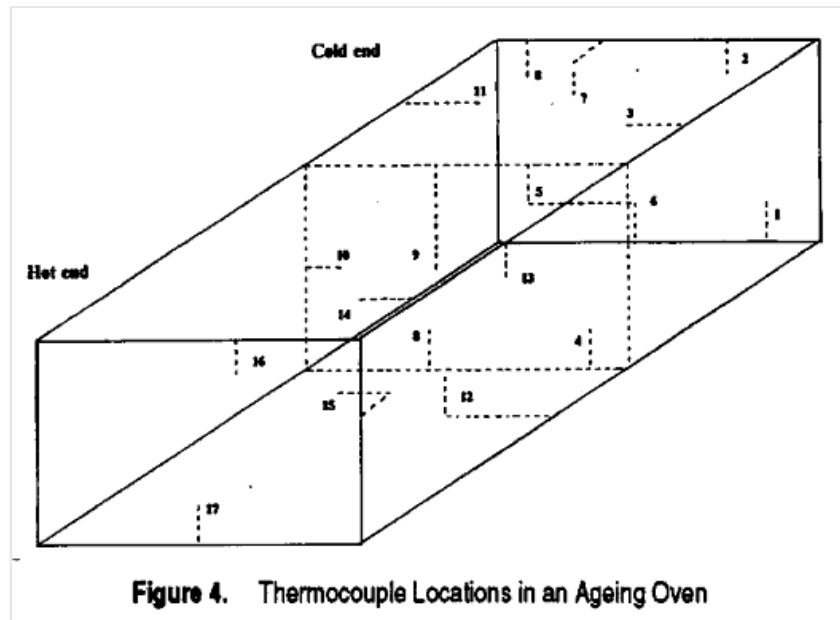
It is important for all of the load to reach temperature before beginning the soak cycle. However, it is not practical to attach thermocouples to all points of the load for every cycle, so it is necessary to know the typical heat distribution throughout the oven. It is more practical to control the cycle by the temperature of the hot air and not by the temperature of the extrusions.

The age oven must be surveyed with thermocouples placed throughout the loads several times in order to learn the characteristics of the oven --- that is, which points are likely to be hottest and which ones less hot. This information tells when the actual soaking cycle can begin.

In some cases where precise ageing is required for some products, these can be placed in the hottest part of the oven.

Temperature Surveys

A new oven must be surveyed to determine its patterns of temperature distribution, and the oven should be re-surveyed periodically, typically at least every year (as recommended by Mr. Ram Ramanan of Alcan⁸). The suggested locations of thermocouples for the survey are shown in the following illustration:



These are suggestions for the first survey, but results may suggest additional locations for later surveys.

The thermocouples may be attached to a multi-point chart recorder, or used with a personal computer through a Multiple I-O plexer interface.

Note that Temperature variations will depend on the loading pattern as well as oven configuration. Very long ovens with end flow are likely to have non-uniform temperatures.

What is the Best Oven Configuration?

Here the engineer has some difficult decisions to make when specifying an age oven:

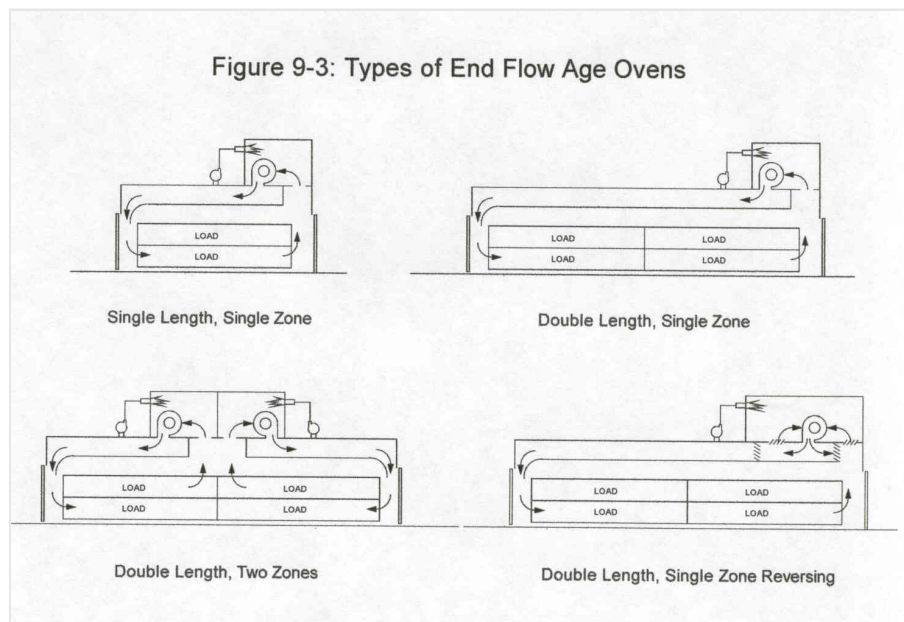
- The longer flow pattern of end flow ovens results in higher efficiency as there is more contact time for heat transfer to the profiles. However,
- The longer the flow direction the greater will be the temperature drop in the hot air, so there is less uniformity.
- With end flow there is usually more opening area in the profiles for hot air to pass through the load.

8. "How to Obtain the Most from Your Ageing Ovens," R. Ramanan and Alain Dery, Proceedings of ET96, Chicago, 1996.

- Cross flow will result in better uniformity of air temperature because of the short travel distance. However,
- Thermal efficiency will be less with cross flow as there is less contact time between hot air and profiles.
- With cross flow there is usually less open space for air to pass through the load and therefore less contact of the hot air with the center part of the load.
- With cross flow, when part of the load profiles are not full length, more of the air can by-pass the load.

What is the best solution? The engineer must evaluate the mix of profiles to be aged and consider how the load will be arranged --- that is, where is space for the heating air to pass through the load and not by-pass it?

The cross-flow design is preferred by some, but my own preference is for end flow with special provisions. To solve the problem of temperature uniformity I recommend that longer end flow ovens be fitted with either multi-zones, or else reversing air flow. To me this is the best of both worlds, and it costs less and requires less floor space.



Of these examples, the double length, single zone has the least uniform temperature patterns.



With a cross-flow oven, loads like this one will not allow hot air to pass through the load. If part of the load is not full length, the hot air may pass around the load instead of through it.

Testing the Results of Ageing

The ageing process is often referred to as "Age Hardening," but the purpose of ageing is not to make the profiles "hard" but to increase the properties of **ultimate tensile strength** and **yield strength**. Testing for these properties requires preparing a sample coupon of a particular shape and testing it in a tensile testing machine. However, testing these properties is difficult and not practical for routine testing on the production floor in most cases. For this reason most extruders use a simple hardness tester such as Webster or Rockwell to confirm the ageing process.

Mr. Bob Werner presented a comparison⁹ of various test methods for quality control of the ageing process. He concluded:

9. "Precision and Accuracy of Several Hardness and Tension Testing Test Methods," Robert I. Werner, ET 84, Atlanta, 1984.

CONCLUSION

The round robin data can provide guidance for extruders who are obliged because of their capabilities to utilize hardness measurements rather than mechanical property (tension) test methods for material evaluations. It is recommended that wherever possible mechanical property test procedures be employed because they are more precise and meaningful.

The ability to identify with precision a -T5 temper versus a -T6 temper is difficult with hardness measurements. While one can discern between -T5 and -T6 with tensile strength property evaluations, it is necessary to perform a chemical analysis to identify different alloys. Tensile strength properties alone are not capable of achieving this separation.

The hardness test method's precision deteriorates significantly with 6063-T5 material due to its relative softness. The Barcol test is the most precise. Second choice would be the Rockwell E method but care is required to avoid the anvil effect. Webster hardness based upon its high relative standard deviation of precision of the test method is not recommended.

Extruders are cautioned to utilize hardness property measurements with care because they are subject to a significantly wider variation than one encounters with tensile strength type measurements.

The tensile strength, yield strength and elongation methods are suitable for more precise evaluation of a material's properties. The various hardness methods, as has been recognized earlier by metallurgists and engineers, are not desirable to be used as the ultimate means of assessment of an alloy's mechanical properties.