

Are Your Kilns In Compliance with NFPA 86 - 2007 Edition?

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Part 1: General Requirements for Fuel Gas Safety Shutoff Valves – Updated **09/11/07**

This series of updated articles is intended to summarize key points of NFPA 86 Standard for Ovens and Furnaces, 2007 edition, limited to the requirements for combustion systems. This article should not be viewed as a comprehensive summary of all NFPA requirements for kiln applications. It is our opinion that ceramic kilns fall within the scope of NFPA 86 as supported by the enumeration of applications governed by NFPA 86 under Annex A.1.1.2. This Standard applies to “new installations or to alterations or extensions to existing equipment”. The Retroactivity clauses may require compliance for existing equipment. It is our opinion that all operating combustion systems should be evaluated and brought into compliance with the current Standards.

Given the complexity and diversity of kilns, this article is not intended to relieve any user or company from taking it upon themselves to gain a thorough understanding of NFPA Codes and Standards and the requirements for compliance of their own operation. As such the authors and The North American Mfg. Co. disclaim liability for any personal injury, property or other damages of any nature whatsoever, whether special, indirect, consequential or compensatory, directly or indirectly resulting from the publication, use of, or reliance on this article.

NFPA 86, Standard for Ovens and Furnaces, 2007 Edition is the current version of the standard addressing the safety aspects of the design, construction, and operation of gas and oil-fired furnaces.

Its Purpose states:

“This standard provides the requirements for furnaces to minimize the fire and explosion hazards that can endanger the furnace, the building, or personnel.”

It defines an “Authority Having Jurisdiction (AHJ)” as *“An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving materials, and installation, or a procedure.”* The AHJ for your location could be your insurer or the local fire marshal, for instance. Whoever it is, the AHJ should be the point of definitive reference for all compliance matters.

The general requirements for fuel gas Safety Shutoff Valves, Ventilation Interlocks, Purge Logic and Interlocks, Fuel and Air Interlocks, Excess Temperature Limit Controller and 1400F Bypass Controller will be outlined in this series of articles along with an overview for continuous and batch kilns. Fuel oil systems have specific requirements that will not be covered.

Safety Shutoff Valves (Fuel Gas)

Section 8.7 has very specific system selection and configuration requirements for the number and type of Safety Shutoff Valves required and emphasizes that;

“8.7.1.1 Safety shutoff valves shall be a key safety control to protect against explosions and fires.”

General SSOV requirements:

- All SSOV's must be Listed for the service intended. (Ref: 8.2.1)
- All SSOV's must be complemented with manual valves for leak tightness tests. (Ref: 8.7.2.3)
- All SSOV's must be tested for leak tightness at least annually. (Ref: 7.5.9)
- Each independently operated burner and/or pilot must be equipped with two (2) SSOV's piped in series. (Ref: 8.7.2.1)
- Each independently operated burner of capacity between 150,000 and 400,000 Btu/hr requires two (2) safety

shut off valves (SSOV) each equipped with open and closed Position Indication. (Ref: 8.7.1.11)

Each independently operated burner of capacity greater than 400,000 Btu/hr requires two (2) safety shut off valves, where one (1) safety shut off valve is equipped with open and closed Position Indication and one (1) safety shut off valve is equipped with open and closed Position Indication and with a Proof of Closure (POC) switch or Valve Proving System. (Ref: 8.7.2.2) Figure A.8.7.2 in NFPA 86 is a very useful illustration.

Key	Safety shutoff valve requirements		
Safety shutoff valve	Under 150,000 Btu/hr	150,000 to 400,000 Btu/hr	Over 400,000 Btu/hr
Safety shutoff valve with visual identification			
Safety shutoff valve with visual identification and proof of closure			

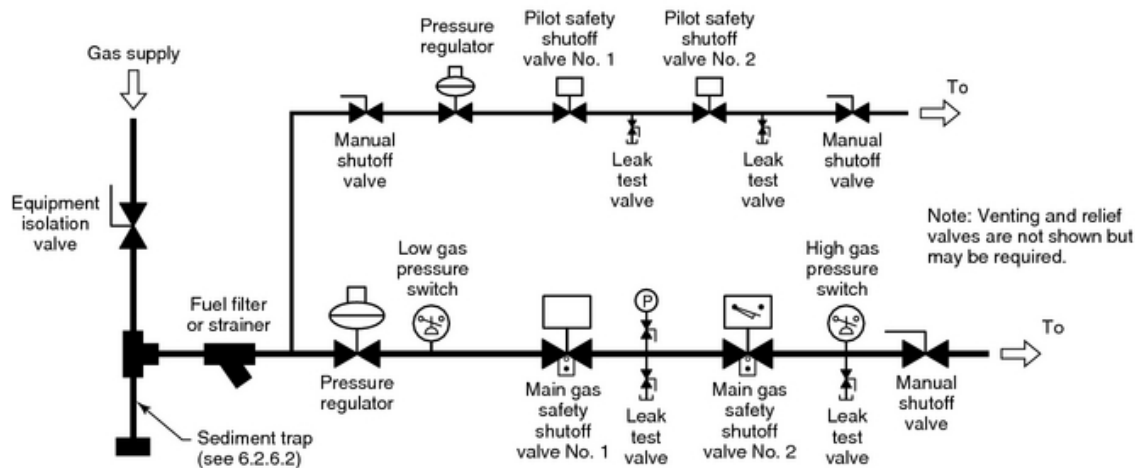


Figure A.8.7.2 Typical Piping Arrangement Showing Fuel Gas Safety Shutoff Valves.

In addition,

- SSOV's must be selected and rated for the design upstream, downstream, and back pressure and ambient conditions. (Ref: 8.7.1.6 & 8.7.1.8 & 8.7.1.9)
- SSOV's must be rated for the pressure upstream of the pressure reducing regulator feeding the SSOV's. (Ref: 7.7.1.10)
- A Closed Position Indicator switch is not accepted as a Proof of Closure Switch. (Ref: 8.7.2.2 (B))
- Valve Proving Systems are permitted but do not relieve the user from the requirement to perform a leak tightness test of all SSOV's at least annually. (Ref: 7.5.9)
- Annex material A.7.5.9(a), A.7.5.9(b) and Table A.7.5.9 provides excellent guidance in conducting leak tightness tests of SSOV's.
- For multi-burner systems, an alternate SSOV arrangement can be used as per 8.7.1.3. The example illustrated below in Figure A.8.7.1.2 identifies a single SSOV equipped with Proof of Closure (POC) switch at each individually operated burner along with a common SSOV equipped with POC switch. If stringent LEL limits cannot be satisfied by the application parameters, this special SSOV arrangement requires the use of additional SSOV supervisory logic. This logic monitors the operation of all POC switches and is designed such that if an individual burner POC switch is not proved closed whenever it is supposed to be closed, then the common SSOV (and all SSOV's downstream) must close.



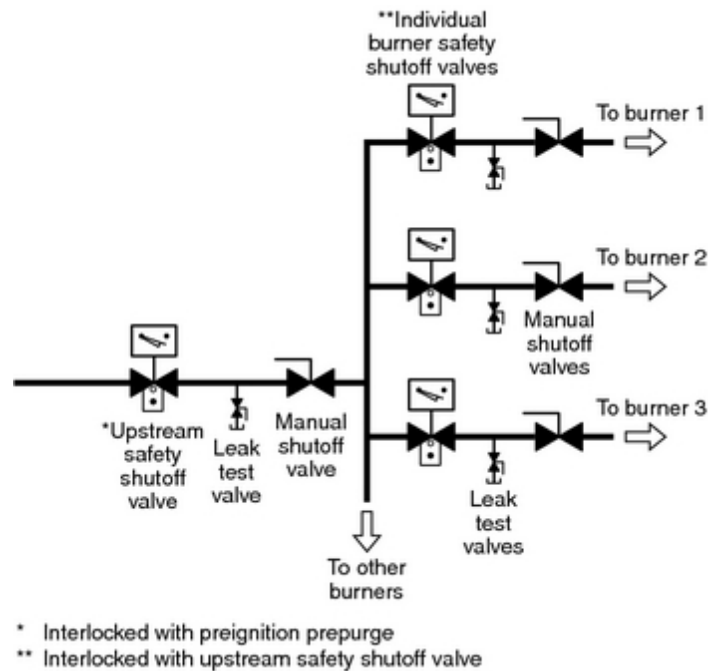


Figure A.8.7.1.2 Multiple Burner System Using Proof of Closure Switches.

It is important to recognize that the implementation calls for the use of Listed Safety Shutoff Valves with Proof of Closure Switch (not Closed Position Indication and not auxiliary switches). "Proof of Closure Switch" is defined in 3.3.64.6 as "Non-field adjustable switch installed in a safety shutoff valve by the manufacturer that activates only after the valve is fully closed."

Safety Shutoff Valves must be supplemented with suitable manual valves and be protected with a sediment trap, i.e. filter/strainer and drip leg. (Ref: 6.2.6 and Figure 6.2.6.2)

- A manual valve (equipment isolation) must be supplied and located remotely so that it can be accessed and turned off in an emergency. (Ref: 6.2.4.1 & 6.2.5.1(A))
- Manual valves must have affixed handles that must indicate the open and closed positions. (Ref: 6.2.5.1.(C) & 6.2.5.1(D))
- Lubricated valves must be lubricated at least annually. (Ref: 6.3.5.1(G))

In addition to the requirement for having the equipment isolation valve described above, NFPA 86 requires that manual fuel valves be closed whenever a furnace is shutdown. (Ref: 8.2.3)

Part 2: General requirements for Combustion System Interlocks - Updated **09/11/07**

NFPA 86, Standard for Ovens and Furnaces, 2007 Edition is the current version of the standard addressing the safety aspects of the design, construction, and operation of gas and oil-fired furnaces. Fuel Gas Safety Shutoff Valves and associated manual valves and leak test provisions were outlined in Part 1 of this series. Part 2 will highlight the general provisions for the combustion systems interlocks.

General Requirements:

- Safety devices must be selected, installed, used and maintained according to the manufacturer's recommendations. (Ref: 8.2.5)
- All safety devices must be inspected and tested at regularly scheduled intervals at least annually. (Ref: 7.5.4 & 7.5.6)
- Operators must be trained in the use of all safety equipment. (Ref: 7.3)



Fuel Gas Interlocks:

- High and low gas pressure switches are required. The high gas pressure switch must be located downstream of the pressure reducing regulator. Settings must be according to the operating limits of the system. (Ref: 8.8)

Combustion Air Interlocks:

- A minimum combustion air pressure or flow interlock is required. (Ref: 8.6.3)
- A combustion air blower motor starter interlock is required. (Ref: 8.6.4)

Safety Ventilation Interlocks:

- Exhaust, Recirculation fan and/or damper interlocks are required. (Ref: 8.5)
- All fans essential to operation have interlocks to prove flow. (Ref: 8.5.1)

Purge Interlocks:

- A minimum purge air flow interlock is required and must be proved throughout the entire purge cycle. (Ref: 8.4.1.2(D))

Excess Temperature Interlock:

- An excess temperature limit controller is required. (Ref: 8.16)

Flame Supervision:

- Flame supervision is required for each pilot and main burner. (Ref: 8.9.2)
- Flame supervision may be bypassed once the combustion chamber is suitably proved to be above 1400F by a listed 1400F Bypass Controller. Unsupervised burners are permitted if suitably equipped with SSOV's and if prevented from operating until the combustion chamber is proven to be above 1400F by a listed 1400F Bypass Controller. (Ref: 8.9.1 (1) & 8.9.1 (3))

NFPA 86 requires that "Safety devices shall be applied and installed in accordance with this standard and the manufacturer's instructions" (Ref: 8.2.2). This is very important in all aspects of Safety Equipment and Application (Chapter 8) and the compliant application of electronic flame supervisory equipment is no exception.

The most commonly used non-self-checking Ultra Violet (UV) flame detectors are subject to failure in either the On or Off state making the required "safe start check" logic very important. (Ref: 8.9.1) Many manufacturers of non-self-checking UV flame detection systems post limits in their recommended hours of continuous service without a "safe start check".

Here are examples of non-self-check UV application requirements from manufacturers and insurers:

- Honeywell UV product literature #60-2026-10 states "The C7027A, C7035A and C7044A Flame Detectors should only be used on burners that cycle on-off periodically or, in the absence of cycling, are periodically checked for proper operation." and clarifies their recommendation in their Amplifier literature #65-0109-7 which states, "Use C7027, C7035 and C7044 Flame Detectors only on burners that cycle on-off at least once every 24 hours.". Honeywell recommends UV tube replacement after 40,000 hours of operation.
- Fireye UV product literature SC-102 recommends the use of self-checking UV systems when the continuous operating interval is greater than 12 hours and does not list a recommended UV tube replacement schedule.
- Protection Controls Inc. Bulletin UV-787R does not list a specific recommendation or operating interval limitation for the use of their non self-checking UV systems and recommends UV tube replacement after 8,000 hours of operation.
- Kromschroder UVS6, UVS8 Product Brochure does not list a specific recommendation or operating interval limitation for the use of their non self-checking UV systems and recommends UV tube replacement after 10,000 hours of operation.



- GE GAP.4.2.0 (formerly Industrial Risk Insurers (IRI) IRInformation IM4.2.0) , which aligns with NFPA 86, states under 7.9.2: "...For furnaces that have burners that continuously operate for more than 24 hours, use only self-checking ultra-violet (UV) flame scanners...."
- FM Global (Factory Mutual) Property Loss Data Sheet 6-9 does not list a specific recommendation or operating interval limitation for the use of non self-checking UV systems.

Flame rod and self checking UV systems offer alternatives to non-self-checking UV systems.

1400F Bypass Controller:

- A properly applied 1400F Bypass Controller can be used to activate unsupervised burners. (Ref: 8.9.1(3))
- A properly applied 1400F Bypass Controller can be used to avoid a re-purge. (Ref: 8.4.1.8(1)) It is our opinion that all fired zones must be suitably proven to be above 1400F in order to apply 8.4.1.8(1).

Part 3: General requirements for Combustion System on Tunnel Kilns - Updated 09/11/07

NFPA 86, Standard for Ovens and Furnaces, 2007 Edition is the current version of the standard addressing the safety aspects of the design, construction, and operation of gas and oil-fired furnaces. Fuel Gas Safety Shutoff Valves and associated manual valves and leak test provisions were outlined in Part 1 of this series. Part 2 highlighted the general provisions for the combustion systems interlocks including flame supervision. This part will outline the compliant use of combustion safety equipment on Tunnel Kilns.

The chart below summarizes the combustion system requirements for a typical tunnel kiln.

Common Interlocks	<ul style="list-style-type: none"> • Electronic flame supervision for all burners operating in a chamber below 1400F. (Ref: 8.9.1(1) & 8.9.1(3)) • A 1400F Bypass Controller may be used to permit the introduction of fuel to burners without flame supervision when the chamber is above 1400F. (Ref: 8.9.1(3)) • Interlocking of auxiliary contacts of motor starters into the safety circuitry for all equipment required for combustion of the fuel. (Ref: 8.6.4) • Flow or pressure interlocks for all fans required for combustion of the fuel. (Ref: 8.5 & 8.6) • Flow interlocks on all flows required for purge proving. Means of minimum-required-flow proving in the exhaust system, if the exhaust system acts to induce air required for combustion of the fuel. (Ref: 8.4) • Permanent and ready means for leak tightness testing for all fuel gas safety shutoff valves (main and pilot). (Ref: 7.5.9) • User supplied regularly scheduled inspection, testing, and maintenance. (Ref: Chapter 7) • User supplied and documented safety inspection and testing at least annually. (Ref: 7.5) • Manufacturer supplied and user maintained operating instructions for startup, shutdown, emergencies, and procedures for inspection, testing, and maintenance. (Ref: Chapter 7) • Excess temperature limit controller(s). (Ref: 8.16) Note: All devices for combustion service safety service shall be "Listed" (Ref: 3.2.4) or "Approved" where Listed devices are not available (Ref:3.2.1).
Fuel Gas Interlocks	<ul style="list-style-type: none"> • High gas pressure switch(s) (Ref: 8.8.2) • Low gas pressure switch(s) (Ref: 8.8.1) • Fuel gas safety shut off valves to requirements of Section 8.7.
Fuel Oil Interlocks	<ul style="list-style-type: none"> • High oil pressure switch (Ref: 8.8.2)



	<ul style="list-style-type: none"> • Low oil pressure switch (Ref: 8.8.1) • Fuel oil temperature switches for preheated oil applications. (Ref: 8.11) • Low atomizing air pressure switch(s) “located downstream from all valves and other obstructions that can shut off or cause excessive pressure drop of atomization media”. (Ref: 8.10) • Oil safety shutoff valves to requirements of Section 8.7.
Other Interlocks	<ul style="list-style-type: none"> • Proof of “through air” flow from cooling zone into the firing zone(s) where primary combustion air supply through burners is below the flow required for stoichiometric combustion of the fuel (or a desired level of incomplete combustion of the fuel in some circumstances). (Ref: 6.5, 8.5 & 8.6)

Kiln Shutdown Cautions:

- It is important to follow the correct shutdown procedures whenever the kiln is shut down, even for short durations.
- Following any shutdown, it must be quickly determined that the fuel to the kiln is stopped simultaneously with the shutdown. The main manual fuel isolation valve(s) is required to be closed immediately following the shutdown. NFPA 86 requires that the operation and leak tightness of the main SSOV’s be tested and documented at the prescribed intervals (and at least annually). We recommend that the SSOV’s be replaced at proper intervals.
- Whenever there is a possibility that there is an indeterminate (and possibly combustible) gas mixture in the kiln, the kiln must be allowed to cool to a temperature that will permit a purge compliant with NFPA 86.

There may be other critical shutdown procedures to be followed, so please refer to and follow the kiln manufacturer’s shutdown procedures.

Kiln Startup:

Once all the required equipment is correctly installed and commissioned, proper procedures must be routinely followed for lighting (introducing fuel into) the tunnel kiln. It is our recommendation that the kiln manufacturer’s operating and maintenance instructions be strictly followed.

The lighting considerations listed below are intended to help the user better understand the many conditions in play whenever lighting a kiln and are not meant to replace the kiln manufacturer’s specific operating instructions.

The range of lighting conditions are COLD START and HOT RE-START.

COLD START

This refers to starting the tunnel kiln when it is being commissioned or after it has been shutdown for a period of time sufficient for any fired zone in the kiln to fall below 1400F.

When shutdown:

- Follow the manufacturer’s shutdown procedure.

Pre-start:

- Follow the manufacturer’s start up procedure.
- Visually check to ensure that all the manual valves in the combustion air supply lines between the blower[s] and the burners are in the open position for purge.
- Visually check to ensure that all the manual valves in the burner or zone fuel supply lines are in the closed positions. Verify that the manual and automatic SSOV’s are closed.
- Start the Exhaust, Cooling and Recirculation fans and Combustion Air blowers in the sequence specified in the manufacturer’s start up procedure. Note: Depending on the location and arrangement of burners equipped with electronic flame supervision, the start up procedure may require specific kiln draft flow conditions to be established during the preheat interval.



- Open the manual (equipment isolation) valve in the main fuel supply to the kiln to permit the Low (Gas or Oil) Pressure Switch to energize.
- If all interlocks are satisfied, the kiln is ready for purging.

Pre-purge:

- Close all the doors on the tunnel kiln. Leaving the charge end door open will allow air to be drawn into the products of combustion exhaust system from outside the kiln rather than through it, diminishing the effectiveness of the purge cycle.
- Start the purge cycle. Purging provides a means of moving fresh air through the kiln to remove any pockets of accumulated combustibles within the kiln that could cause an explosion. The time of purge must be calculated based on the air that is put through the kiln and exhausted. This is normally set to provide five [5] complete air changes before delivering permission to start lighting the burners. NFPA 86 paragraph 8.4.1.2 requires a minimum of four (4) system volume changes. *“The system volume shall include the heating chambers and all other passages that handle the recirculation and exhaust of products of combustion.”* (Ref: 8.4.1.2(B))
- After completion of the purge cycle it is not uncommon to open [at least partially] the doors on the kiln in order to provide pressure relief in the unlikely event that there were some pockets of combustible gases that were not completely removed during the purge cycle. The doors may remain open during the trial for ignition. (Ref: A.8.4.1.1)

Start up Flame Supervised Burners:

- With purge complete, open the main Safety Shutoff Valves and begin lighting the burners in those sections that are equipped with flame supervision.
- Raise the temperatures in these sections as prescribed in the kiln manufacturer’s start up instructions. Follow the established procedures to progressively elevate the kiln temperatures (zone by zone) to be above 1400F.
- Use a compliant 1400F Bypass Controller as a permissive to bring on the fuel to unsupervised burners. The operator should visually inspect the unsupervised burners for proper operation before proceeding to the next zone.

Note: If the kiln is not equipped with compliant SSOV’s and controls as described herein, we recommend that you consult with the kiln manufacturer or your AHJ for specific instructions.

HOT RE-START

This is the abnormal situation when there is a brief interruption of the electrical power supply or interlock trip causing the tunnel kiln to shut down.

Upon Shutdown:

- Follow the manufacturer’s shutdown procedure.

Re-start:

- If it is determined that the main fuel was immediately shut off and there is certainty that there is no accumulated fuel in the kiln, the blowers and fans can be sequentially re-started according to the kiln manufacturer’s start up procedure.
- Visually check to ensure that all the manual valves in the burner or zone fuel supply lines are in the closed positions. Verify that the manual and automatic SSOV’s are closed.
- Pre-position the zone temperature control combustion air valves to the low fire positions.
- A properly applied 1400F Bypass Controller can be used to avoid a re-purge as per 8.4.1.8 (1). It is our opinion that all fired zones must be suitably proven to be above 1400F in order to apply 8.4.1.8 (1) described above.
- With purge complete, open the main SSOV’s and then start lighting the burners in those sections that are equipped with electronic flame supervision. Raise the temperatures in these sections as prescribed in the kiln manufacturer’s start up instructions. Follow the established procedures to progressively elevate the kiln temperatures (zone by zone) to be above 1400F and use a properly designed and listed 1400F Bypass Controller as a permissive to bring on the fuel to unsupervised burners. The operator should visually inspect the unsupervised burners for proper operation before proceeding to the next zone.



Note: If the kiln is not equipped with compliant SSOV's and controls as described herein, we recommend that you consult with the kiln manufacturer or your AHJ for specific instructions.

Summary

The following quote is an excerpt from The North American Manufacturing Company's standard proposal language.

“In the interest of safety, The North American Mfg. Co. joins the NFPA and insurance underwriters in recommending that you maintain and, if necessary, upgrade, your combustion systems to be in compliance with the current applicable NFPA Codes and Standards. The decision to do so rests solely with the User, the User's insurance underwriter and/or the Authority Having Jurisdiction.”

It reflects our long term commitment to working towards a higher level of code compliance in combustion systems among our clients. This article is a further part of our ongoing efforts to educate and inform users of combustion equipment on compliance matters. In addition to highlighting the requirement for the use of electronic flame supervision, this series of updated articles will highlight the general requirements for Safety Shutoff Valves, Ventilation Interlocks, Purge Logic and Interlocks, Fuel and Air Interlocks, Excess Temperature Limit Controller and 1400F Bypass Controller to achieve a compliant combustion system.

Although this article is not intended to be a comprehensive summary of all of the items needed to attain compliance with the NFPA 86 Standard, we hope that you have found it useful in understanding some of the key combustion requirements of the NFPA 86 Standard for your application. We recommend that you purchase a copy of the Standard and continue to work to ensure that all of your heat processing equipment is in compliance.

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