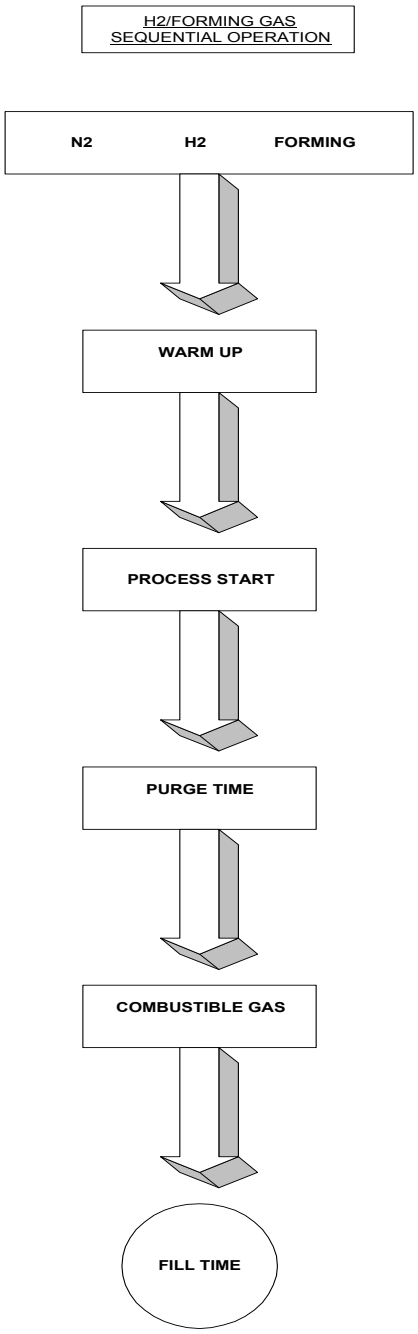

7.4.2. Description

The hydrogen operation system uses existing furnace plumbing and an additional gas flow control system to introduce hydrogen into the furnace chamber. The hydrogen is introduced into the furnace by allowing it to permeate through the porous ceramic fiber insulation, which preheats the gas before it enters the process area.

Entrance and exit baffles, located at each end of the furnace chambers, generate an inert gas curtain which effectively keeps ambient air from entering the furnace chamber and mixing with the hydrogen atmosphere. Venturi assisted exhaust stacks, located in the entrance baffle or in both entrance and exit baffles, draw off the excess hydrogen and direct it into a burner assembly. The excess hydrogen, which is drawn through the exhaust stack, is directed into the burner where it is mixed with ambient air and ignited with a hot wire Igniter.

Figure 7.4.2.1 H2 / Forming Gas Sequential Operation

7.4.2.1. Control System

The hydrogen control system is designed to prevent the possibility of introducing a combustible mixture of hydrogen into the furnace chamber. This is accomplished through logic which requires that nitrogen be run continuously in the exhaust venturis, entrance/exit baffles, furnace chamber, and in the transition tunnel/cooling muffle, if so equipped. The hydrogen control logic provides an automatic timed purge of from 5 to 30 minutes, with nitrogen, before hydrogen is allowed to enter the furnace. Nitrogen and hydrogen pressure switches, together with additional control logic, enhance the safety of the system by requiring that the following conditions be met.

7.4.2.1.1. Nitrogen Pressure

Nitrogen pressure must be present at all times during the purge cycle, as well as during straight hydrogen operation. In the event of nitrogen failure, hydrogen is automatically shut off, and the hydrogen cycle is aborted with alarm and display indication. Only after nitrogen pressure is restored can the cycle be restarted.

7.4.2.1.2. Hydrogen Pressure

Hydrogen pressure must be present during the purge cycle and during straight hydrogen operation. In the event of hydrogen failure, the cycle is aborted and nitrogen flow is initiated with an alarm and display indication. Only after hydrogen pressure is restored can the cycle be restarted.

7.4.2.1.3. Igniter

The hydrogen Igniter element(s) must start when the hydrogen burn-off operation is initiated, and run continuously during the delay cycle, as well as in the steady state. The furnace is manufactured with dual (2) igniters per stack. If both igniters in a single stack fail, the cycle is aborted with alarm and display indication. Manual restart is required to reinitiate the cycle. If only one igniter fails, the process is not aborted, but an alert occurs.

7.4.2.1.4. Seal or Plenum Pressure

Sensing a lack of seal pressure parts puts the machine into heat shut down with alarm and display indication.

7.4.2.2. Gas Flow Control

Gas flow control is accomplished manually with flowmeters. See section 2.12.4 for operating instructions.

7.4.3. Installation Requirements

Hydrogen is a flammable gas and, under certain conditions, it can be explosive. The user of this equipment must take adequate precautions to prevent the escape of hydrogen into the room air and to eliminate possible sources of ignition from the working environment. A common practice is to vent the upper part of the ceiling of the room containing the furnace, and to install a hydrogen leak detector system.

7.4.3.1. The room containing the furnace must be arranged to prevent direct air drafts from hitting the furnace. A direct air draft at the entrance or exit end of the furnace will unbalance the gas curtains and could cause hydrogen to escape into the room, or create an explosive mixture of air and hydrogen inside the furnace.

CAUTION: The flowmeters installed in the control panel are rated for 70 psi maximum; operating beyond 70 psi exposes the operator to possible injury.

7.4.4. Operating Instructions, OPTO22 Control System

7.4.4.1. Process Screen Controls and Indicators (Hydrogen Atmosphere)

Go to Process screen and click on "H_2." Button. Click on "Warm-Up". Wait until the process start light is flashing, and click on "Process Start". This starts an automatic timed purge with nitrogen and lasts from 5 to 30 minutes. When the purge cycle is complete, click on "Combustible Gas On". Nitrogen will be shut off and hydrogen will be turned on.

7.4.4.2. Hydrogen/Nitrogen (Forming Atmosphere)

Go to Process screen. Click on "Forming" button. Click on "Warm-Up". Wait until the process start light is flashing, and click on "Process Start". This starts an automatic timed purge with nitrogen and lasts from 5 to 30 minutes.

When the purge cycle is complete, click on "Combustible Gas On" and hydrogen will be turned on. This starts an automatic timed fill (manual set).

NOTE: Fill is defined as the amount of time required for the combustible gas to enter and fill the chamber cavity. Fill time is factory preset for 5 minutes, and can be user altered.

7.4.4.3. Terminate

Click on "Cooldown" (this returns the furnace to nitrogen operation), or go to Recipe screen and "Load Run" a new recipe.

7.4.4.4. Nitrogen or Manifold Pressure, Low

Low nitrogen pressure is indicated with a message and an audible alarm. The hydrogen operation cycle is aborted, and the machine goes into a heat shut down mode. The cycle cannot be restarted until nitrogen pressure is restored.

7.4.4.5. Hydrogen Pressure, Low

Low hydrogen pressure is indicated with a message and an audible alarm. The hydrogen operation cycle is aborted, and cannot be restarted until hydrogen pressure is restored.

7.4.4.6. Plenum Pressure, Low

Low seal pressure is indicated with a message and an audible alarm. The machine goes into a heat shut down mode and the hydrogen cycle is terminated.

CAUTION: Low plenum pressure can cause damage to the heating lamps. Do not continue to operate the machine with low plenum pressure indication. In the event of low plenum pressure indication, the machine should be shut down until the problem is found and corrected.

7.4.4.7. Igniter Failure

Igniter failure is indicated with a message and an audible alarm. If both igniters in a single stack fail, the hydrogen operation cycle is aborted and cannot be restarted until the igniters are repaired. If only one igniter fails in a single stack, the process is not aborted, but an alert occurs.

7.4.5. Hydrogen Flowmeters

Each of the hydrogen flowmeters is identified with a label as to specific function, and is adjustable from zero flow to full scale by means of an integral control valve. See section 2.12.6.7.i for flow correction factors.

7.4.5.1. Control Knob

Turning this knob clockwise decreases the flow; counterclockwise increases the flow.

7.4.6. Functional Checkout (With Helium)

RTC recommends that a functional checkout of the hydrogen system be made using helium gas for safety. It is further recommended that a trace oxygen analyzer and helium detector be made available for the checkout.

RTC has taken precautions to design the furnace so that it can be safely and reliably operated on hydrogen. However, if the gas flows are not properly set, air can be drawn into the machine, or the furnace atmosphere can be discharged out the entrance or exit, causing a fire hazard. If it is not possible to perform a functional

checkout with helium, RTC recommends, as a minimum, a trace oxygen analyzer and combustible gas monitor be used to guide final process settings.

7.4.6.1. Furnace System Functional Check

First perform the recommended furnace system functional checkout. Correct any malfunctions, as necessary, before proceeding.

7.4.6.2.Helium Supply Gas

Temporarily connect a supply of helium gas to the hydrogen input line and adjust the input regulator to 50 psi. Make sure that the hydrogen flowmeters are completely shut off at this time.

7.4.6.3.Turn On Furnace

Turn on the furnace and bring it up to a fully operational state using the suggested gas flow settings from your operation manual.

7.4.6.4.Initiate the Hydrogen Operation Cycle

Adjust the hydrogen flowmeters to the same flow rates that the equivalent nitrogen flowmeters were set at.

7.4.6.5.Check Oxygen Concentration

Check the oxygen concentration inside each zone of the furnace, using a trace oxygen analyzer. The oxygen concentration can vary considerably, depending on flow settings; but as long as 100 ppm, or less, is maintained in the furnace, combustion will not occur. If the concentration of oxygen is above the 100 ppm limit, increase the flow of helium in small increments and retest the oxygen level. Allow several minutes between gas flow corrections and oxygen testing for the analyzer to stabilize.

7.4.6.6.Check For Escaping Gas

Check each end of the furnace with a helium detector to see if any furnace gas is escaping. If furnace gas escapes, increase the flow to the appropriate eductor in small increments and retest.

The eductor operates with a venturi assisted exhaust stack that produces an approximate multiplication ratio of 10:1. In general, the gas flows into the furnace chamber and baffles should be balanced by the gas flows out of the eductor stacks.

For example, if the total flow of gas into the furnace chamber and end baffles is 1000 SCFH, the flow of gas to each eductor should be as follows for a two exhaust system:

Total Exhaust = 500 SCFH through each eductor

Drive Gas = 50 SCFH to each eductor venturi

7.4.6.7.Nitrogen/Hydrogen Mixing

Selecting the nitrogen/hydrogen atmosphere, with the furnace in the hydrogen mode will unbalance the ratio of input to exhaust gas. This happens because nitrogen is introduced in addition to the volume of hydrogen that is already flowing into the furnace. Before pressing nitrogen/hydrogen mixing, perform the following:

Calculate the volume of helium flowing into the furnace when the machine is running in a balanced condition.

Decide what ratio of helium to nitrogen is to be run and the volume of each gas required.

Select the nitrogen atmosphere mode to return the furnace to nitrogen operation.

Adjust the nitrogen volume to the values calculated in 2.12.6.6. Shut off the hydrogen flowmeters.

Select the hydrogen atmosphere mode, and select the nitrogen/hydrogen mix mode before the purge cycle is complete.

Then adjust the hydrogen flowmeters. The machine should now be operating in a balanced condition, with the proper volume of nitrogen/hydrogen.

Check the oxygen level in the furnace and ends of the furnace for helium, and correct as necessary.

This completes the functional checkout.

Gas Correction Factors

GAS	SP.G
Argon (A)	1.38
Carbon Monoxide (CO)	.966
Carbon Dioxide (CO_2)	1.51
Helium (He)	1.38
Hydrogen (H_2)	.070
Hydrogen Chloride (H_2Cl)	1.59
Hydrogen Sulphide (H_2S)	1.39
Methane (Me)	.553
Natural Gas	.55-.66
Nitrogen (N_2)	.966
Nitrous Oxide (N_2O)	1.52
Oxygen (O_2)	1.103