Fired Heater Start-up

Purge and Leak Test

General

This document describes the purge of the reformer furnace and the leak test of the fuel header system. The furnace is purged with air to ensure that there is no explosive mixture of gases present when the burners are ignited. The leak test should ensure that the individual burner valves are in closed position and not leaking before the primary reformer trip system is reset. The trip system has to be designed so that it is not allowed to reset IS-1 before both purge and leak test has been successfully performed. The trip group I-14, trip of purge gas to burners, must not be allowed to reset before IS-1 is reset.
A brief description of the primary reformer interlock system is given below.
The primary reformer is among others tripped in the following cases:

- At high and low fuel gas pressure.
- At trip of flue gas fan or combustion air blower.
- At high and low pressure in the furnace.

The following automatic actions are among others carried out when the primary reformer trips:

- The fuel gas line is blocked by means of double block and bleed (closing of USV-2541 and USV-2542 and opening of USV-2543)
- The flue gas fan and combustion air blower are stopped in order to protect the reformer furnace from too high draft.
- False air dampers on top of the reformer furnace are opened to avoid overpressure in the furnace due to the chimney effect. In case of a trip, the plant field operators must carry out the following actions:
- Visually check the position of the automatic double block and bleed valves.
- Manually close all the 576 burner fuel valves.

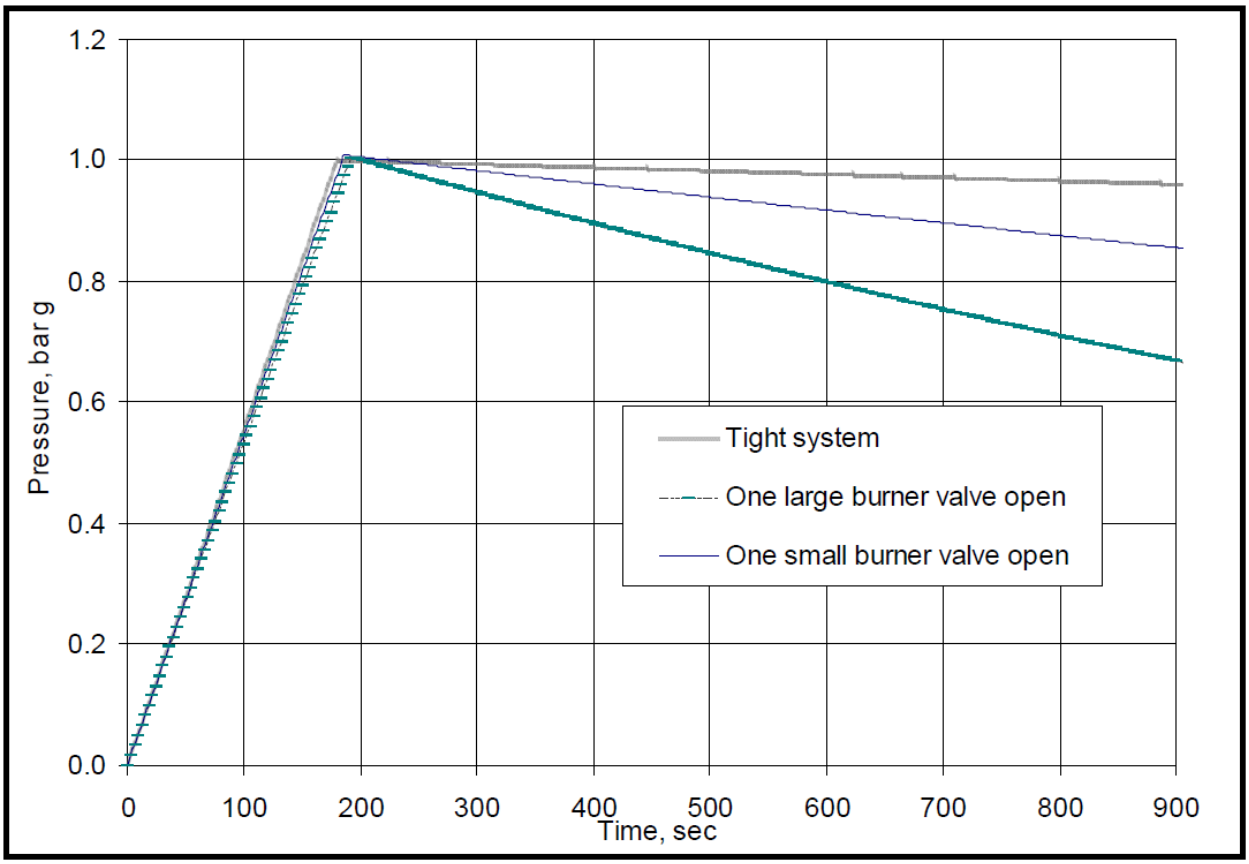
2.Furnace purge system

Before igniting the burners, the furnace must be purged in order to remove any combustible gases inside the furnace. When the plant is ready to be started, the flue gas blower is started and PIC-2224 is set in operation, then the combustion air blower is started and the operator brings the combustion air flow through the furnace above 100,000 Nm3/h, when the flow rate (FIC-2111) exceeds 100,000 Nm3/h the furnace purge timer starts automatically. The purge is to continue for 15 minutes at a flow rate above 100,000 Nm3/h. If the combustion air rate falls below 100,000 Nm3/h, the purge is considered failed and the timer is reset. The principles of the purge and leak test are shown in the flow chart attached as Appendix 1.

3.Fuel header leak test

Before the double block and bleed on the fuel gas line can be reset, a leak test is performed. The leak test prevents that a global explosive atmosphere can exist inside the furnace chambers/WHS before igniting the burners. It is ensured that a possible leakage flow through burner valves unintentionally left open is below the explosion limit.
This is done firstly, by pressurising the fuel header with natural gas to 1 bar g and observing the pressurization rate and secondly, to evaluate the depressurisation for a certain time. If the pressurization rate is too low or the depressurisation exceeds a predetermined value, the leak test has failed and a new fuel header leak test must be performed. If an entire row of burners has been left open it will be detected during the pressurization and the leak test will fail. The holding time at 1 bar g is used to detect if a single burner valve is still open. It is acceptable to use N_2,

and not start the flue gas fan and combustion air blower, for the very first leak test when no natural gas has been introduced to the plant.



In order to avoid an explosive mixture during the test (if some burner valves are unintentionally left open), the flue gas fan and combustion air blower must be kept running with -5 mmWg in top of furnace (PIC-2224). The natural gas flow for pressurisation is restricted by a flow orifice ensuring that the global fuel gas/air mixture will not exceed 50% of the lower explosion limit. PCV 2552 / PG-2552 is set at 3 bar g and the flow rate through the orifice (FO-2552) is 620 Nm3/h. If the flue gas fan and combustion air blower trip or the combustion air flow is lower than 100,000 Nm3/h, the leak test has failed.

3.1 Pressurisation

Pressurisation of the fuel header is performed with natural gas. The operator starts the leak test by pressing a push-button (HS-2550). The double block and bleed (USV-2547/2548/2549) in the 2" natural gas line will then open, and natural gas will flow into the fuel headers. A pressurisation rate of 0.33 bar per minute is foreseen (at PIC-2554), i.e. the fuel header is pressurised to 1 bar g within 180 seconds. If the pressurisation rate is below 0.25 bar per minute (75%), the double block and bleed in the pressurisation line is closed, and the leak test is restarted by the operator when the reason for the low pressurisation rate has been found. (The pressurisation rate for failed leak test must be adjusted during commissioning of the system).

The reasons for slow pressurisation can be:

- Low natural gas supply pressure.
- Blocking of the restriction orifice.
- Burner valves left open.

When the pressure reaches 1 bar, the double block and bleed in the pressurisation line are closed and the pressure test period is started.

3.2 Pressure test

The depressurization timer runs for 12 minutes. If one small burner valve is open after pressurisation, it is estimated that the pressure will drop to about 85% of the starting pressure (in bar g). The leak test fails if the pressure has decreased to 90% of the starting pressure within the 12 minutes. A new furnace purge and leak test is required before the plant can be started. The minimum pressure for a failed leak test must be adjusted during commissioning of the system. If the pressure is above 90% of the starting pressure after 12 minutes, the leak test is successful. The fuel header is depressurized to below 0.1 bar g through the manual vent valves placed at the end of the fuel headers. Only after the successful leak test, the depressurisation and the furnace purge, IS-1 can be reset and the double block and bleed in the fuel gas or NG fuel line may be opened (local reset).

4.Commissioning and maintenance

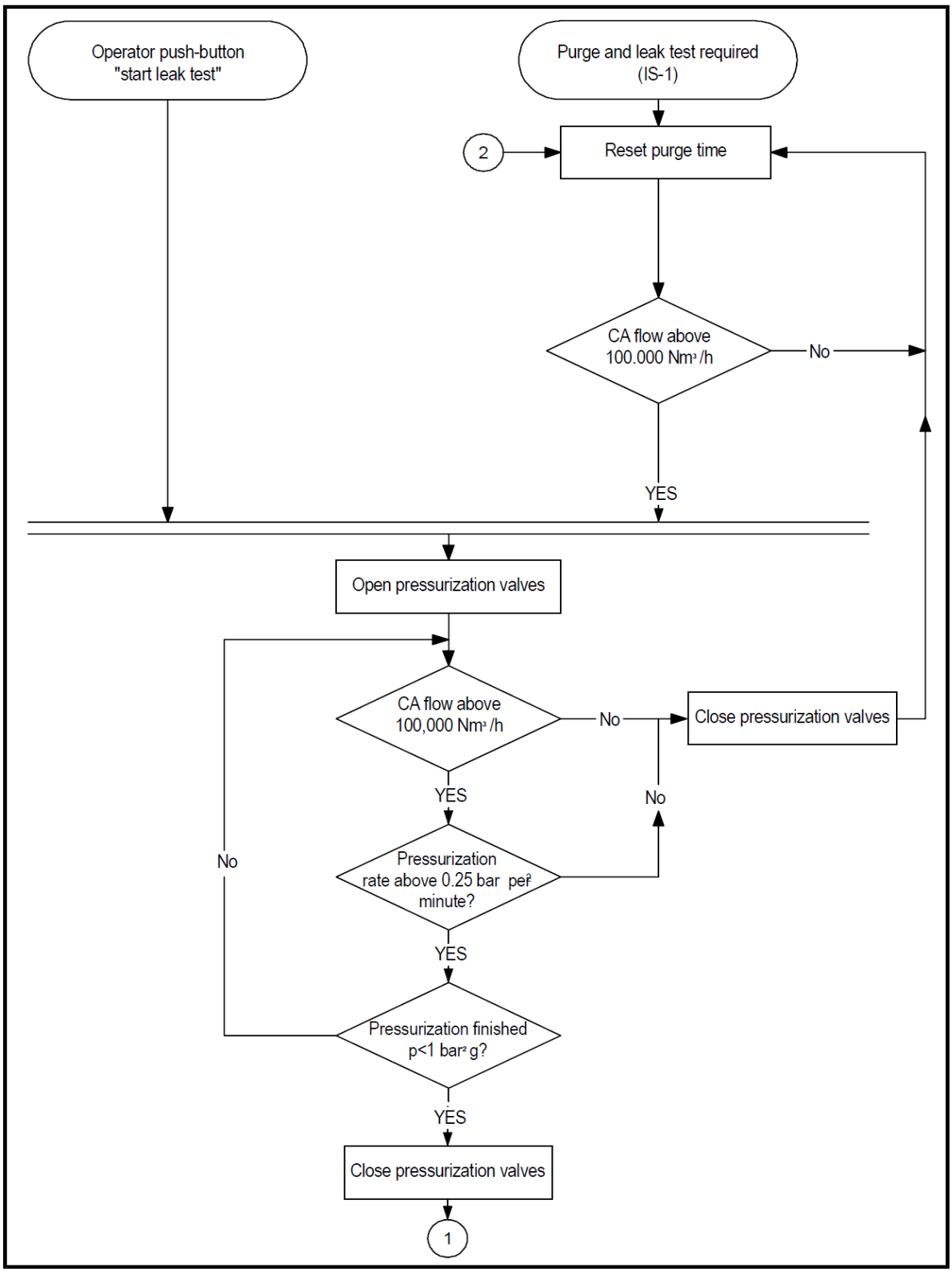
The figures given for pressurisation rate and minimum allowable pressure for the test are calculated values based on an estimate of the volume in the fuel headers. During commissioning of the system, the values must be fixed based on tests. The tests can be performed only after a tightness test of the fuel system.

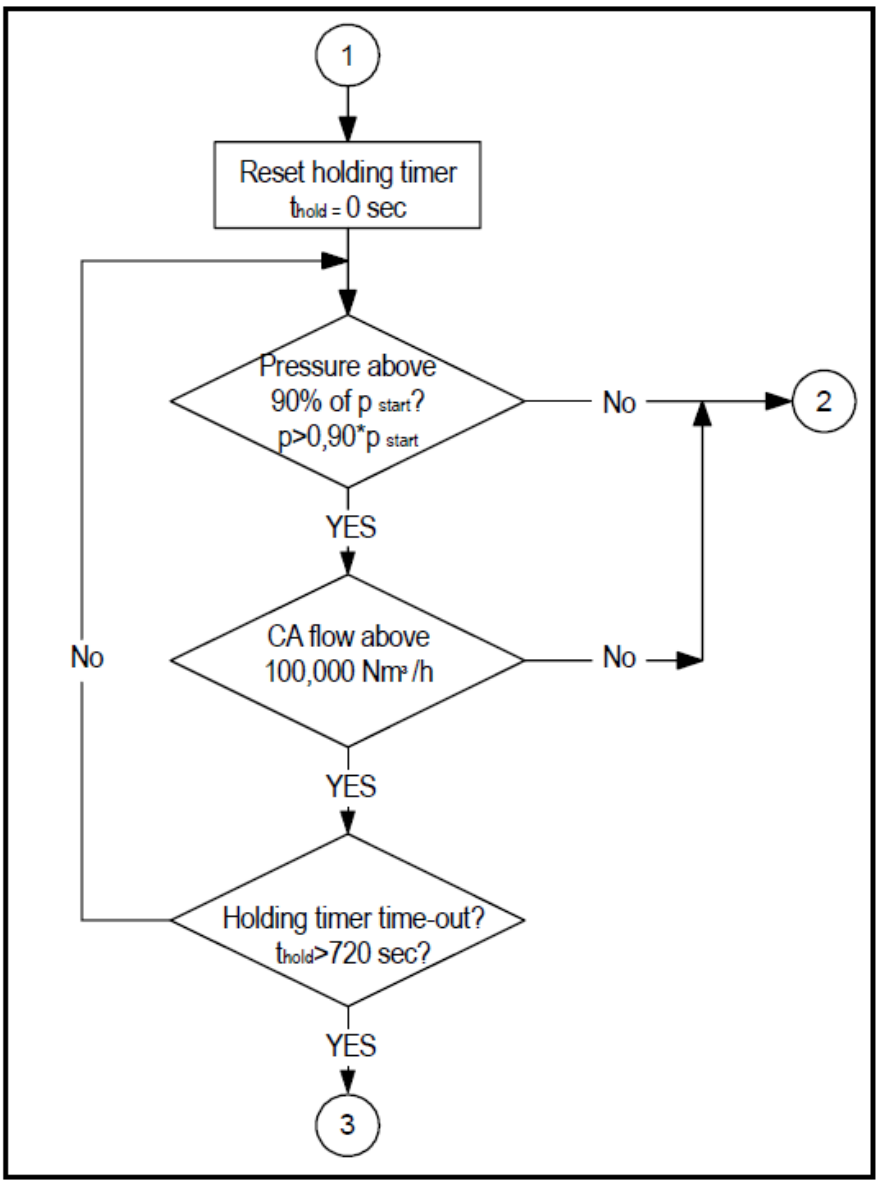
Test of pressurisation rate All burner valves are closed, the pressurisation is started and the pressurisation rate is found: The failure during pressurization is set at 75% of this value.

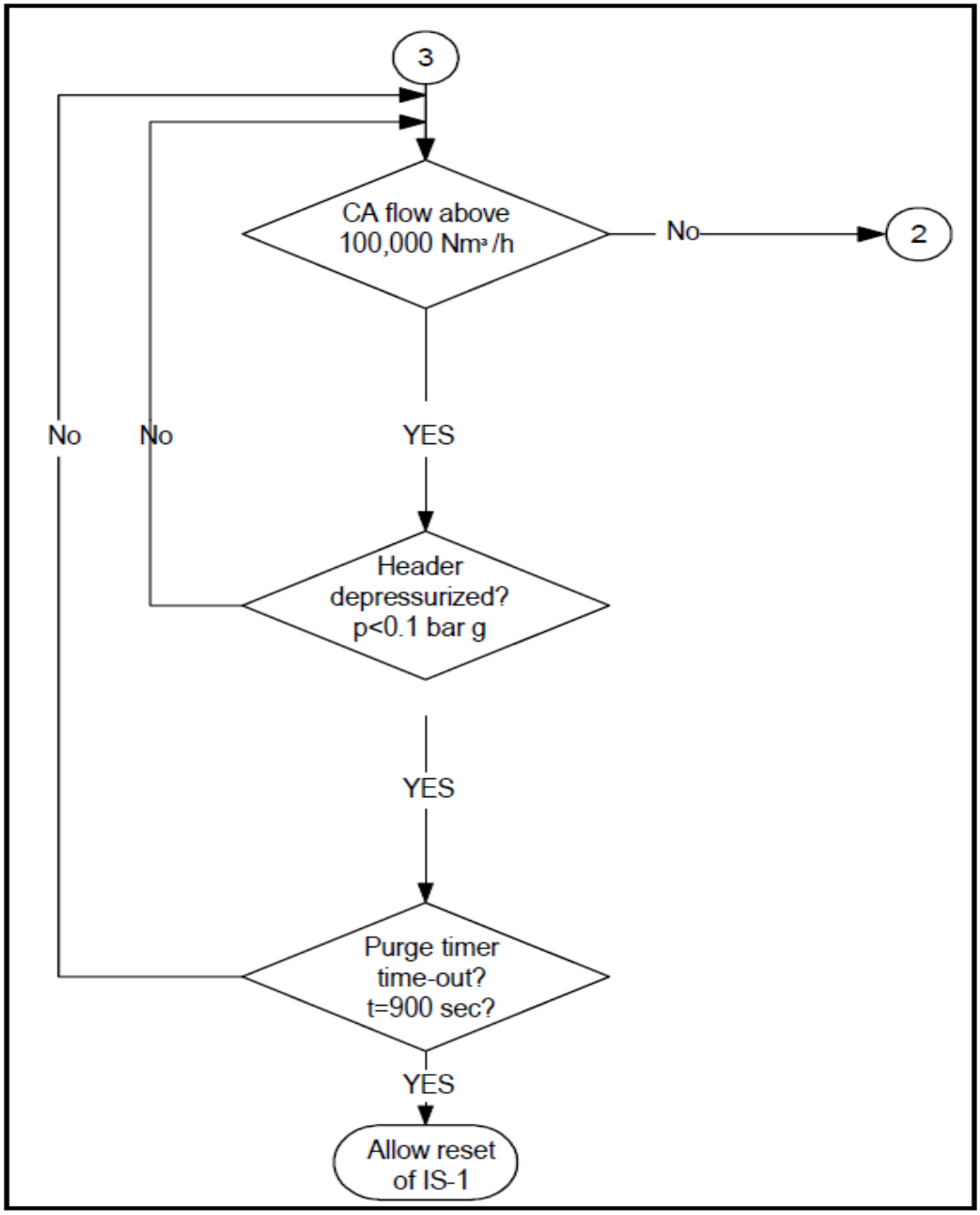
Determining allowable decrease in pressure

All burner valves are closed and the fuel headers are pressurised with natural gas. One small burner valve is opened, the leak test is performed and the pressure drop is found in the course of 12 minutes. The value for a failed test is set 0.05 bar higher than the pressure drop found in the test.

The leak test is repeated with all valves closed in order to verify that the open valves caused the leak. The allowable decrease in pressure with all burner valves closed is less than one fifth of the pressure decrease with one burner fuel valve open. The above tests should be performed on a regular basis, i.e. at each plant turn-around, and the results should be logged.


Operator push-button "start leak test"
Purge and leak test required (IS-1)
2
Reset purge time
CA flow above 100.000 Nm³/h
No
YES
Open pressurization valves
CA flow above 100,000 Nm³/h
No
Close pressurization valves
YES
No
Pressurization rate above 0.25 bar per minute?
No
YES
Pressurization finished p<1 bar g?
YES
Close pressurization valves
1


1
Reset holding timer
thold = 0 sec
Pressure above
90% of p start?
p>0,90*p start
No
2
YES
CA flow above
100,000 Nm³/h
No
No
YES
Holding timer time-out?
thold>720 sec?
YES
3


3
CA flow above
100,000 Nm³/h
No
2
No
No
YES
Header
depressurized?
p<0.1 bar g
YES
Purge timer
time-out?
t=900 sec?
YES
Allow reset
of IS-1

When the headers have been depressurised and the furnace purge is completed, the double block valves in the main fuel header (USV-2541, USV-2542) may be opened and bleed valve (USV-2543) is closed (U01).

Ignition primary reformer burners

The furnace must be purged and the burner tightness test must be completed successfully before the burners may be ignited. A natural gas flow through the HDS unit has been established to protect coils in the waste heat section from over heating, Natural gas is vented through PV-1045. HDS and saturation units are isolated.

Switch the main fuel header pressure controller, PIC-2554 (U01), and the duty controller, QIC-2535 (U01) on manual with an output of 0%. The fuel headers are pressurized and purged through the vent at the top of the reforming section. Keep the vents slightly open, adjust the PIC-2554 output to obtain the minimum burner operating pressure (to be defined during workshop test) and switch the controller to automatic mode. Later, when a number of burners has been ignited and the fuel gas flow is sufficient to enable proper control the vent should be closed.

The burners are lit one by one, starting at row one (bottom row) with uneven numbered burners. Establish a small flow of combustion air by slightly opening the combustion air damper, open the fuel block valve, and ignite the burner. The combustion air damper is adjusted to give the correct flame conditions. A correct flame is blue with yellow tip. If the flame is yellow, the combustion is incomplete and more combustion air is required. A large amount of excess air will give a blue and very clear flame without a yellow tip.

All instructions given by the supplier of the burners must be followed. The flame must always burn along the reformer wall. The flame must never touch the reformer tubes; otherwise, it will damage the tubes. Burners, which cannot be adjusted to give the normal flat flame must be removed and checked in the workshop. The reformer must never operate on reducing flue gas as this will damage the reformer tubes.

During start-up operations, i.e. when operating on natural gas feed at low capacity, the burners should operate with a larger than normal amount of excess combustion air, judged from the color of the flames which should be clear blue without yellow tips. This is necessary to achieve the required flue gas flow. Also, less adjustment (manual) of the air flow will be required when the load and fuel gas flow is increased. The excess air ratio is ensured by watching online analyzer AI-2224 (P13). When more combustion air is required, the set point of FIC-2111 (P11) is increased. It is important to fire symmetrically in both chambers and on both sides of the furnace. In order to have a uniform heat release and even temperature distribution in the furnace chambers it is essential to have as many burners as possible in operation at lower capacity rather than a few burners at higher capacity.

The firing in the reformer is now increased by igniting more and more burners. Initially, 3 burners in each reformer chamber, i.e. 6 burners in total, in row one (bottom row, uneven numbered), are ignited. The heating rate should not exceed 30°C/h, measured in flue gas leaving the reformer furnace (TI-2295 and TI-2297, equipped with high rate of change alarm TDAH-2295 and TDAH-2297 (P15)). Additional burners are ignited 3 at a time, one on each wall in each reformer chamber, until every uneven numbered burner in the bottom row has been ignited. Then the even numbered burners in row number two are ignited, 3 at a time, until every second burner in the

second row has been ignited. The rows three to five should be ignited following the same procedure.

Heating of reformer unit:
The heating in circulating nitrogen is continued until the following conditions have been reached.
Temperature outlet pre-reformer, TI-2268: 400°C
Temperature outlet primary reformer, TIC-2305: 550-650°C
Further, it is to be checked that the firing in the primary reformer is symmetrical by observing the temperatures of the individual outlets collectors, indicated by TI-2303 and TI-2304 (P15). In case of mal-distribution, the firing pattern is to be corrected accordingly.

5.10 Control of heat distribution in the primary reformer
The heat distribution between the radiant and waste heat sections in the primary reformer should be controlled during the heating-up process to avoid exceeding the design temperatures of the coils in the waste heat section.
The heat distribution can be controlled by changing one or more of the following operating parameters:

- the firing profile in the radiant section
- the false air flow into the waste heat section
- the excess combustion air to the radiant section

While maintaining a constant heat input, the heat distribution between the radiant and waste heat sections and the temperature profile in the reformer tubes can be changed by altering the firing profile. By moving the firing downwards in the radiant zone, the heat distribution is shifted from the waste heat section to the radiant section.

By admitting false air into the waste heat section, the heat distribution within the waste heat section will be affected, moving the heat input towards the cold end of the section.
By increasing the combustion air to the burners, heat is moved from the bottom to the top of the reformer tubes and the heat input is shifted towards the waste heat section.