MANUAL

CONTROL SYSTEM AND INSTRUMENTED PROTECTIVE FUNCTIONS FOR FIRED EQUIPMENT
- System for a manually-started, forced draught, multi-burner furnace or boiler (S 24.021)

DEP 32.24.20.37-Gen.

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DESIGN AND ENGINEERING PRACTICE

PREFACE

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NOTE: In addition to DEP publications there are Standard Specifications and Draft DEPs for Development (DDDs). DDDs generally introduce new procedures or techniques that will probably need updating as further experience develops during their use. The above requirements for distribution and use of DEPs are also applicable to Standard Specifications and DDDs. Standard Specifications and DDDs will gradually be replaced by DEPs.

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1. INTRODUCTION

1.1 SCOPE

This new DEP specifies requirements and gives recommendations for control systems and instrumented protective functions for a **manually-started, dual-fuel fired, forced draught, multi-burner furnace/boiler** (i.e. without flame detection). This DEP may also be used for a furnace firing one fuel only, i.e. if the furnace is fired on gas only, all fuel oil related instrumentation may be disregarded, and vice versa. This DEP shall not be used for single burner systems or natural draught furnaces/boilers.

This DEP contains a control and IPF narrative and logic diagrams and refers to a standard specific process engineering flow scheme.

This DEP shall be used together with Standard Drawing S 24.021.

This DEP is written for systems which use DCSs for control and monitoring and PLC or Solid State / magnetic core type Instrumented Protective Functions.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIOP and SIEP, the distribution of this DEP is confined to companies forming part of or managed by the Royal Dutch/Shell Group, and to Contractors nominated by them (i.e. the distribution code is "C", as defined in DEP 00.00.05.05-Gen.).

This DEP is intended for use in oil refineries, chemical plants, gas plants, onshore and offshore exploration and production facilities, and supply/marketing installations.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS AND ABBREVIATIONS

1.3.1 General definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Principal** is the party which initiates, and ultimately pays for, the project. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant, authorised to act for the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Furnace	Includes both furnaces and boilers
Instrumented protective function (IPF)	A function comprising the Initiator function, Logic Solver function and Final Element function for the purpose of preventing or mitigating Hazardous Situations.

NOTE: The term "safeguarding" is not widely used in this DEP because safeguarding relates not only to instrumented protective functions but also to protective equipment of a mechanical nature such as non-return valves, relief valves and bursting disks.

1.3.3 Abbreviations

ARWU	Anti reset wind-up
DCS	Distributed control system
IPF	Instrumented protective function
PEFS	Process engineering flow scheme
PLC	Programmable logic controller
SRF	Standard refinery fuel
TSOV	Tight shut off valve

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced by this DEP are listed in (5).

2. GENERAL

This DEP shall be used as the basis for the control systems, IPFs, narratives, functional logic diagrams and PEFS for the installation for which it has been specified by the Principal.

The Contractor shall prepare installation-specific narratives based on this DEP, and shall add relevant tag numbers, set points, controller configurations, etc. The installation-specific narratives shall not contain general information which is not relevant to the specific installation.

Like this DEP, the narrative shall contain a functional description including operational aspects and a detailed technical description.

3. FUNCTIONAL (OPERATIONAL) DESCRIPTION

3.1 LOAD CONTROL

Flow control is the lowest level of control function for both gas and liquid fuel and for combustion air.

Minimum combustion air flow is ensured by an adjustable mechanical minimum stop on the combustion air damper, while the maximum combustion air flow is limited by the capacity of the blower and air register resistance.

Minimum fuel flows are ensured by minimum stop pressure controllers for both fuel oil and fuel gas, which guarantee a minimum burner load irrespective of the number of burners in operation. Similarly, maximum burner loads are limited by maximum stop pressure controllers.

NOTE: The fuel pressure control limiters do not provide absolute limits to burner loads; with fuel gas, density variations of that gas exert an influence; in (steam-atomised) fuel oil burners, fuel oil temperature and atomising steam pressure likewise exert an influence.

In addition to the minimum stop fuel pressure controllers, the fuel control valves are provided with mechanical minimum stops. These are adjusted to correspond to minimum load with only one burner in operation, and act as a pre-set valve position for start-up of the first burner. In multi-burner installations this valve position may be too low for start-up of the first burner(s), in which case the mechanical stop should be limited to at least 5% valve lift (which gives higher loads at the first burner start-up). Alternatively, the use of parallel control valves (low and high capacity, acting in split-range) should be considered.

Atomising steam for fuel oil burners is controlled at a (constant) pressure differential relative to the burner fuel oil pressure. The furnace load controller (outlet temperature) acts on the fuel and combustion air flow controller set points via a "double-ratio cross-limiting" system. The basic principle is that both fuel and combustion air flows are controlled in parallel, with limits (maximum for fuel, minimum for air) to avoid sub-stoichiometric combustion.

The control system works as follows:

The output signal of the furnace outlet temperature (load) control can be adapted with signals from the furnace inlet temperature and/or the process coil flow in order to add a feed-forward control signal. The resultant signal, which represents the total fuel demand, is then passed to the fuel flow controllers as follows:

- the set point of the fuel gas flow controller is the total fuel demand, minus the (measured) fuel oil flow;
- the set point of the fuel oil flow controller is the total fuel demand, minus the (measured) fuel gas flow.

NOTE: It is part of the design philosophy that only ONE fuel is on cascade load control at any time; the other fuel may be either out of operation or on local set point control, operator adjustable.

The fuel gas flow measurement shall be corrected for changes in gas density or molecular weight (see Section 4.3, Y3). This density compensation compensates for errors in flow measurement and for changes in stoichiometric air requirement.

As the compensated signal also gives a reasonably accurate representation of heat input this signal is also used as input to the fuel flow controller. In this way the fuel gas flow controller indicates a flow in Standard Refinery Fuel (SRF). An additional indication of actual mass flow should be provided for mass balance purposes.

3.2 AIR/FUEL RATIO CONTROL

In parallel to adjusting the fuel flow, the total fuel demand signal passes via the air/fuel ratio relay to adjust the set point of the combustion air flow controller. The required air/fuel ratio can either be manually set by the panel operator, or automatically set by a closed-loop stack oxygen controller. Limits should be set to the range over which the air/fuel ratio can be adjusted, in order to prevent settings that correspond to sub-stoichiometric combustion.

In addition to the basic parallel control system described above, limits are imposed on the adjustment of the set points of fuel and combustion air, as follows:

- The measured fuel oil and fuel gas flows are added (the fuel gas flow being converted to a "fuel oil equivalent" flow, in terms of air requirement) in order to derive the total measured fuel flow. This fuel flow is multiplied by a factor (typically 0.9) and provides a minimum limit (via a high selector) to the total fuel demand signal to be sent to the combustion air flow controller set point. If the total fuel demand decreases, and the actual fuel flows do not react, this signal will limit the decrease in the combustion air flow to prevent sub-stoichiometric combustion. The control system changes from a "parallel" control system to a "fuel-leading" system (fuel decrease leads air decrease) after the high selector has limited the decrease in combustion air flow.

A similar system applies to the fuel flow as follows:

- The measured combustion air flow passes through a "minimum air/fuel ratio" relay (with a setting typically 10% lower than the normal air/fuel ratio), and the signal provides a maximum limit (via a low selector) to the total fuel demand signal to be sent to the fuel flow controller set point. If the total fuel demand increases, and the actual combustion air flow does not follow, this signal will limit the increase in fuel flow demand. The control system changes from a "parallel control" system to an "air leading" system (air increase leads fuel increase) after the low selector has limited the increase in fuel flow.

When only one fuel is in operation small zero errors in the flow transmitter of the fuel not in service can transmit significant errors to the total fuel signal. For this reason, the fuel measurement is set to a hard zero when the TSOV of the fuel concerned is closed (deactivated).

3.3 WASTE GAS FIRING

If the waste gas flow represents more than 15% of the design heat input of the furnace, it shall be taken into account in the load and air/fuel ratio control (i.e. the waste gas flow shall be measured and subtracted from the total fuel demand before it is fed to the fuel flow controllers). Similarly, the measured waste gas flow shall be added to the fuel flow, which is then used in the air/fuel ratio control scheme.

A fixed heating value and stoichiometric air requirement may be used for the waste gas.

If the waste gas flow represents not more than 15% of the design heat input, it may be fed uncontrolled to the furnace provided that the main burners are in operation.

3.4 START-UP

The system described below is intended for furnaces whose dimensions and start-up load are such that a manual start can be performed safely. The Principal shall indicate whether manual start is permitted, on the basis of Trial For Ignition Time calculations and other possible risk factors. Although the system is referred to as a '”manual start system”, some features are automated and/or safeguarded.

The system is equally suitable for start-up on oil as well as on gas.

The system is equipped with an automatic purge sequence. Upon activation of the "purge start" the air damper is opened fully for the period of the purge timer.

After the purge time has elapsed and other conditions are healthy, ignition burners can be started.

A new purge cycle is only required in the event of a combustion air failure. After any other trip a waiting time of 1 minute suffices.

The system is designed such that, for both fuels, the first burner is started upon opening of the main TSOV, i.e. with the burner cock already open. By pressing the reset button the TSOV is opened.

By installing the start and stop buttons close to the observation window of the first burner to be started (preferably a central burner), the operator can watch the flame ignite whilst activating the buttons.

This, in conjunction with the TSOV downstream of the control valve, enables a properly controlled start without the need for start-up overrides and/or operational bleeds to flare or safe location.

During the start of the first burner, the fuel control valve will rest on its mechanical minimum stop, which is adjusted for single burner operation.

Since, prior to start-up, the fuel oil pressure downstream of the TSOV is zero, the atomising steam differential pressure controller can operate automatically, thus giving the correct steam pressure during start-up.

If the first burner does not ignite, the TSOV can be closed by the stop button.

The next burners can be started using the manual burner cocks whilst the operator watches the flame and the fuel and steam/oil differential pressures. Pressure indicators shall be installed in the vicinity of the observation window, indicating measured values from the maximum pressure controllers and the steam/oil differential pressure controller.

Introduction of fuel gas is done in a similar way as introduction of fuel oil, i.e. with the burner cock of the burner to be started open, prior to resetting the fuel gas TSOV.

To ensure that this is the only burner of which the gas cock is open, the other gas burner cocks shall be closed prior to allowing the fuel gas TSOV to be opened.

Upon starting the first burner on gas, the header TSOV opens and the vent TSOV closes. The vent TSOV opens again after the main TSOV closes.

Note: The vent TSOV only acts as a bleed, i.e. it only releases the pressure when the header TSOV is closed.

4. TECHNICAL DESCRIPTION

4.1 IMPLEMENTATION CONSIDERATIONS

Both minimum and maximum fuel gas pressure controllers for both fuels (PIC-1, PIC-2, PIC-3 and PIC-4) shall be locked in auto mode. The operator shall not be able to change the setpoints of the maximum pressure controllers (PIC-2 and PIC-4). The operator may be given limited control over the setpoints of the minimum pressure controllers (PIC-1 and PIC-3) up to 2 times the minimum pressure. The latter flexibility is sometimes useful to prevent flame loss due to too low a pressure when manipulating burners.

The minimum and maximum pressure controllers (PIC-1, PIC-2, PIC-3 and PIC-4) shall be fast-acting (like compressor anti-surge controllers).

If the fuel gas flow controller FRC-1 or fuel oil flow controller FRC-3 is forced to manual with 0% output (minimum stop) the operator shall not be able to change mode or output.

If the QRCA (oxygen controller) is forced to manual it shall retain its last output setting unless manually changed by the operator.

For furnaces with 3 or more burners equal percentage valves shall be used so that the performance of the (minimum stop) pressure controller is independent of the number of burners in operation.

The interfacing between the instrumented protective system and the DCS shall be hard-wired for those connections which are IPF Class II switching functions (no serial link). This applies for example to the force to minimum stop. The reason for this is that a delay (related to the serial link) may ultimately activate a total furnace trip initiator.

The Anti Reset Wind-Up (ARWU) to the fuel FRCs and the minimum and maximum pressure controllers is provided to ensure bumpless transfer when one controller overrides another.

ARWU protection shall also be implemented on the master temperature controller TRC-1 and the oxygen controller QRCA-1.

If neither fuel is on cascade, the TRC output shall be initialised to the total fuel flow.

If the combustion air is not on cascade, the oxygen QRC output shall be initialised to the (current) air/fuel ratio.

If the chosen DCS/controller algorithm supports the use of external feedback as ARWU protection then external feedback can be configured from Y10 to QRCA. This external feedback improves the response of the oxygen QRCA during changes in load of the furnace. The principle behind this external feedback is as follows:

If the load of the furnace is reduced and the air flow is reacting more slowly than the fuel flow (due to parallel lead/lag control configuration), the external feedback ensures a minimum overshoot. If there were no external feedback, the QRCA would react to the excess air and further reduce the air, thereby resulting in an overshoot when approaching the final steady state value.

If the control scheme is implemented in a DCS which does not support external feedback (i.e. only ARWU is used), the QRCA should be tuned to slow response to minimise the overshoot during transients.

The control scheme is not designed to operate with both fuel flow controllers in cascade mode, due to possible interaction between the two loops. Therefore, when switching over between cascade and automatic modes, both flow controllers should be placed in automatic mode. However, it is recognized that this alone does not ensure a bumpless transfer and therefore the appropriate initialisation techniques shall be configured.

4.2 LOCATIONS OF ALARMS, SWITCHES ETC.

The start system requires one dedicated "first burner to be started".

Whenever possible, the central burner in the group shall be selected for this purpose (i.e. in a 3-burner furnace it shall be the centre burner).

If the above is not possible (e.g. in a 2-burner furnace), the burner which is located closest to the control and TSOVs should be selected.

The start and stop buttons (to open and close the fuel TSOVs) shall be located close to the observation window of the "first burner to be started".

The fuel valve selector switch shall be installed close to the TSOVs.

The fuel oil and gas maximum pressure controllers and the steam/oil differential pressure controller shall be provided with suitable indicators installed so as to be visible to the person operating burner cocks.

The burner cocks shall be installed so that the operator can manipulate them whilst watching the flame.

4.3 CALCULATION FORMULAE

The following computing formulae shall be used:

Y1) If the fuel oil TSOV is closed, the oil flow signal to the total fuel flow summer is zero (Y5, Y6).

NOTE: The measured value is still fed to the fuel oil FRC, so that the operator is informed about possible measurement offsets prior to introducing oil.

Y2) If the fuel gas TSOV is closed, the gas flow signal to the total fuel flow summer is zero (Y4, Y6).

NOTE: The measured value is still fed to the fuel oil FRC, so that the operator is informed about possible measurement offsets prior to introducing gas.

Y3) Corrects fuel gas flow measurement for fuel gas density, and (optionally) for pressure and temperature at the transmitter, and converts that signal into an SRF-equivalent flow.

The actual formula to be used depends on the type of flow meter (vortex or orifice type) as well as the type of density meter (line density or Molecular Weight).

In setting up the actual formulae, the following equations shall be used:

$$M_{\text{air stoichiometric}} = 14.77\left(1 + \frac{2.68}{MW}\right) * M_{\text{fuel gas}} \qquad [t / d]$$

$$\text{Fuel gas density} = 12.03\left(\frac{MW * P}{T}\right)$$

where:

P = Pressure, bar (abs)

T = Temperature, °C

$$M_{\text{fuel SRF}} = \frac{M_{\text{air stoichiometric}}}{13.66} \qquad [tSRF / d]$$

The above formula assumes typical refinery fuel gases, i.e. mixtures of paraffinic hydrocarbons and hydrogen (with inerts less than 2%) and is only valid for MW > 5.

It further assumes the stoichiometric air requirement of SRF to be constant at 13.66 kg air/kg SRF.

If the anticipated Molecular Weight (MW) variations are less than ± 20% of the average molecular weight, a fixed (average) value for MW may be used.

Y4) Output = required (total) fuel flow - gas flow - waste gas flow [t/d SRF]
(see Note 1)

Y5) Output = required (total) fuel flow - oil flow - waste gas flow [t/d SRF]
(see Note 1)

Y6) Output = gas flow + oil flow + waste gas flow [t/d SRF]
(see Note 1)

NOTE 1: Waste gas flow shall only be incorporated in calculations if the heat input by waste gas represents more than 15% of the total design heat input.

Y7) Sets a minimum limit for the combustion air flow.
Output = 0.9 * Total fuel flow

Y8) Calculates a maximum allowable fuel flow.

Output = M_{air} / (0.9 * 13.66 * [0.8 + 0.8 * QRC]) ;

in which: QRC = Output of oxygen controller [signal 0-1]

M_{air} = Measured air flow [t/d]

The formula limits the air/fuel ratio between 0.8 and 1.6.

Y9) Calculates the required air flow.

Output = Fuel flow * 13.66 * [0.8 + 0.8 * QRC]

in which the fuel flow is the master signal or (0.9 * total fuel flow), whichever is higher.

The formula limits the air/fuel ratio between 0.8 and 1.6

Y10) Calculates air/fuel ratio for low alarm and trip.

Output = M_{air} / (13.66 * Total fuel flow) ;

Alarm shall be set at a ratio of 1.0.
Trip to minimum firing shall be set at 0.8.

The total fuel flow shall be given a minimum value to avoid "division by zero", which can give spurious alarms when the furnace is out of operation.

Calculation blocks for (optional) feed-forward (see Note)

- For feed-forward from process flow through furnace:

NOTE: Anti-reset wind up of TRC is always required.

Y12) $$\text{Output} = \frac{[\text{fuel flow}]}{[\text{process flow}]}$$

Y13) Output = [process flow] * [TRC output]

- For feed-forward from process flow and furnace inlet temperature:

Y12) $$\text{Output} = \frac{[\text{fuel flow}]}{[\text{process flow}]} + k * [\text{inlet temperature}]$$

Y13) Output = [process flow] * {[TRC output] - k * [inlet temperature]}

$$\text{where } k = \frac{[\text{Specific heat process fluid}]}{[\text{fuel LHV}] * [\text{furnace efficiency}]}$$

Y14) Output = DeltaP + k1 * (P_{oil} + k2)

where k1 and k2 are constants with initial setting k1 = 0 and k2 = 0

Y15) Output = DeltaP - k3 * (P_{oil} + k4)

where k3 and k4 are constants with initial setting k3 = 0 and k4 = 0

Y16) Low selector to set a maximum to the signal to the fuel flow controllers.

Y17) High selector to set a minimum to the signal to the air flow controller.

4.4 DESCRIPTION OF INSTRUMENTED PROTECTIVE FUNCTIONS

The IPFs are described by the functional logic diagrams (Appendix 1) and by the IPF narrative given below.

The functional logic diagrams are set up in a modular structure. This section follows the same structure but only describes the main modules. Auxiliary modules such as the "general trips" module are not described separately. Their functionality is described in the modules where they are relevant.

4.4.1 Safe atmosphere module

The function of this module is to continuously check for, and if necessary re-establish by purging, a safe atmosphere for firing the furnace.

If: i. the combustion air flow is not low; and

ii. the fuel oil and fuel gas header TSOVs are closed; and

iii. the local and panel trip switches are in the healthy position; and

iv. the "safe conditions" signal is not present; then

the purge sequence can be started by activating the "start purge" switch.

This initiates the full opening of the common air damper via a signal to the DCS. As soon as sufficient air flow for the purging is available, the purge timer starts running.

If there are no disruptions of the above conditions and after the timer has run out, a purge ready indication is given and the combustion air damper is placed back under flow control (under cascade).

If: i. the purge is completed; and

ii. the combustion air flow is not low; and

iii. the local and panel trip switches are in the healthy positions,

a "safe conditions" signal is given to the fuel TSOV modules and to the igniter modules.

If during normal furnace operation any one of the above conditions fails, the safe conditions signal disappears. Then a complete new purge is required.

As long as the "safe conditions" signal is healthy, the power to the ignition burner sockets is switched on, i.e. igniters cannot be started if there is no safe atmosphere.

4.4.2 Minimum stop module

The purpose of this module is to control the set and release of the fuel minimum stops.

If: i. the "not minimum firing" signal from the process is present (where applicable) and

ii the air/fuel ratio is healthy; and

iii. the module receives a "gas TSOV open" signal; and

iv. the fuel gas pressure is not above "high-high"; then

the fuel gas FRC can be taken into operation by activating the gas minimum firing reset in the control room.

If the fuel gas pressure is not below twice the set pressure of the minimum stop the module produces a "failure trip to minimum firing" signal to the fuel gas header module.

If: i. the "not minimum firing" signal from the process is present (where applicable); and

ii the air/fuel ratio is not low; and

iii. the module receives an "oil TSOV open" signal; and

iv. the fuel oil pressure is not above "high-high"; then the fuel oil FRC can be taken into operation by activating the oil minimum firing reset in the control room.

If the fuel oil pressure is not below twice the set pressure of the minimum stop, the module produces a "failure trip to minimum firing" signal to the fuel oil header module.

4.4.3 Igniter module

The function of this module is to monitor the conditions to allow power to be supplied to the igniter power sockets.

When the "safe conditions" signal is available, the power to the igniter sockets is automatically switched on.

The power supply is interrupted for a period of one minute after closure of any of the fuel TSOVs.

During this period a "start inhibit" signal is given to the fuel oil and fuel gas TSOV modules.

Additionally, a "start inhibited" status indication is given both locally and in the control room.

4.4.4 Fuel oil header module

The function of this module is to monitor all the conditions required to open and close the fuel oil header TSOV and to control this valve.

If:
- i. the safe atmosphere module produces the safe atmosphere signal; and
- ii. other process conditions (process trips) are healthy; and
- iii. the fuel oil pressure is not low; and
- iv. the atomising steam/oil differential pressure is not low; and
- v. the atomising steam/oil differential pressure is not high; and
- vi. the stop oil firing switch is not activated; and
- vii. the "(NOT) failure trip to minimum stop" signal is healthy; and
- viii. the fuel oil control valve is in the start position (start permissive only); and
- ix. the module does not receive the "(not) start inhibit" signal from the igniter module (start permissive only); then:

a “healthy for oil firing” indication is given. Then the oil TSOV can be opened by pushing the oil reset button, which is mounted close to the observation window of the dedicated “first burner to be started”.

At the same time the output of the oil flow meter is incorporated in the firing and air/fuel ratio control.

The oil TSOV can be closed by pushing the local stop button, which is mounted next to the reset button.

Upon closing the oil header TSOV, the output of the oil flow meter ceases to influence the furnace controls.

If the fuel oil TSOV proximity switch (GBSA-05) does not indicate that the valve has closed within 15 seconds after initiating the valve to close, an “oil TSOV closing failure” alarm is given.

If the fuel oil control valve proximity switch (GBSA-06) does not indicate that the valve is in its start position within 15 seconds after initiating the oil TSOV to close, an "oil control valve not in start position" alarm is given.

4.4.5 Fuel gas header and vent module

The function of this module is to monitor all the conditions required to open and close the fuel gas header and vent TSOVs and to control these valves.

There are two parallel TSOVs to facilitate tightness testing during operation. By means of a selector switch either gas header A or gas header B can be selected to be in operation.

If:
- i. the safe atmosphere module produces the "safe conditions" signal; and
- ii. other process conditions (process trips) are healthy; and
- iii. the fuel gas pressure is not low; and
- iv. there is no high level in the fuel gas KO drum; and
- v. the stop gas firing switch is not activated; and
- vi. the "(NOT) failure to minimum stop" signal is healthy; and
- vii. (NOT) all burner cocks are closed; and
- viii. all burner cocks are detected closed except the dedicated start-up gas burner cock (start permissive only); and
- ix. the fuel gas control valve is in the start position (start permissive only); and
- x. the module does not receive the "(not) start inhibit" signal from the igniter module (start permissive only); then:

a “healthy for gas firing” indication is given. Then the pre-selected gas TSOV can be opened by pushing the gas reset button, which is mounted close to the observation window of the dedicated “first burner to be started”.

At the same time, the gas vent valve is closed and the output of the gas flow meter is incorporated in the firing and air/fuel ratio control.

The gas TSOV can be closed by pushing the local stop button, which is mounted next to the reset button.

Upon closing the gas TSOV the output of the gas flow meter ceases to influence the furnace controls and the vent valve is opened.

If the vent TSOV proximity switch (GBSA-009) does not indicate that the valve has closed within 15 seconds after initiating the valve to close, an alarm is given.

If the gas TSOV proximity switch (GBSA-02/03) does not indicate that the valve has closed within 15 seconds after initiating the valve to close, an alarm is given and any further ignition burner starts are inhibited.

If the fuel gas control valve proximity switch (GBSA-01) does not indicate that the valve is in its start position within 15 seconds after initiating the oil TSOV to close, a "gas control valve not in start position" alarm is given.

4.4.6 Waste gas firing module

The function of the waste gas firing module is to monitor all conditions required to open and close the waste gas TSOV(s) and to control this (these) valve(s).

If:
- i. the module receives a "furnace NOT on minimum stop" signal; and
- ii. there is no high level in the waste gas KO drum (if applicable); and
- iii. the fuel gas flow OR the fuel oil flow is above 25 % of design; and
- iv. the waste gas firing stop button is not activated; then:

the waste gas TSOV to the furnace can be opened by activating the waste gas reset button. Usually the waste gas TSOV to the furnace is operated in conjunction with a vent TSOV (i.e. the vent TSOV is automatically opened if the furnace TSOV is closed).

If the waste gas flow represents more than 15 % of the design heat input, the waste gas flow shall be added to the total fuel flow measurement (only when the waste gas TSOV is opened; when the TSOV is not open, the flow indication shall still be available to inform the operator of possible measurement errors).

4.5 IPF CLASSIFICATION AND CAUSE AND EFFECT DIAGRAM

The Instrumented Protective Functions discussed in (4.4) have been classified and implemented in accordance with DEP 32.80.10.10-Gen. The classification results are indicated in the cause and effect diagram (Table 1).

The notes applicable to Table 1 are as follows:

1) - = No action

0 = Unclassified, but serves purpose in sequence control

II = IPF class II

III = IPF class III

IV = IPF class IV

2) It is assumed that if the (process I) trip to minimum firing fails to operate, a process II trip is automatically initiated (e.g. if an outlet temperature remains too high for too long a period).

3) High fuel pressure only initiates a total trip in case of failure of trip to minimum firing.

4) (Not) oil or gas TSOV open signal inhibits for 60 seconds the starting of ignition burner and re-opening of TSOVs

Table 1 Cause and effect diagram

Initiators		Actions 1)							
TAG	Service	Abort/ Inhibit start sequence	Header fuel oil TSOV close	Trip to minimum firing fuel oil	Header fuel gas TSOVs close	Vent fuel gas TSOV open	Trip to minimum firing fuel gas	Switch oil flow meas. to zero	Switch gas flow meas. to zero
FZA-01-LL	Combustion air	-	IV	0	IV	II	0	-	-
FZA-02-L	Combustion air (for purging)	III	-	-	-	-	-	-	-
XZA-01-LL	Air/fuel ratio	-	-	II	-	-	II	-	-
PZA-01a-HH	Fuel gas	-	-	-	-	-	II	-	-
PZA-01b-H	Fuel gas	-	-	-	IV 3)	II 3)	0 3)	-	-
PZA-03a-HH	Fuel oil	-	-	II	-	-	-	-	-
PZA-03b-H	Fuel oil	-	IV 3)	0 3)	-	-	-	-	-
HZA-01/02	Manual trips	0	IV	0	IV	II	0	-	-
LZA-01HH	Fuel gas KO drum	-	-	-	IV	II	0	-	-
GBSA-01-S	Fuel gas control valve in start position	III	-	-	-	-	-	-	-
GBSA-02/03-C	Fuel gas header TSOVs closed	III	-	-	-	-	-	-	-
GBSA-06-S	Fuel oil control valve in start position	III	-	-	-	-	-	-	-
GBSA-05-C	Fuel oil header TSOV closed	III	-	-	-	-	-	-	-
Process I	General process trips 2)	-	-	II	-	-	II	-	-
Process II	General process trips	-	III	0	III	II	0	-	-
GBSA-14-C	Vent TSOV closed	-	-	-	-	-	-	-	-
GBSA-14-n4-C	Gas burner TSOVs closed	III	-	-	0	-	0	-	-
(Not) Oil TSO open		III 4)	-	-	-	-	-	II	-
(Not) Gas TSO open		III 4)	-	-	-	-	-	-	II
PZA -02-LL Fuel gas		0	-	-	IV	II	0	-	-
PZA-04-LL Fuel oil		0	IV	0	-	-	-	-	-
XZA-03-HH Atom. steam		0	IV	0	-	-	-	-	-
XZA-04-LL Atom steam		0	III	0	-	-	-	-	-

5. REFERENCES

In this DEP, reference is made to the following publications:

NOTE: Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Classification and implementation of instrumented protective functions	DEP 32.80.10.10-Gen.

STANDARD DRAWING

Fuel-oil and fuel-gas system for a manually started forced draught multi-burner furnace/boiler	S 24.021

APPENDIX 1 FUNCTIONAL LOGIC DIAGRAMS FOR A MANUALLY STARTED, FORCED DRAUGHT MULTI-BURNER FURNACE

Furnace safeguarding logics for a manually started, forced draught, multi burner furnace.

References:

S24.021:
Fuel oil and fuel gas system for a manually started, forced draught, multi burner heater or boiler.

Note:
When these logics are used for a single fuel system, e.g. gas only, the relevant fuel oil signals must be disregarded / deleted where applicable.

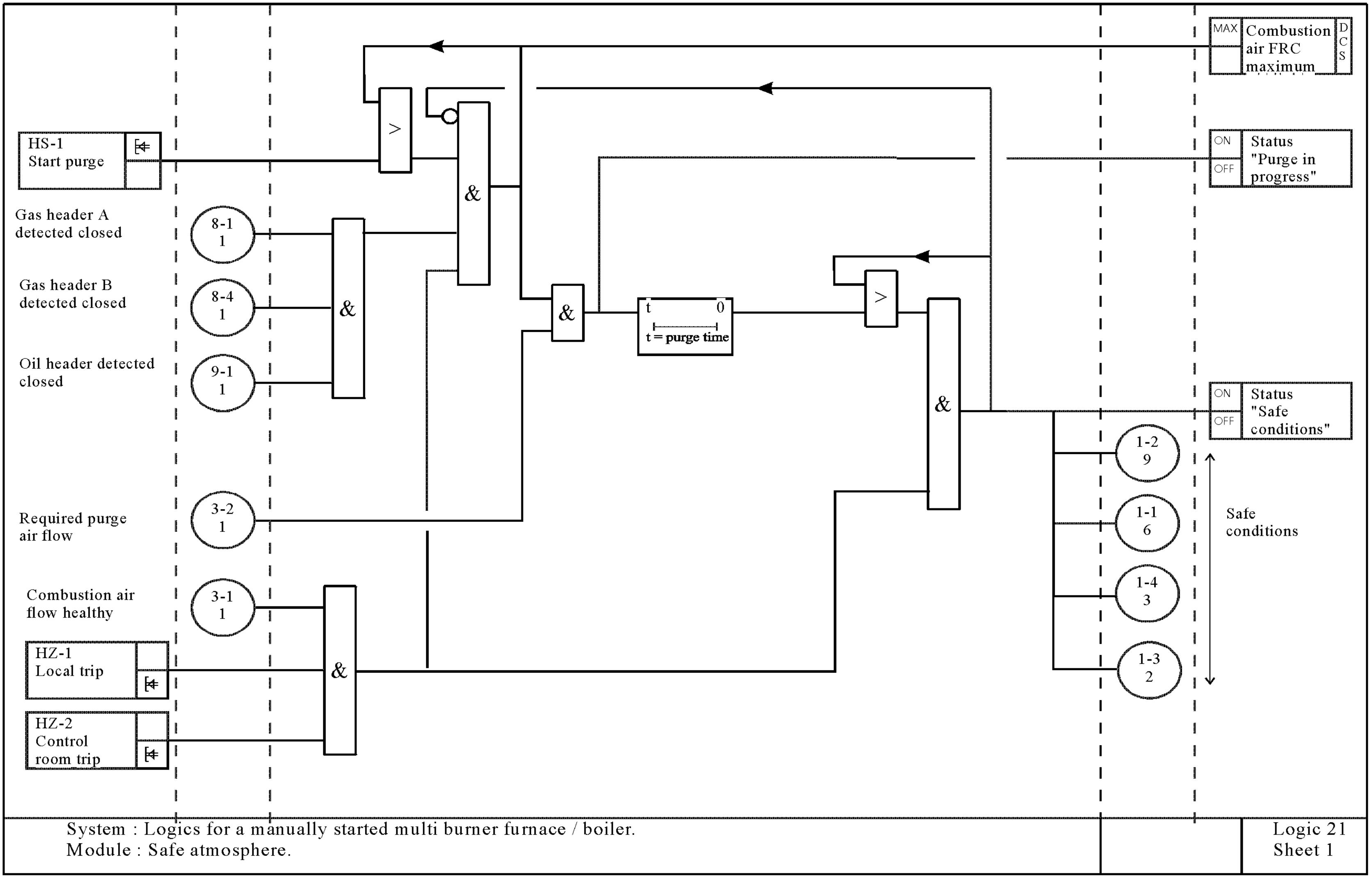
Sheets:

1. Safe atmosphere
2. Igniter power supply
3. General trips
4. Minimum stop
5. Fuel gas burner cocks
6. Fuel gas header + vent
7. Gas firing trips
8. Fuel gas TSOV selection
9. Fuel oil header
10. Fuel oil firing trips

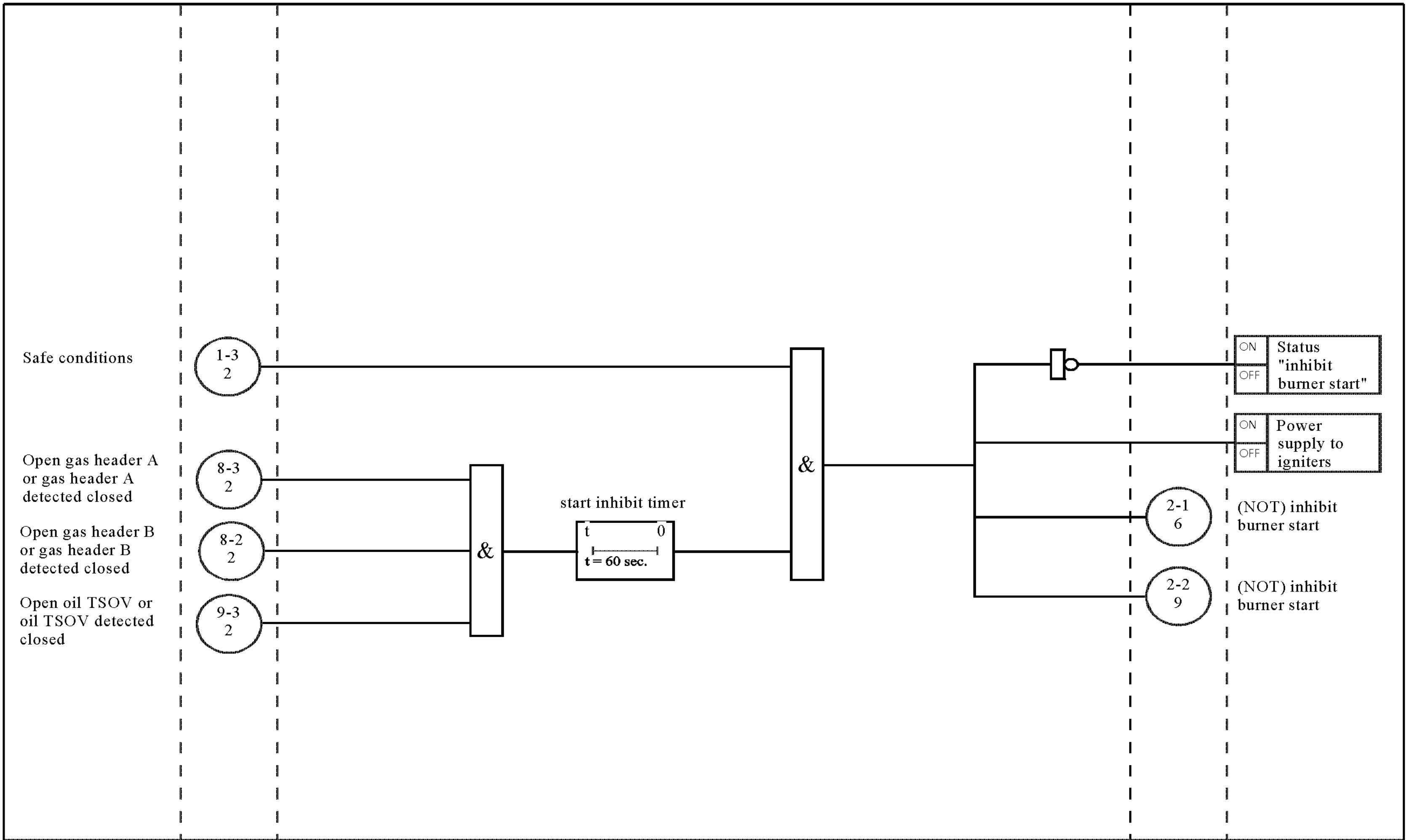
99. Status indications, alarms, switches

FURNACE SAFEGUARDING LOGICS		Logics 21 Sheet 0

Logic 21 (Sheet 1)



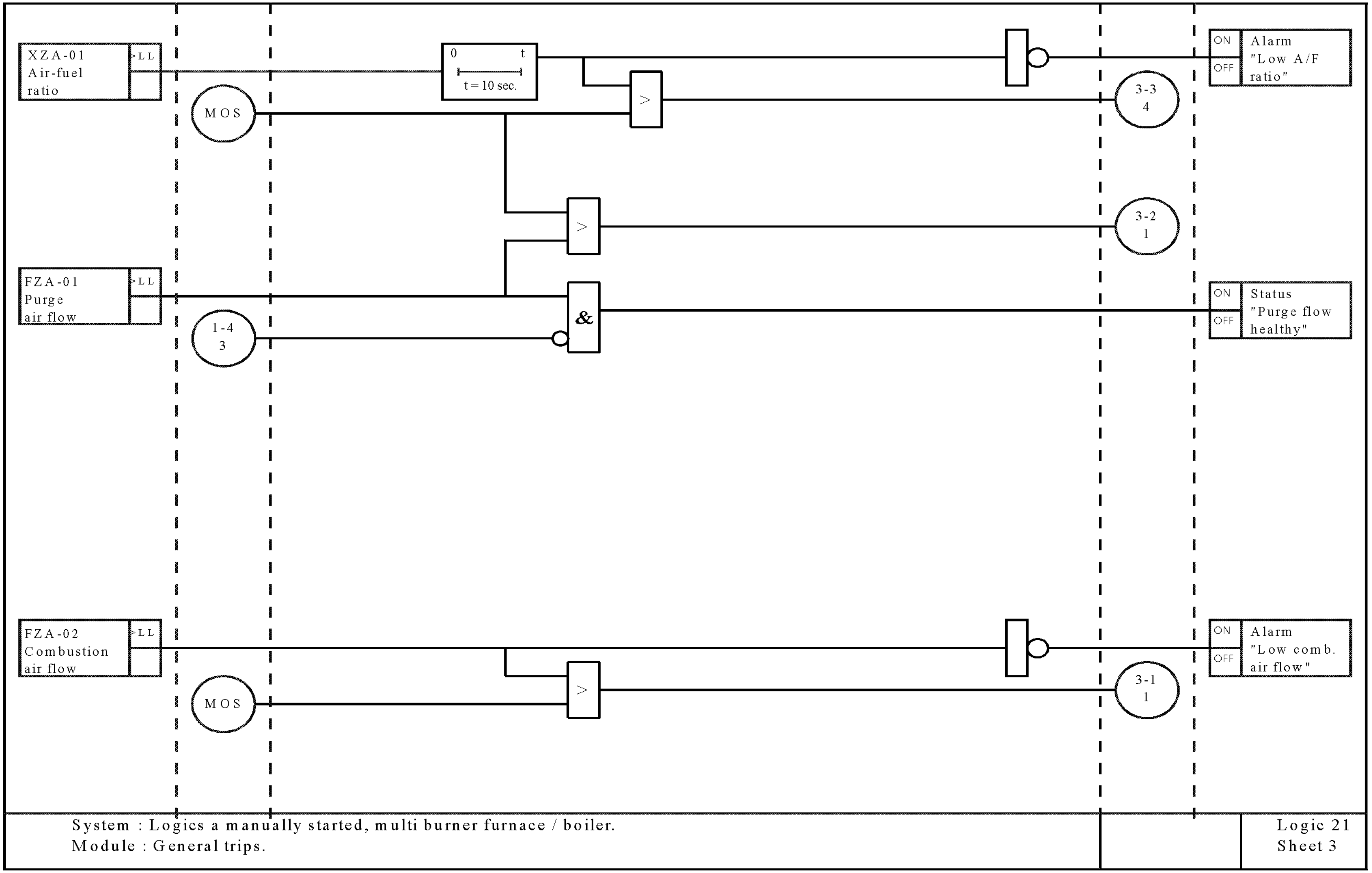
Logic 21 (Sheet 2)



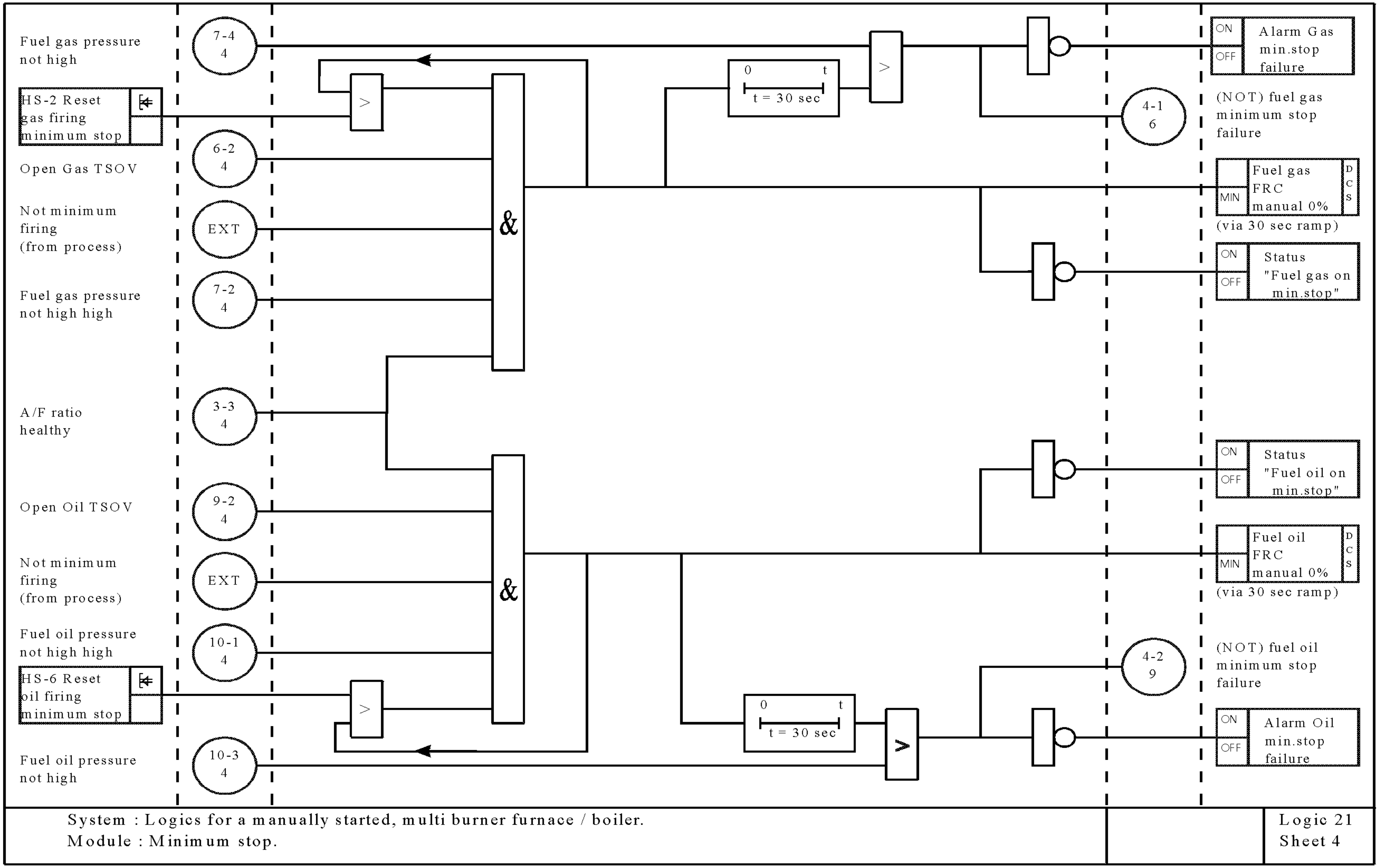
System : Logics for a manually started, multi burner furnace / boiler.
Module : Igniter power supply.

Logic 21
Sheet 2

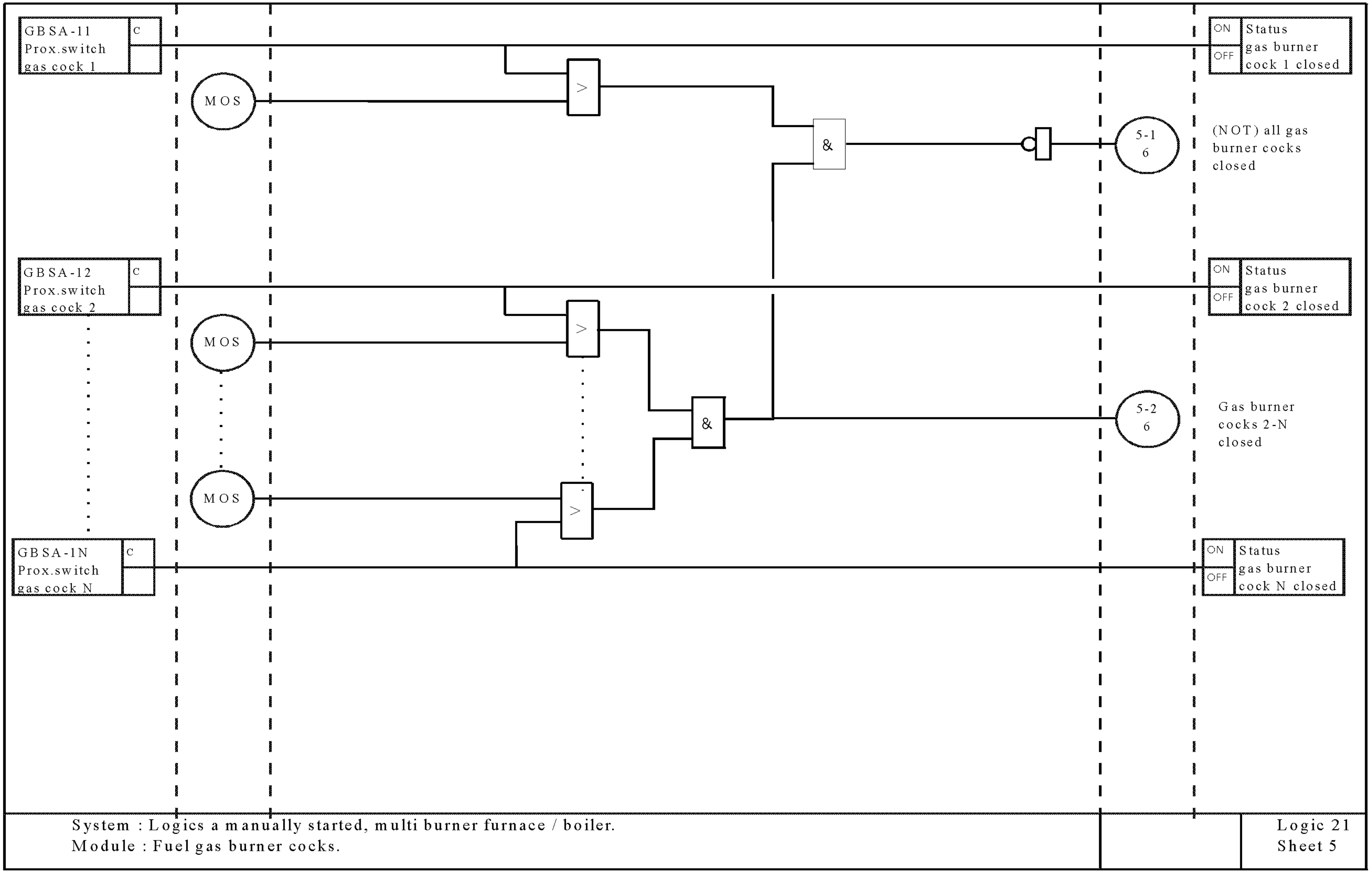
Logic 21 (Sheet 3)



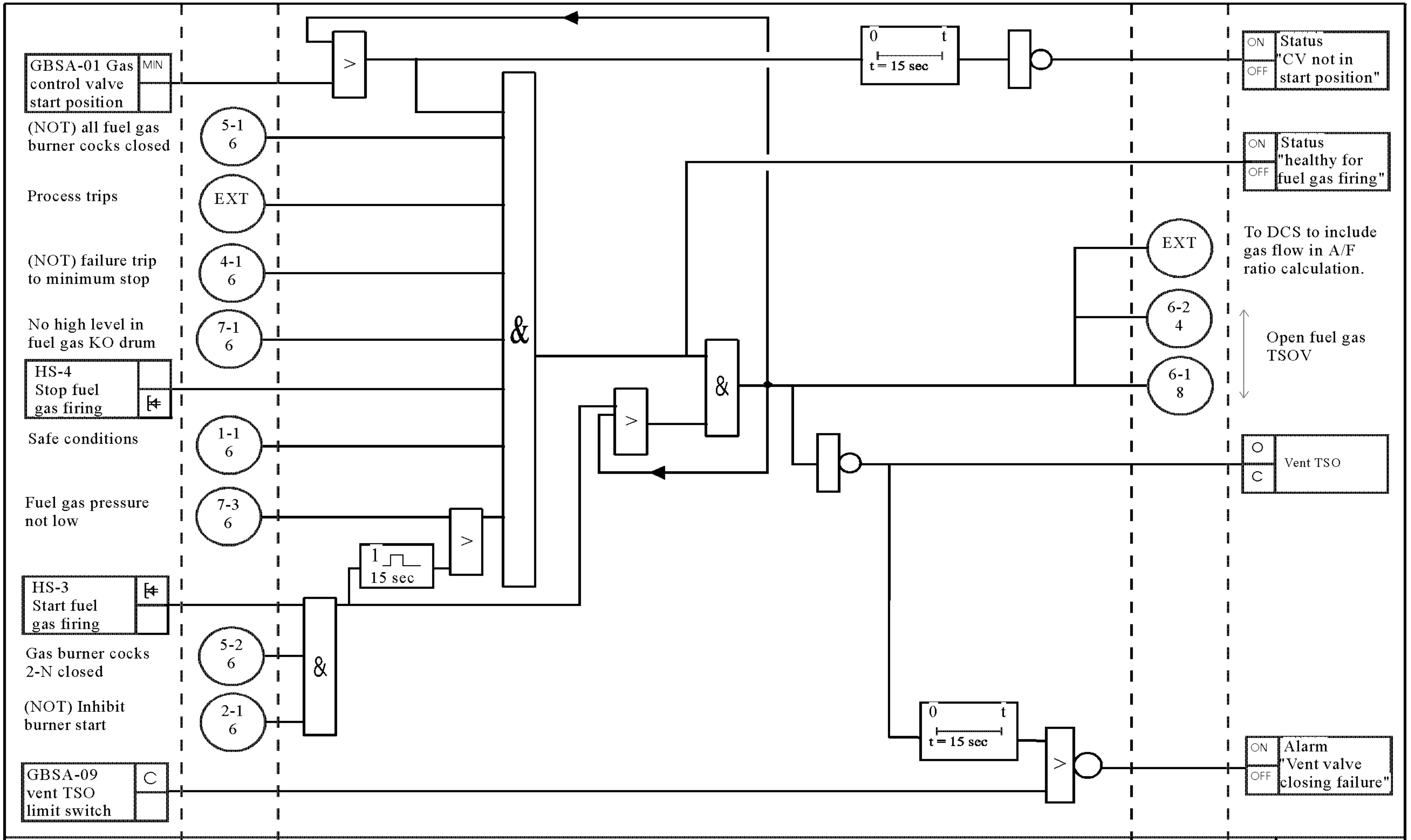
Logic 21 (Sheet 4)



Logic 21 (Sheet 5)



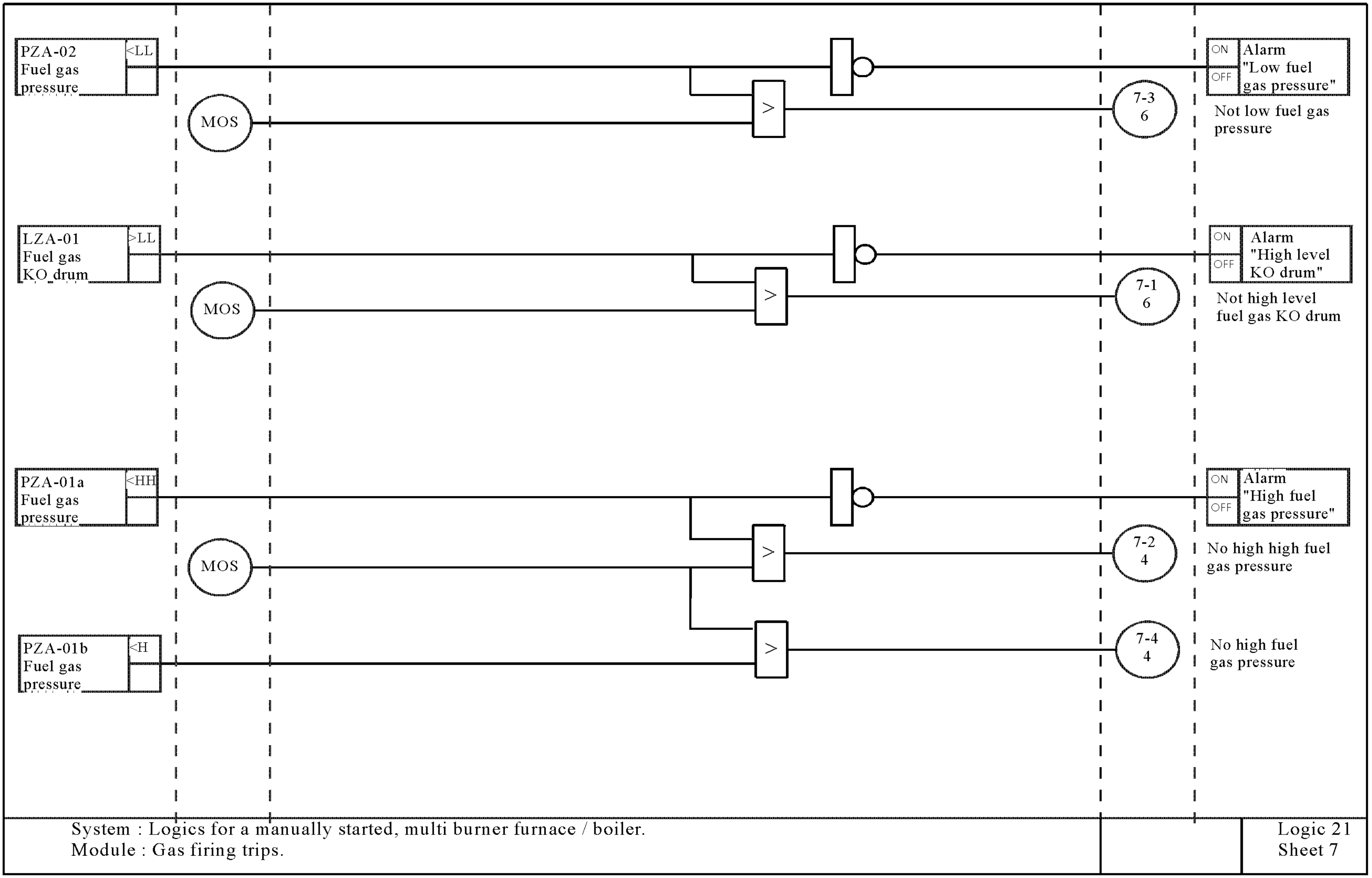
Logic 21 (Sheet 6)



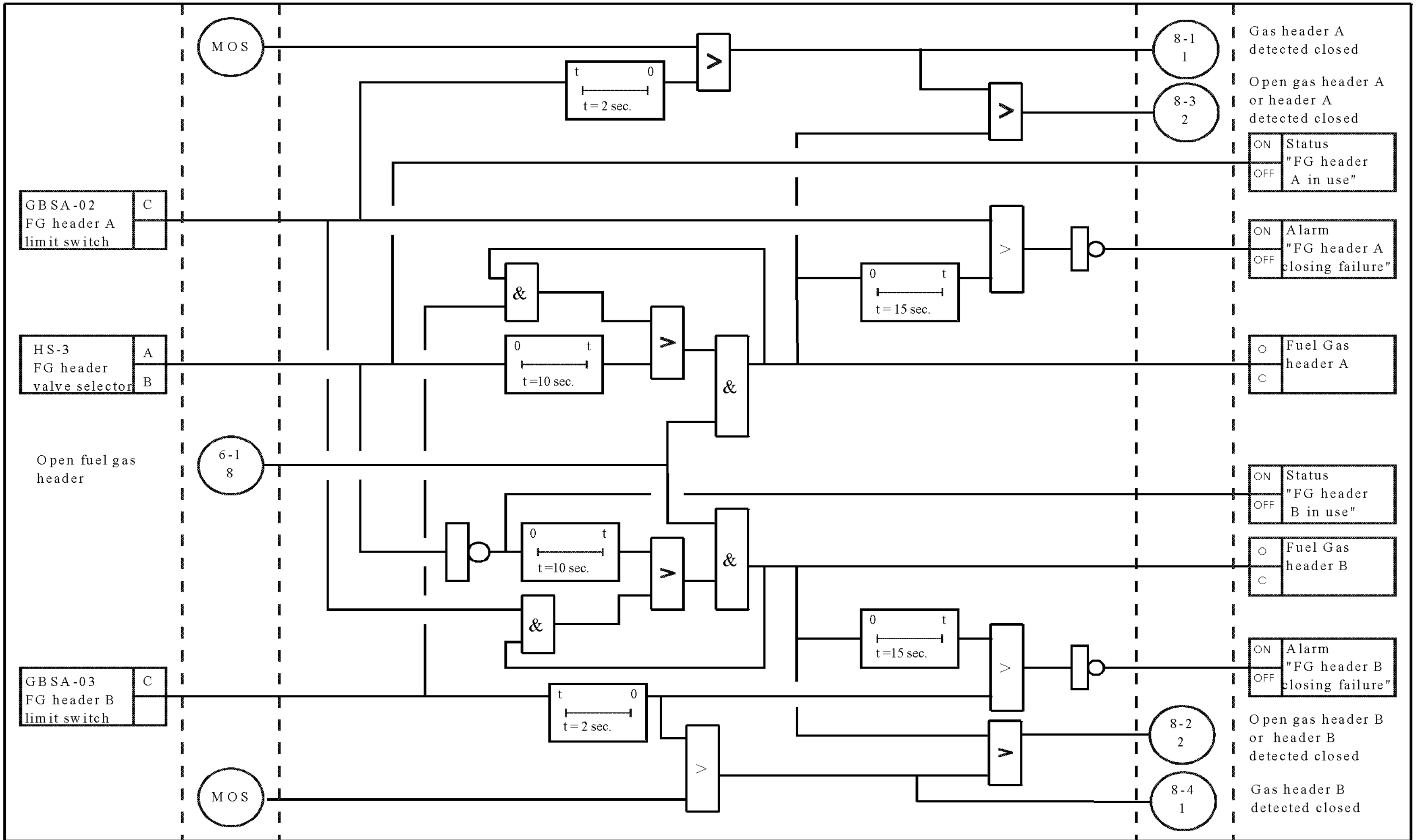
System : Logics for a manually started, multi burner furnace / boiler.
Module : Fuel gas header & vent.

Logic 21
Sheet 6

Logic 21 (Sheet 7)



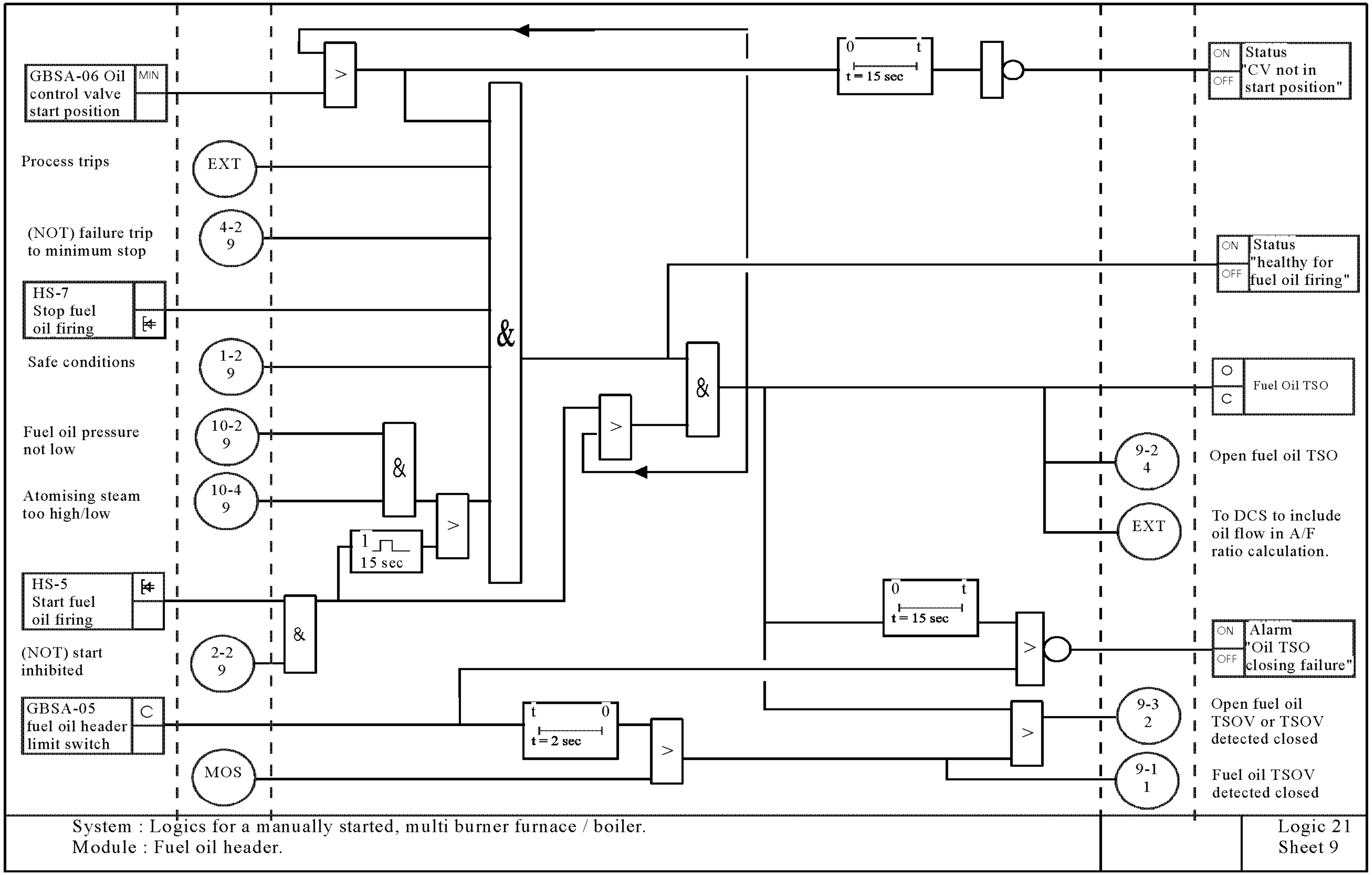
Logic 21 (Sheet 8)



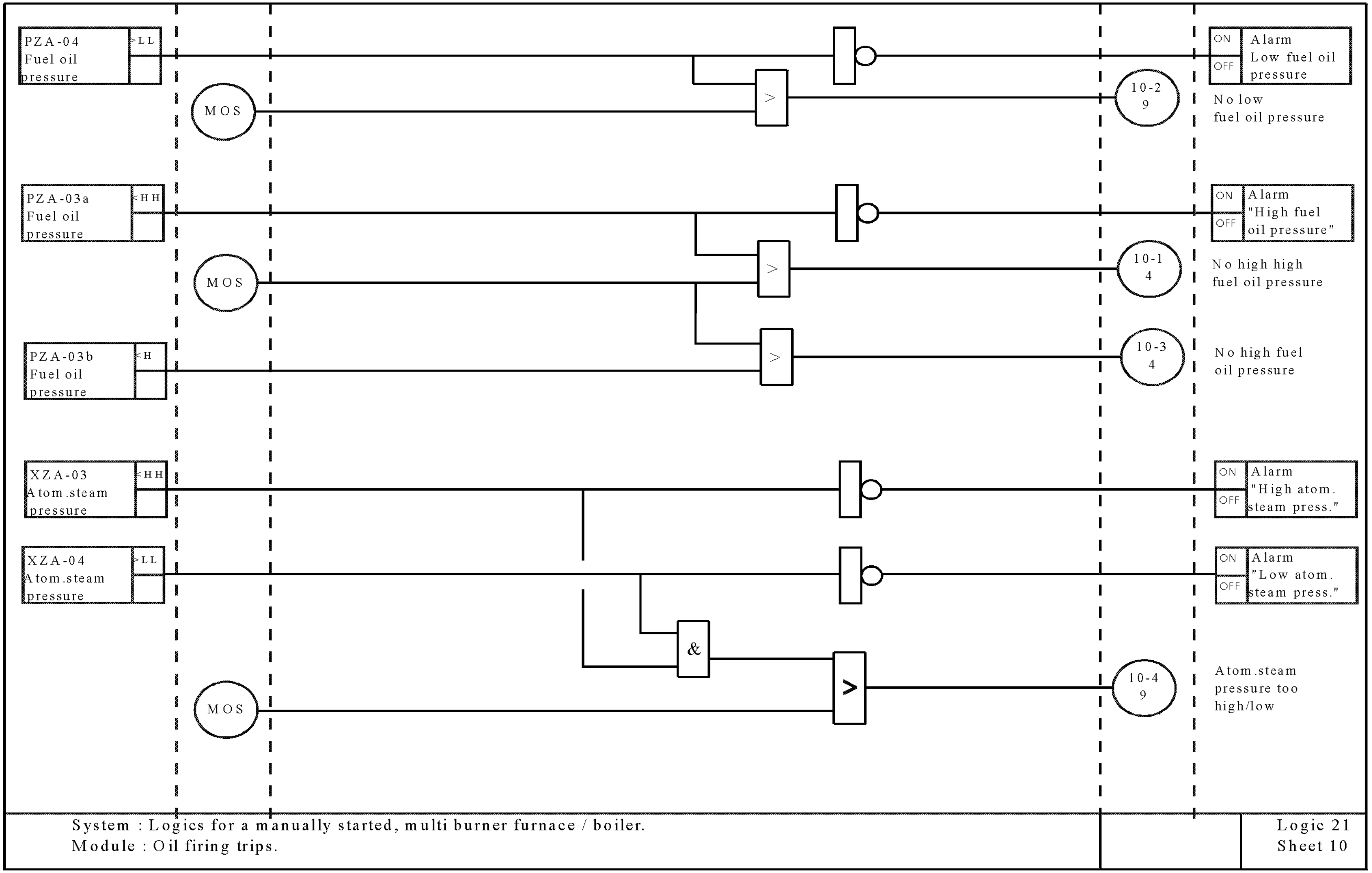
System : Logics for a manually started, multi-burner furnace / boiler
Module : Fuel gas header valve selection

Logic 21
Sheet 8

Logic 21 (Sheet 9)



Logic 21 (Sheet 10)



Logic 21 (Sheet 99)