

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

TECHNICAL SPECIFICATION

CONTROL SYSTEM AND INSTRUMENTED PROTECTIVE FUNCTIONS FOR FIRED EQUIPMENT

- System for a manually-started,
forced draught, multi burner furnace or boiler (S 24.021)

PTS 32.24.20.37

FEBRUARY 2011



© 2010 PETROLIAM NASIONAL BERHAD (PETRONAS)

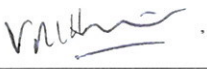
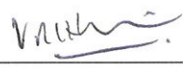
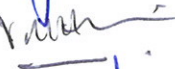
All rights reserved. No part of this document may be reproduced, stored in a retrieval system or transmitted in any form or by any means (electronic, mechanical, photocopying, recording or otherwise) without the permission of the copyright owner.

PTS Circular 2011 - 13	PETRONAS 
PTS No:	32.24.20.37
Publication Title:	CONTROL SYSTEM AND INSTRUMENTED PROTECTIVE FUNCTIONS FOR FIRED EQUIPMENT - System for a manually-started, forced draught, multi burner furnace or boiler (S 24.021)
Base PTS Version:	<Release 14>

This revision of PTS **32.24.20.37 – CONTROL SYSTEM AND INSTRUMENTED PROTECTIVE FUNCTIONS FOR FIRED EQUIPMENT - System for a manually-started, forced draught, multi burner furnace or boiler (S 24.021)** has been updated incorporating PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards.

The previous version of this PTS (**Release 13 December 1998**) will be removed from PTS binder/e-repository from herein onwards.

Document Approval

	Name	Designation	Date	Signature
Prepared/ Reviewed	V R Harindran		24/2/11	
Approved	V R Harindran	TP (Technical Authority)	24/2/11	
Verified	Dzulkifli A Razak	Senior Manager, PAO Engineering - GTS	25/2/11	
Verified	V R Harindran	Acting General Manager, Engineering, GTS	24/2/11	
Endorsed	Pau Kiew Huai	Senior General Manager, GTS	28.2.11	

Revision History

Date	Version	Description of Updates	Author

PREFACE

PETRONAS Technical Standards (PTS) publications reflect the views, at the time of publication, of PETRONAS OPU/Divisions.

They are based on the experience acquired during the involvement with the design, construction, operation and maintenance of processing units and facilities. Where appropriate they are based on, or reference is made to, national and international standards and codes of practice.

The objective is to set the recommended standard for good technical practice to be applied by PETRONAS' OPU/Divisions in oil and gas production facilities, refineries, gas processing plants, chemical plants, marketing facilities or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where PTS may not cover every requirement or diversity of condition at each locality. The system of PTS is expected to be sufficiently flexible to allow individual operating units to adapt the information set forth in PTS to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use PTS they shall be solely responsible for the quality of work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, the Principal will expect them to follow those design and engineering practices which will achieve the same level of integrity as reflected in the PTS. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the Principal or its technical advisor.

The right to use PTS rests with three categories of users :

- 1) PETRONAS and its affiliates.
- 2) Other parties who are authorized to use PTS subject to appropriate contractual arrangements.
- 3) Contractors/subcontractors and Manufacturers/Suppliers under a contract with users referred to under 1) and 2) which requires that tenders for projects, materials supplied or - generally - work performed on behalf of the said users comply with the relevant standards.

Subject to any particular terms and conditions as may be set forth in specific agreements with users, PETRONAS disclaims any liability of whatsoever nature for any damage (including injury or death) suffered by any company or person whomsoever as a result of or in connection with the use, application or implementation of any PTS, combination of PTS or any part thereof. The benefit of this disclaimer shall inure in all respects to PETRONAS and/or any company affiliated to PETRONAS that may issue PTS or require the use of PTS.

Without prejudice to any specific terms in respect of confidentiality under relevant contractual arrangements, PTS shall not, without the prior written consent of PETRONAS, be disclosed by users to any company or person whomsoever and the PTS shall be used exclusively for the purpose they have been provided to the user. They shall be returned after use, including any copies which shall only be made by users with the express prior written consent of PETRONAS. The copyright of PTS vests in PETRONAS. Users shall arrange for PTS to be held in safe custody and PETRONAS may at any time require information satisfactory to PETRONAS in order to ascertain how users implement this requirement.

TABLE OF CONTENTS

1	INTRODUCTION	1
1.1	SCOPE.....	1
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS.....	1
1.3	DEFINITIONS AND ABBREVIATIONS.....	2
1.4	CROSS-REFERENCES.....	2
1.5	DEVIATIONS FROM INTERNATIONAL STANDARDS.....	3
2	GENERAL	4
3	FUNCTIONAL (OPERATIONAL) DESCRIPTION	5
3.1	LOAD CONTROL	5
3.2	AIR/FUEL RATIO CONTROL	6
3.3	WASTE GAS FIRING.....	7
3.4	START-UP	7
4	TECHNICAL DESCRIPTION	10
4.1	IMPLEMENTATION CONSIDERATIONS.....	10
4.2	LOCATIONS OF ALARMS, SWITCHES ETC.	11
4.3	CALCULATION FORMULAE	12
4.4	DESCRIPTION OF INSTRUMENTED PROTECTIVE FUNCTIONS.....	14
4.5	SIL CLASSIFICATION AND CAUSE AND EFFECT DIAGRAM	20
5	SYSTEM BACKGROUND AND DEVIATIONS FROM INTERNATIONAL STANDARDS ...	23
5.1	GENERAL	23
5.2	LINE UP OF TSO VALVES AND USE OF DOUBLE BLOCK AND BLEED VALVES.....	23
5.3	HIGH FUEL PRESSURE TRIP	24
5.4	PURGING REQUIREMENTS	25
5.5	NO FLAME SAFEGUARDING	25
6	REFERENCES	26

1 INTRODUCTION

1.1 SCOPE

This new PTS 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 PTS 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 PTS is intended to be used on forced draft furnaces/boilers with high capacity burners (typically >5 MW) having a high combustion air side pressure drop (> 50 mm water column) as can normally be found in systems with air preheat. This PTS is only intended for heaters that have a relatively low burner start load in relation to the fire box volume (this shall be at the discretion of the Principal). This PTS shall not be used for systems with multiple small capacity, low pressure drop burners. This PTS shall also not be used for single burner systems or natural draught furnaces. This PTS shall not be used for single burner systems or natural draught furnaces/boilers.

This PTS assumes the selection of reliable FD burners that have stable flames over the entire range from low fuel pressure to high fuel pressure in combination with no excess air rates. Only with this assumption may a safeguarding system with no flame detection be selected for new installation. This PTS contains a control and IPF narrative and logic diagrams and refers to a standard specific process engineering flow scheme.

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

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

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS, the distribution of this PTS is confined to companies forming part of PETRONAS Group, and to Contractors nominated by them.

This PTS 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 PTS 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 PTS 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 PTS 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** indicate a requirement.

The word **should** indicate 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 PTS 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
Safety PLC	TUV SIL certified PLC
SRF	Standard refinery fuel
TSOV	Tight shut off valve

1.4 CROSS-REFERENCES

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

1.5 DEVIATIONS FROM INTERNATIONAL STANDARDS

A number of international standards are available that provide safety requirements for fired equipment, the most frequently used being NFPA 85 and EN 746-2.

Although these standards are quite detailed, they leave some degree of freedom with regard to their interpretation and implementation.

The objective of this PTS is to provide a generic, detailed specification of the required control and safeguarding scheme, which does not leave room for differences in interpretation and implementation – thereby preventing errors in execution of projects.

Generally, the system as described in this PTS fulfils the requirements as given in the above-mentioned standards, thereby taking into account the typical conditions and operating requirements in the refinery environment.

In some cases the choice is made to deviate from the standards above, for good reasons and with sound alternatives being applied where needed.

Section 5 provides some of the reasoning behind the main deviations, but does not relieve the Contractor of its obligations as described in (1.2).

2 GENERAL

This PTS 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 PTS, 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 PTS, 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.

Depending on the variation in the MW of the fuel gas, the fuel gas flow measurement shall be corrected for changes in gas density ([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, asking for a "long" or a "short" purge, depending on the cause of the trip preceding the purge. Each purge is automatically started, provided the combustion airflow and other start permissives are (or have become) healthy. A "long" purge is required if the trip was initiated via the low airflow trip or via the manual trip switches. Duration of this purge is sufficient to replace 5 times the firebox volume at minimum airflow. All other trips require a "short" (5 min) purge.

Note The purge sequence does not include an automatic opening of the combustion air damper.

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

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.

Prior to start-up of the first burner, the fuel oil¹ and fuel gas header TSOVs are closed, the fuel gas vent TSOV is open, and the fuel flow controllers as well as the master

¹ For boilers or furnaces that are solely equipped with oil firing, and therefore by definition will always be started on oil, the system with starting the burners without having a fuel oil return downstream of the control valve is less suitable

TRC are automatically set to "manual" with zero output. The minimum stop pressure controller is also temporarily forced to manual x % output, where x corresponds to the mechanical minimum stop setting (set for minimum load of one burner).

The control valves are equipped with a proximity switch (GBSA-1), to detect the valve is in a not too far open position during ignition of the first burner.

Before start-up on oil the atomising steam differential pressure controller should be on automatic, maintaining a slight steam pressure on the burner. As the fuel header pressure increases, the atomising steam pressure will increase to maintain the correct steam/oil differential pressure, aiding a smooth light-off.

Ten seconds after the TSO valve opens, the minimum pressure controller will be forced to automatic, at the required minimum pressure setting. This pressure setting is lower than the fuel pressure obtained with the mechanical minimum stop. Higher settings of the minimum pressure controller may result in start problems of the first burner, due to the dynamic behaviour of the controller in combination with the detection of the minimum opening position (GBSA-01).

It is not necessary to take the combustion airflow controller out of "cascade" control mode during furnace start-up because while the fuel flows are low, the combustion airflow will be limited by the mechanical minimum stop on the air control damper. At minimum burner loads, the combustion air will remain at minimum stop until all burners are lit. When burner load is increased, the set point of the combustion airflow controller will increase automatically to take up the load, and increase the combustion airflow above the minimum stop.

This 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.

(caused by pressure dips when opening fuel valves and not being able to flush lines prior to starting). It is recommended that in such cases a fuel oil return line is installed. This will require some modifications to the safeguarding system as given in this PTS.

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.

For furnaces with a common stack, the low air/fuel ratio trip is considered to be SIL 1 (see section 4.5), which implies that in these cases the low A/F ratio trip shall be implemented in the safety PLC, with trip transmitters separate from control. For furnaces having their own stack, a too low A/F ratio is expected to lead to little or no damage, for which reason the low A/F ratio trip can be implemented as an automatic action in the DCS with the transmitters shared between control and trip (SIL a) in these cases. The low A/F ratio trip however shall not be implemented as an alarm only.

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:

$$M_{air\,stoichiometric} = 14.77 \left(1 + \frac{2.68}{MW} \right) * M_{fuel\,gas} \quad \left[\frac{kg}{d} \right]$$

$$Fuel\,gas\,density = 12.03 \left[\frac{MW * P}{T} \right]$$

where:

P = Pressure, bar (abs)

T = Temperature, °C

$$M_{fuel\,SRF} = \frac{M_{air\,stoichiometric}}{13.66} \quad \left[\frac{kg\,SRF}{kg} \right]$$

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.

Fuel oil flows normally do not require compensation and a fixed density and heating value based on laboratory analysis is 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 = $0.9 * \text{Total fuel flow}$

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

Measured air flow

[signal 0-1] $M_{air} =$

[t/d]

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

Y9) Calculates the required air flow.

Output = $\text{Fuel flow} * 13.66 * [0.8 + 0.8 * QRC]$

in which the fuel flow is the master signal or $(0.9 * \text{total fuel flow})$, 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 = $M_{air} / (13.66 * \text{Total fuel flow})$;

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.

$$Y11) \text{ Output} = \frac{\text{fuel flow}}{\text{process flow}}$$

$$Y12) \text{ Output} = [\text{process flow}] * [\text{TRC output}]$$

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

$$Y13) \text{ Output} = \frac{[\text{fuel flow}]}{[\text{process flow}]} + k * [\text{inlet temperature}]$$

$$Y14) \text{ Output} = [\text{process flow}] * \{[\text{TRC output}] - k * [\text{inlet temperature}]\}$$

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

$$Y15) \text{ Output} = \text{DeltaP} + k1 * (\text{Poil} + k2)$$

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

$$Y16) \text{ Output} = \text{DeltaP} - k3 * (\text{Poil} + k4)$$

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

Y17) Low selector to set a maximum to the signal to the fuel flow controllers.

Y18) 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. An IPF review shall be carried out to ensure all safety related instrumentation meets the required IPF classification.

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. all burner cocks are detected in closed position; and
- iv. the local and panel trip switches are in the healthy position; and
- v. the "safe conditions" signal is not present; then

the purge sequence is automatically started.

This initiates the maximum purge timer to start running.

This maximum purge timer is set to give a minimum of 5 complete air changes of the fire box (assuming a minimum combustion air flow of at least 25%).

If there are no disruptions of the above conditions and after the timer has run out, a purge ready indication is given.

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 above safe conditions signal remains healthy, no "full purge" cycle is required.

However, after **any** total trip of the furnace control However, after **any** total trip of the furnace (shown in the functional logics by the closing signal to the header TSO valves), a "short" purge cycle of 5 min is automatically started via the "minimum purge timer" timer.

During purging a "purge in progress" indication is given.

NOTE: In none of the purge cycles is the airflow changed from normal.

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 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.

Since the control valve is installed downstream of the TSO valves, the minimum pressure controller PIC-3 has to be forced to manual 0 % if the "open gas header" signal is not available. As soon as the "open gas header" signal becomes healthy, PIC-3 is forced to manual, x % opening for a period of 10 s. Thereafter PIC-3 is

permanently forced to automatic, with minimum setpoint as required for the burners, whilst maintaining a minimum output limit of x %.

"x" is the minimum opening to achieve a reliable and safe start on the first burner to be started (this opening corresponds to the mechanical minimum stop setting). This opening shall give a higher pressure than that is obtained with the minimum pressure controller (with one burner in operation).

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.

Since the control valve is installed downstream of the TSO valves, the minimum pressure controller PIC-1 has to be forced to manual 0 % if the "open gas header" signal is not available. As soon as the "open gas header" signal becomes healthy, PIC-1 is forced to manual, x % opening for a period of 10 s. Thereafter PIC-1 is permanently forced to automatic, with minimum setpoint as required for the burners, whilst maintaining a minimum output limit of x %.

"x" is the minimum opening to achieve a reliable and safe start on the first burner to be started (this opening corresponds to the mechanical minimum stop setting). This opening shall give a higher pressure than that is obtained with the minimum pressure controller (with one burner in operation).

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 SIL CLASSIFICATION AND CAUSE AND EFFECT DIAGRAM

The possible hazardous situations as may occur in and around the fired equipment have been assessed, and the results thereof are given in Table 1, thereby defining the initiators that (may) detect such hazardous situation. The safeguarding system as described in this PTS is in line with the SIL levels as shown in this table.

A full SIL classification exercise should be carried out on the actual fired heater design to confirm that the required SIL of all the safeguarding loops are in line with the heater configuration and take into account site specifics (e.g. common fuel gas KO vessels, proximity to other plant, special environmental requirements).

For completeness sake the relevant Cause and Effect diagram is given in Table 2.

Table 1 Possible Hazardous Situations and SILs

Hazardous situation	Demand	Health & Safety	Economics	Environment	SIL
Flame detector trip	D2	S4/mitigation -1	4	1	2
Low fuel pressure trip (in systems with flame detection)	D2	0	0	0	-
Low fuel pressure trip (in systems without flame detection)	D2	S4/mitigation -1	4	1	2
Atomising steam Delta P trips (with flame detection)	D1	0	0	0	-
Atomising steam Delta P trips (without flame detection)	D1 ¹	S4/mitigation -1	4	1	1
Low air flow trip	D1 ²	S4/mitigation -1	4	1	1
FD fan motor trip (in systems with low air flow trip)	D1 ²	0	0	0	-
FD fan motor trip (in systems without low air flow trip)	D1 ²	S4/mitigation -1	4	1	1
Low air/fuel ratio trip	D1 ³ D1 ³	S0 S4/mitigation -1	3 4	0 1	a2 1
High fuel pressure trip	D2 ⁴ D2 ⁴	S0 S4/mitigation -1	3 4	0 1	a2 1
High level fuel gas KO drum level trip	D2 ⁵ D1 ⁵	S0 S4/mitigation -1	3 4	0 0	a2 1
Control valve in minimum stop position during start-up	D1 ⁶	S4	4	1	1
Fuel gas ESD valves closed detection prior to start	D1 ⁶	S4	4	1	1
Low purge air flow (during automatic purge sequence)	D1 ⁶	S4	4	1	1

¹ Too low atomising steam differential pressure results in less than 10 % of the cases in flame failure. If flame detection is installed this has no serious HSE consequence.

² Too low an airflow results in less than 10 % of the cases to major damage. A failing FD fan is generally detected by a low air flow trip and has therefore no HSE consequence if a low air flow trip is installed.

³ For furnaces connected to a common stack, a too low A/F ratio in one furnace could lead to an explosion in a flue duct or stack, leading to serious damage – in less than 10 % of the cases (S4/ mitigation -1). For furnaces with own stack, a too low A/F is expected to lead to little damage. I.e. only for furnaces with common stack a low A/F ratio is classified as SIL1.

⁴ Too high fuel gas pressure is expected to result in over firing, after burning or a minor explosion, leading to minor damage. On some burners (not the standard Shell Lyunet or LN burners), too high fuel gas pressure leads to flame blow off and - if not safeguarded with flame detectors - to an explosion with major damage.

⁵ Too high level in the high KO drum level in most cases leads to minor damage, but in less than 10 % of cases the damage will be extensive.

⁶ Failures of start-up checks, such as control valve position check, ESD valves closed checks and purge air flow check result in less than 10 % of the cases in major damage.

Table 2 Cause and effect diagram

INITIATORS		ACTIONS							
TAG	Service	Abort/ Inhibit start sequence	Header fuel oil TSOV close	Trip to minimu m 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/purge	X	X	X	X	X	X	-	-
XZA-01-LL	Air/fuel ratio ⁽¹⁾	-	-	X	-	-	X	-	-
FZA-02	Fuel gas ⁽¹⁾	-	-	-	-	-	X	-	-
FZA-03	Fuel oil ⁽¹⁾	-	-	X	-	-	-	-	-
PZA-01a-HH	Fuel gas	-	-	-	-	-	X	-	-
PZA-01b-H	Fuel gas	X	-	-	X	X	X	-	-
PZA-03a-HH	Fuel oil	-	-	X	-	-	-	-	-
PZA-03b-H	Fuel oil	X	X	X	-	-	-	-	-
HZA-01/02	Manual trips	X	X	X	X	X	X	-	-
LZA-01HH	Fuel gas KO drum	-	-	-	X	X	X	-	-
GBSA-01-S	Fuel gas control valve in start position	X	-	-	-	-	-	-	-
GBSA-02/03-C	Fuel gas header TSOVs closed	X	-	-	-	-	-	-	-
GBSA-06-S	Fuel oil control valve in start position	X	-	-	-	-	-	-	-
GBSA-05-C	Fuel oil header TSOV closed	X	-	-	-	-	-	-	-
Process I	General process trips	-	-	X	-	-	X	-	-
Process II	General process trips	-	X	X	X	X	X	-	-
GBSA-14-C	Vent TSOV closed	-	-	-	-	-	-	-	-
GBSA-n4-C	Gas burner TSOV closed	X	-	-	X	X	X	-	-
PZA-02-LL	Fuel gas	X	-	-	X	X	X		
PZA-04-LL	Fuel oil	X	X	X					
XZA-03-LL	Atomising steam ΔP	X	X	X					
XZA-04-LL	Atomising steam ΔP	X	X	X					
(Not) healthy for oil firing / (Not) TSO open		X	X	-	-	-	-	X	-
(Not) healthy for gas firing / (Not) TSO open		X	X	-	-	-	-	-	X

(1) Dedicated transmitters in PLC only required if low A/F ratio trip has to be implemented as SIL 1 (typically only for furnaces with common stacks).
NOTE: This is a generic Cause and Effect diagram which is used for all types of furnaces and is not tailored for the type of furnace described in this particular PTS.

5 SYSTEM BACKGROUND AND DEVIATIONS FROM INTERNATIONAL STANDARDS

5.1 GENERAL

The system as described in this PTS has been reviewed against the following international standards:

- NFPA 85
- EN 746-2

The main deviations are given in this Section, including the reasoning behind these deviations and the applied alternatives (where needed).

EN 746-2 specifically states that the preventative measures as specified should not be considered as the only possible solution. Any other solution leading to the same risk reduction is permissible if an equivalent level of safety is achieved.

The system as described in this PTS is considered to have an equivalent level of safety as that of EN 746-2 (and for that matter also of NFPA 85), and is therefore considered to be in line with EN 746-2.

This Section does not relieve the Contractor of its obligations as described in (1.2).

5.2 LINE UP OF TSO VALVES AND USE OF DOUBLE BLOCK AND BLEED VALVES

The different standards apply different approaches with regard to the number and line-up of TSO valves. NFPA 85 specifies for each burner two TSO valves in series. EN 746-2 specifies two TSO valves in series, whereby the common TSO valve may be regarded as the first of the two TSO valves.

Both codes require an automatic vent valve between the two TSO valves and an automatic leak test (of the TSO valves).

For the system as specified in this PTS the following considerations have been taken into account:

- It is based on appropriate SIL.
- The fuel gases as applied in the petrochemical industry are often of a fouling nature, which occasionally leads to TSO valve closing failures. Application of two-valves-in-series often is not a proper solution in view of the possible common mode failure (both valves fouling up).
- Refinery fired equipment often operates for a number of years in succession. Therefore facilities are incorporated to allow on-line testing of TSO valves, at a frequency as set by the SIL or RCM analysis in the event of dominant age related failures (fouling).
- The system is geared towards minimum nuisance during operation and start-up, as any such nuisance (e.g. trips, start-up delays, etc.) intrinsically has a negative impact on safety.

- For environmental reasons, the number of vents must be minimized, thereby minimizing the chance of unintentional venting to atmosphere (due to passing vent valves).

The system as specified in this PTS applies two common TSO valves in parallel (for fuel gas) with a manual block valve on each burner and an automatic vent TSO valve.

The above setup allows on-line testing (and if required repair) of the common TSO valves.

Since implementation of the TSO valves (number and test frequency) is done in line with their SIL class, the system as specified in this PTS **does not** include automatic leak test systems. Experience has shown that such systems often lead to nuisance (typically caused by instrument failures) during start-up – thereby reducing the safety level.

Notwithstanding the above, the system as specified in this PTS **does** include a permissive for the closed position of the common TSO valves and of the burner manual valves during purging and prior to main burner ignition.

Small leakage rates (below 1 % of valve rating) are not considered harmful, since the mixture of fuel and air exiting the burner will still be well below LEL.

NOTE: The current recommended practice is that the TSO valves in the fuel gas supply to the burners are Class V valves and actual leak rates are well below 0.01 %.

5.3 HIGH FUEL PRESSURE TRIP

Most codes prescribe the application of a high fuel gas pressure trip (PZA-HH), initiating a shut off of the relevant fuel supply. This is indeed essential for those cases where the high fuel gas pressure could lead to flame blow-off.

For more reliable burners, however, when applying the risk based approach in accordance with PTS 32.80.10.10., the effect of a failure on demand of this high-pressure trip can be considered at most (in safety terms) overfiring of the furnace. That is to say, if the PZA-HH fails to see the pressure exceeding its threshold, the flame(s) will not extinguish, only individual burners may be overloaded, resulting in overheating of furnace tubes or sub-stoichiometric firing.

This approach is only acceptable with reliable burners that are stable over the entire range of conditions from low fuel pressure to high pressure and from no excess air to high excess air rates. Flame stability testing at a certain frequency is required to demonstrate the PZA-HH value of the safeguarding systems is a realistic setting and will ensure stable flames.

It is considered that a total trip initiation is not required but only– to prevent overfiring – an initiation of a trip **to minimum firing** is preferred. A trip to minimum firing gives the least process disturbance. Even more importantly, such a trip gives the smallest change in firing conditions, thereby minimizing the chance of explosions (when going from a fuel rich environment into a flammable environment).

It is for the above reasons that the system as specified in this PTS only includes the high fuel pressure trip to minimum firing.

5.4 PURGING REQUIREMENTS

The system as specified in this PTS no longer automatically increases the air to maximum during the purge cycle. This is in line with the NFPA 85 requirement not to increase the airflow rate after a trip. The background of this requirement is that a sudden increase in airflow into a hot fuel rich environment could cause an explosion.

Moreover, in the system as specified in this PTS, the minimum airflow during purging (being minimum 25 % of the design airflow) is equal to the minimum airflow during normal operation.

Both NFPA 85 and EN 746-2 do **not** distinguish between the causes of a trip, and assume that prior to each purge, the fire box could be filled with 100 % hydrocarbons. This results in the requirement that each purge shall be long enough to give a minimum of 5 complete air changes of the fire box volume or 5 min, whichever is the longer.

The system as specified in this PTS distinguishes **two** purge “cycles”:

- The maximum purge cycle, as is required after a combustion air related trip, e.g. a low airflow trip as well as after a manually initiated emergency trip. This requires a full purge cycle, which implies purging at a minimum flow rate of 25 % of the design airflow rate, and with a purge time which gives a minimum of 5 complete air changes of the fire box volume or 5 min, whichever is the longer. This full purge cycle is automatically initiated as soon as the airflow (and other start permissives) are healthy. The five air changes are based on the assumption that the fire box could be filled with 100 % hydrocarbons.
- The minimum purge cycle, which is required after any other (non-combustion air related) firing trip. This purge cycle starts immediately after the shut-off of the fuel supply, and implies purging at a minimum flow rate of 25 % of the design airflow rate, and with a purge time of 5 min.

The reasoning here is that if the airflow has remained at least 25 % of design, the fire box is filled with at most 40 % hydrocarbons (assuming the most extreme condition of a fuel input of 100 % and an air input of 25 %).

Since prolonged purging generally has serious consequences on a Unit re-start, the purge time under these circumstances has been limited to 5 min.

NFPA 85 requires an immediate start of the burner at the end of the purge cycle, whereby the end of the purge cycle could be interpreted as the moment when the purge timer expires.

Provided there is no interruption of the combustion air supply, it can be argued that the purge cycle only ends at the moment when the first burner is started.

This PTS applies the latter interpretation.

5.5 NO FLAME SAFEGUARDING

The system as specified in this PTS does not include flame safeguarding. It assumes ignition of the main flames into the flame of a portable ignition burner. Once ignited and with the safeguarding of the boundary limits in place the high capacity forced draft burners will have stable flames.

6 REFERENCES

In this PTS, 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.

PETRONAS STANDARDS

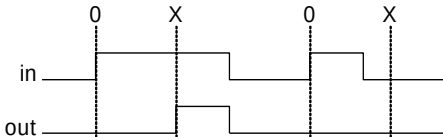
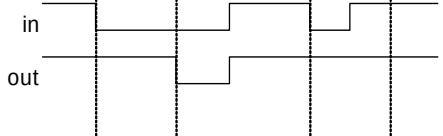
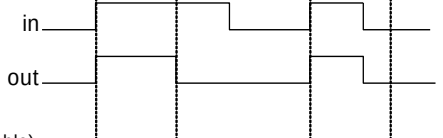
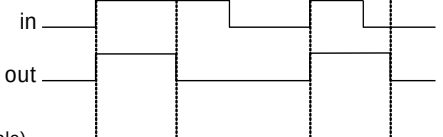
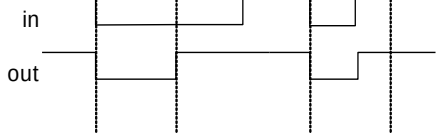
Index to PTS publications and standard specifications [PTS 00.00.05.05](#)

Classification and implementation of instrumented
protective functions [PTS 32.80.10.10](#)

STANDARD DRAWING

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

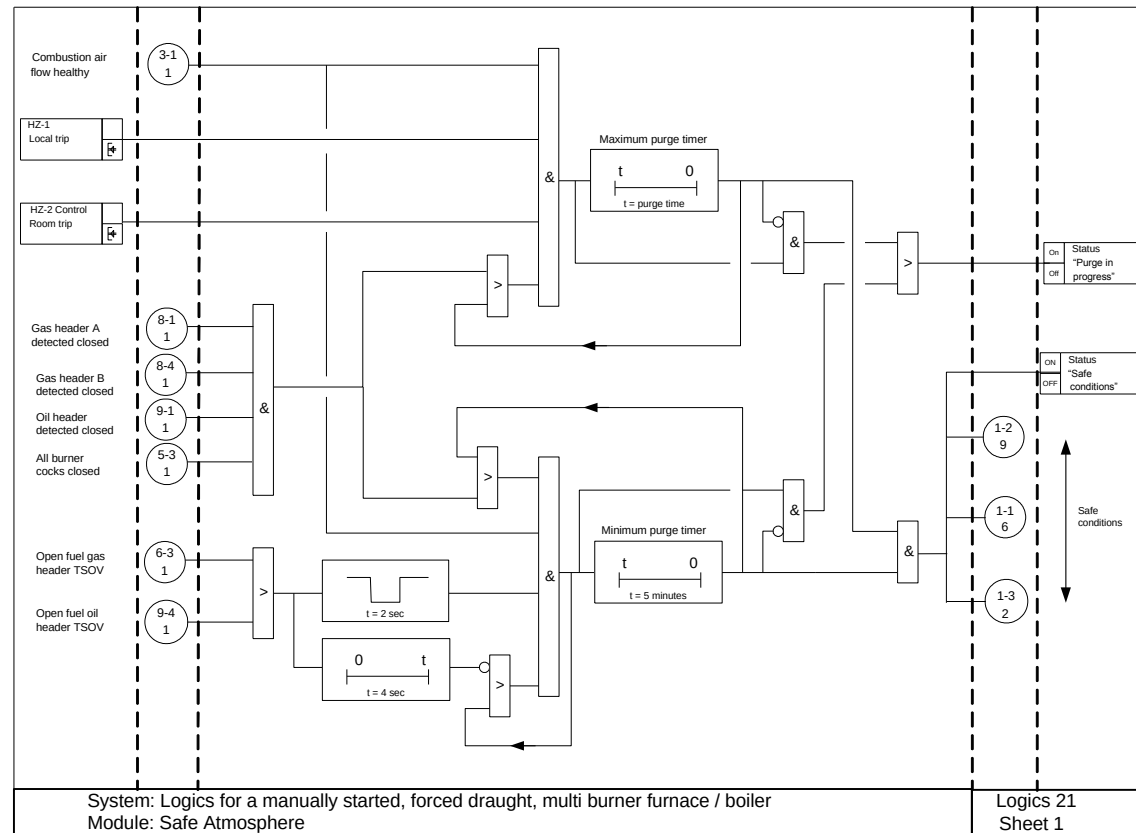
APPENDIX 1 FUNCTIONAL LOGIC DIAGRAMS FOR A MANUALLY STARTED, FORCED DRAUGHT MULTI-BURNER FURNACE

Input symbols <table><tr><td>Tag</td><td>x</td><td>(a)</td></tr><tr><td>Service</td><td>y</td><td></td></tr></table> x Physical condition corresponding to a logical '1' at (a) y Physical condition corresponding to a logical '1' at (a)	Tag	x	(a)	Service	y		Timers Delay-on <table><tr><td>t</td><td>0</td></tr><tr><td colspan="2">t = X sec</td></tr></table> Delay-off <table><tr><td>0</td><td>t</td></tr><tr><td colspan="2">t = X sec</td></tr></table> Pulse-up (resettable) <table><tr><td>t</td><td>X sec</td></tr></table> Pulse-up (not-resettable) <table><tr><td>1</td><td>t</td></tr><tr><td colspan="2">t = X sec</td></tr></table> Pulse-down (resettable) <table><tr><td>t</td><td>X sec</td></tr></table>	t	0	t = X sec		0	t	t = X sec		t	X sec	1	t	t = X sec		t	X sec
Tag	x	(a)																					
Service	y																						
t	0																						
t = X sec																							
0	t																						
t = X sec																							
t	X sec																						
1	t																						
t = X sec																							
t	X sec																						
Output symbols <table><tr><td>(b)</td><td>x</td><td>Tag</td></tr><tr><td></td><td>y</td><td>Service</td></tr></table> x Physical condition corresponding to a logical '1' at (b) y Physical condition corresponding to a logical '1' at (b) Transfer Indicators <table><tr><td>x-y</td></tr><tr><td>z</td></tr></table> Signal y from sheet x is transferred to sheet z Logical symbols <table><tr><td>&</td><td>AND gate : Output is '1' in case all inputs are '1'</td></tr><tr><td>></td><td>OR gate : Output is '1' in case at least one input is '1'</td></tr><tr><td></td><td>Invertor : Output is '1' when input is '0' and vice versa</td></tr><tr><td></td><td>AND gate with inverted input</td></tr></table>	(b)	x	Tag		y	Service	x-y	z	&	AND gate : Output is '1' in case all inputs are '1'	>	OR gate : Output is '1' in case at least one input is '1'		Invertor : Output is '1' when input is '0' and vice versa		AND gate with inverted input	Explanation of logic symbols SYMBOLS						
(b)	x	Tag																					
	y	Service																					
x-y																							
z																							
&	AND gate : Output is '1' in case all inputs are '1'																						
>	OR gate : Output is '1' in case at least one input is '1'																						
	Invertor : Output is '1' when input is '0' and vice versa																						
	AND gate with inverted input																						

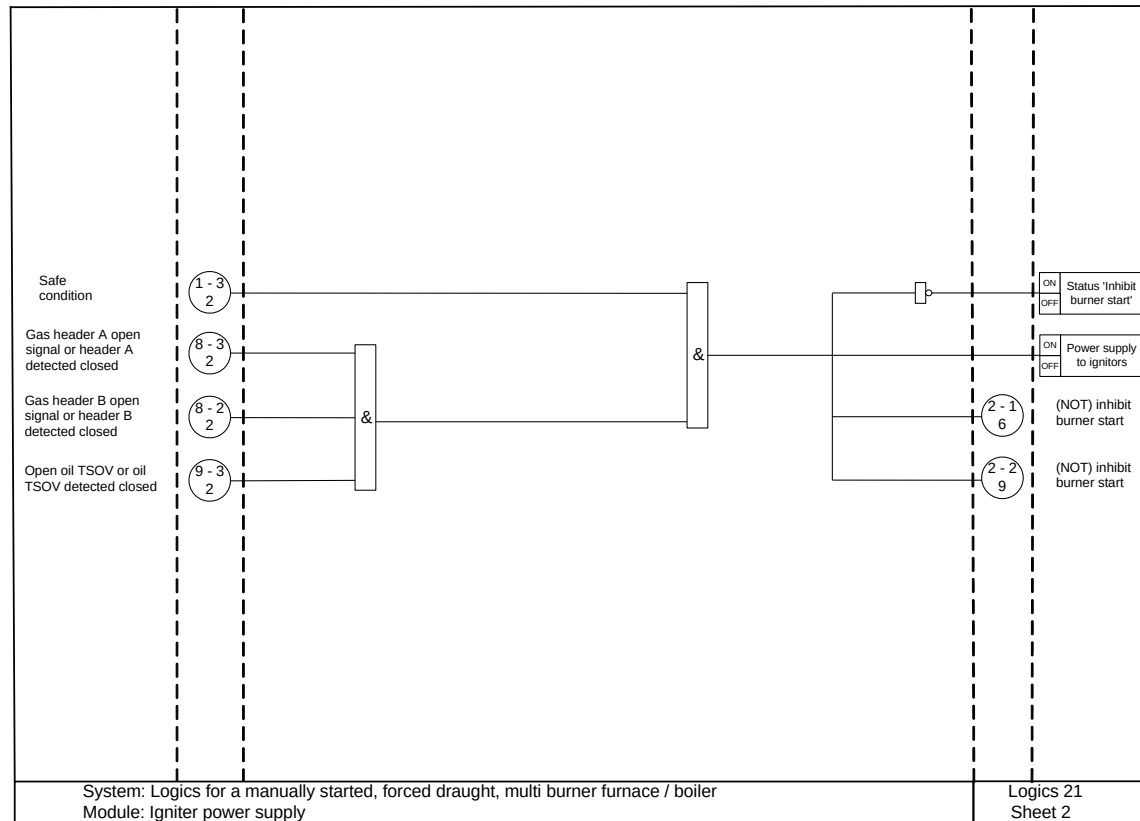
Logic 21 (Sheet 0)

Furnace safeguarding logics for a manually started, forced draught, multi burner furnace References: S24.021: Fuel oil and fuel gas system for an manually started, forced draught, multi burner furnace 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
System: Logics for a manually started, forced draught, multi burner furnace / boiler		Logics 21 Sheet 0

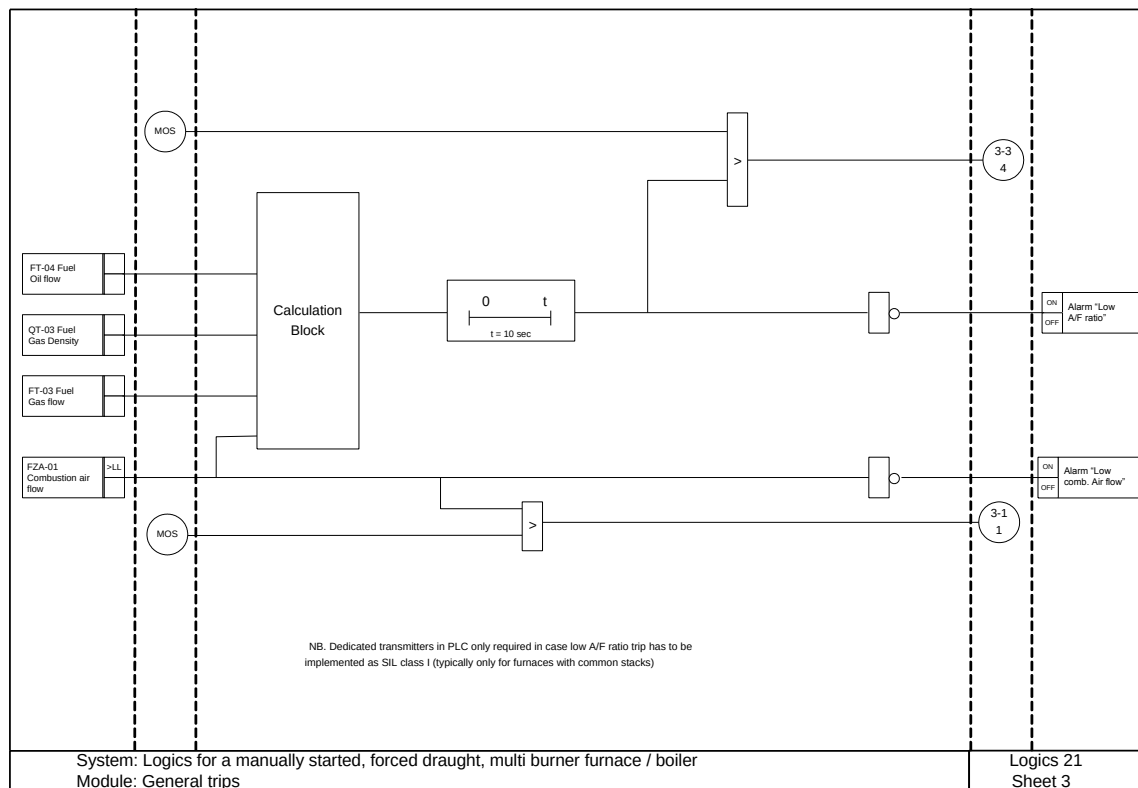
Logic 21 (Sheet 1)



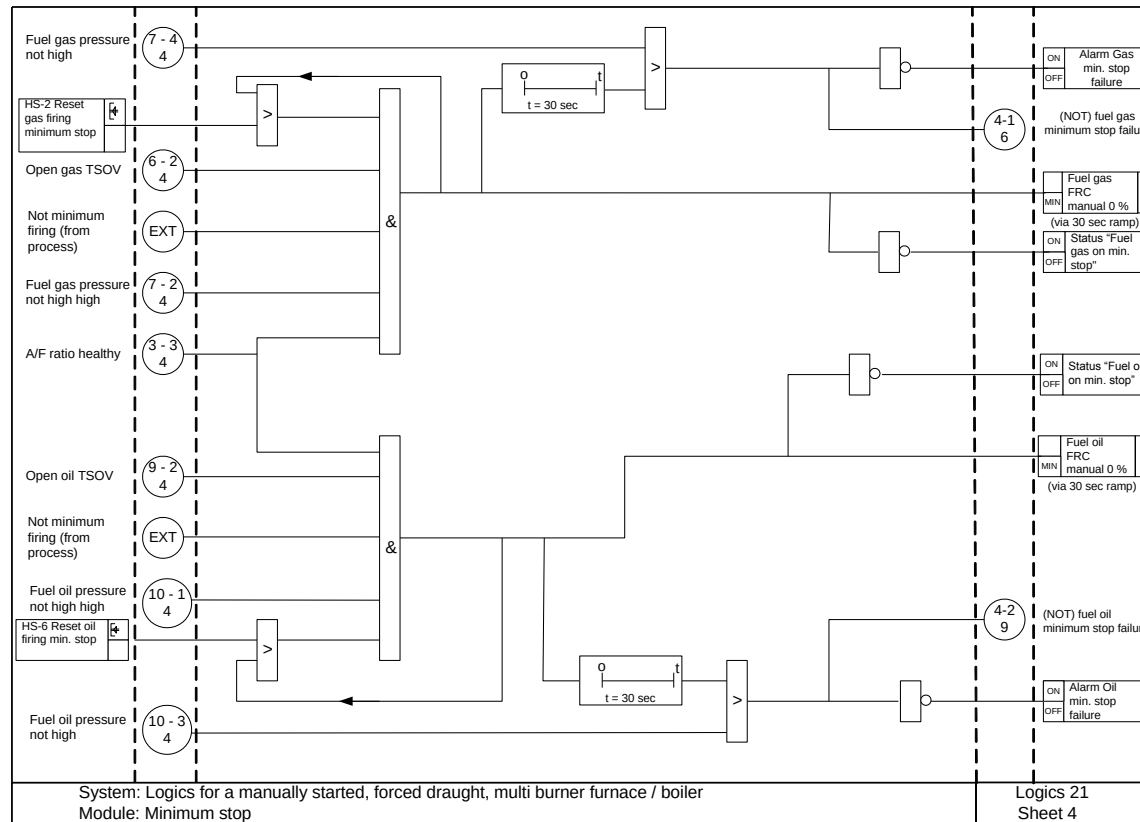
Logic 21 (Sheet 2)



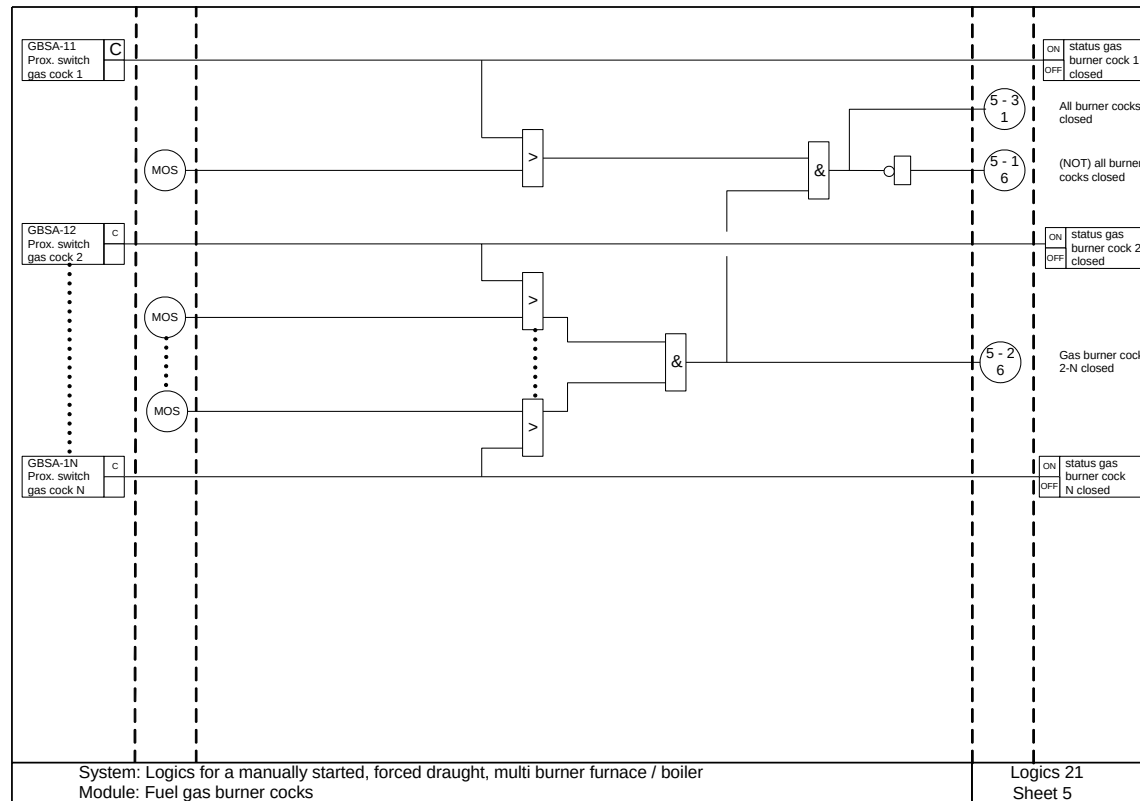
Logic 21 (Sheet 3)



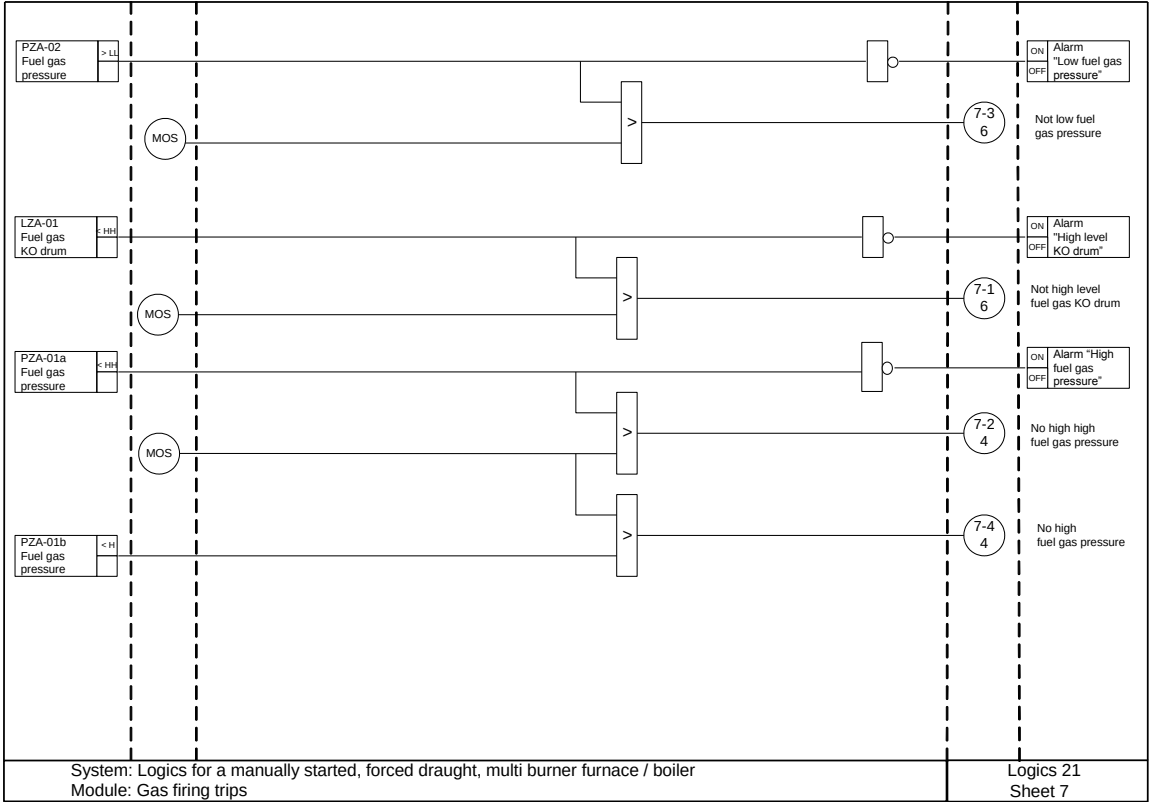
Logic 21 (Sheet 4)



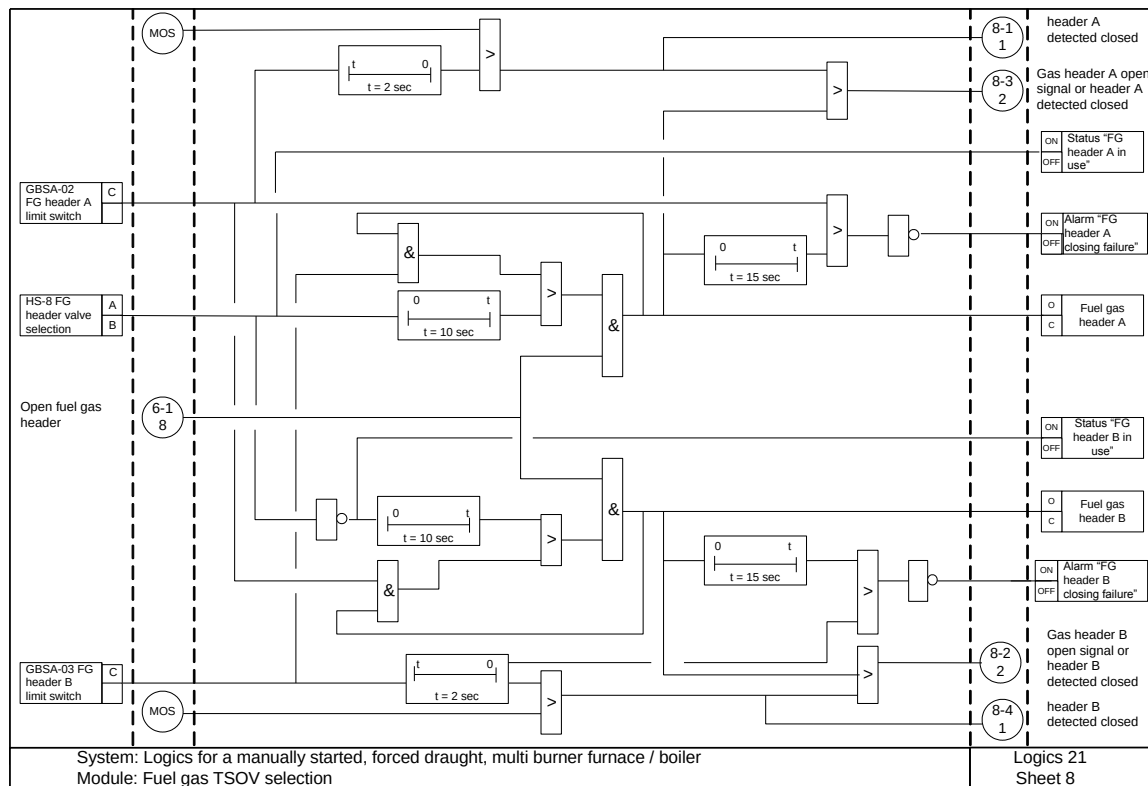
Logic 21 (Sheet 5)



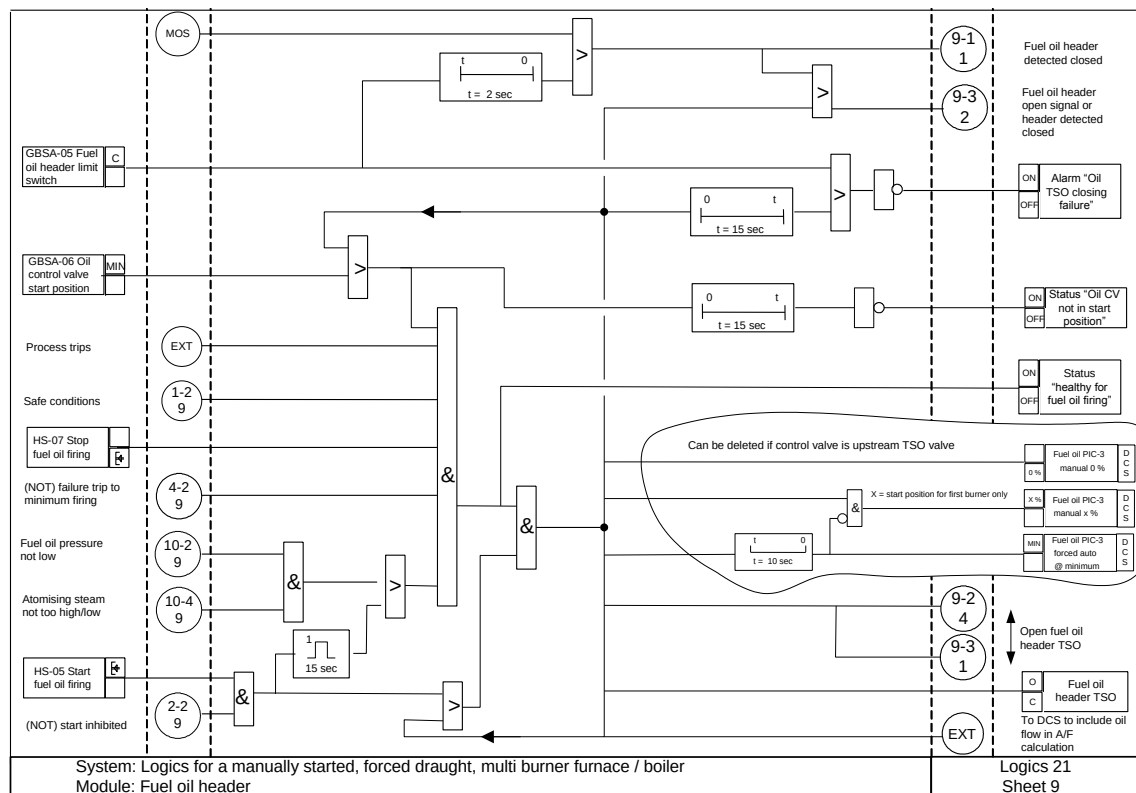
Logic 21 (Sheet 7)



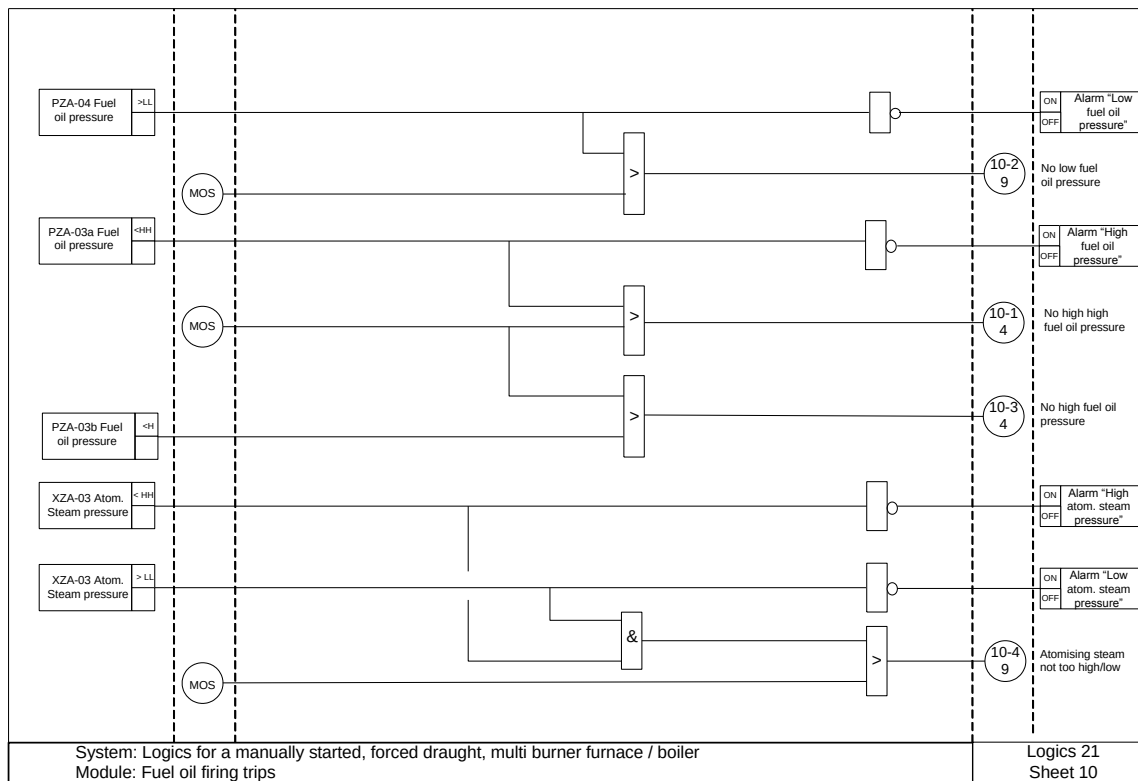
Logic 21 (Sheet 8)



Logic 21 (Sheet 9)



Logic 21 (Sheet 10)



Logic 21 (Sheet 99)

