

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

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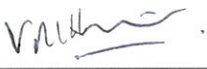
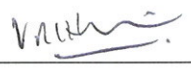
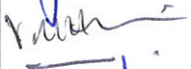
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This revision of PTS **32.24.20.37 – CONTROL SYSTEM AND INSTRUMENTED PROTECTIVE FUNCTIONS FOR FIRED EQUIPMENT - System for a manually-started, forced draught, multi burner furnace or boiler (S 24.021)** has been updated incorporating PETRONAS Lessons 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

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PREFACE

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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.

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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.