

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

MANUAL

CONTROL SYSTEM AND INSTRUMENTED PROTECTIVE FUNCTIONS FOR FIRED EQUIPMENT – Systems for Co-fired Gas Turbine Waste Heat Recovery Units

PTS 32.24.20.42

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 - 16



PTS No:	32.24.20.42
PTS Title:	Control System and Instrumented Protective Functions for Fired Equipment - Systems for Co-Fired Gas Turbine Waste Heat Recovery Units

This revision of PTS **32.24.20.42 – Control System and Instrumented Protective Functions for Fired Equipment - Systems for Co-Fired Gas Turbine Waste Heat Recovery Units (February 2011)** has been updated to incorporate PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards. All updates in the document are highlighted in *italic* font.

The previous version of this PTS **32.24.20.42 (April 2003)** will be removed from PTS binder / e-repository from herein onwards.

Document Approval

	Name	Designation	Date	Signature
Reviewed	V R Harindran	Custodian Engineer, Instrument & Control, PA&O, GTS	24/2/11	
Approved	V R Harindran	Custodian Engineer, Instrument & Control, PA&O, GTS	24/2/11	
Verified	Dzulkifli A Razak	Senior Manager, PA&O, Engineering, GTS	24/2/11	
Verified	V R Harindran	for General Manager, Engineering, GTS	24/2/11	
Endorsed	Pau Kiew Huai	Senior General Manager, GTS	25.2.11	

Revision History

Rev No.	Reviewed by	Approved by	Date

PREFACE

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

They are based on the experience acquired during their 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 applied by PETRONAS OPU in oil and gas production facilities or any other such facility, and thereby to achieve maximum technical and economic benefit from standardisation.

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) or 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 disclaim 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	1
1.4 ABBREVIATIONS	2
1.5 CROSS-REFERENCES	2
2. GENERAL	3
3. FUNCTIONAL DESCRIPTION OF GT - WHRU WITHOUT BYPASS STACK.....	4
3.1 BURNER CONTROL.....	4
3.2 START-UP SEQUENCE	5
4. FUNCTIONAL DESCRIPTION OF GT - WHRU WITH BYPASS STACK	7
4.1 BURNER CONTROL.....	7
4.2 TEG BYPASS SYSTEM.....	7
4.3 START SEQUENCE IF GT AND WHRU ARE SHUT DOWN.....	7
4.4 START SEQUENCE IF GT IS RUNNING AND WHRU IS SHUT DOWN.....	7
5. FUNCTIONAL DESCRIPTION OF GT - WHRU WITH FRESH AIR SUPPLY	8
5.1 GENERAL	8
5.2 TEG / FRESH AIR CONTROL.....	8
5.3 START-UP	9
5.4 TAKE OVER MODES.....	9
6. HARDWARE REQUIREMENTS	12
6.1 INTRODUCTION.....	12
6.2 IGNITION BURNERS.....	12
6.3 FLAME DETECTORS	12
6.4 CABLING OF IGNITERS AND DETECTORS	13
6.5 DAMPERS AND SPADING FACILITIES.....	13
6.6 PROXIMITY SWITCHES	13
6.7 SAMPLE AND PURGE STEAM CONNECTION	13
6.8 MAXIMUM FIRE BOX TEMPERATURE CONTROL.....	13
6.9 FUEL GAS VALVES.....	13
7. SAFEGUARDING LOGIC DIAGRAMS.....	14
7.1 INTRODUCTION.....	14
7.2 GENERAL BURNER START & TRIP CONDITIONS MODULE (APPENDIX 1, SHEET 1) ...	14
7.3 HRU PURGE MODULE (APPENDIX 1, SHEET 7)	15
7.4 IGNITION BURNERS MODULE (APPENDIX 1, SHEET 2)	15
7.5 MAIN BURNER MODULE (APPENDIX 1, SHEETS 3 AND 4)	15
7.6 GAS TURBINE / DIVERTER INTERLOCK (APPENDIX 1, SHEET 8)	16
8. REFERENCES.....	17
APPENDIX 1 FUNCTIONAL LOGIC DIAGRAMS.....	22

1. INTRODUCTION

1.1 SCOPE

This new PTS specifies requirements and gives recommendations for control systems and Instrumented Protective Functions for co-fired Gas Turbine Waste Heat Recovery Units. It covers the IPFs and control of burners and damper systems.

This PTS is valid for:

- systems where the available oxygen in TEG is, in all circumstances, sufficient for complete combustion of the gas supplied to the auxiliary burners. Typically for GTs that have a turn down in TEG flow between 100 % to 70 %;
- systems with and without fresh-air back-up;
- auxiliary burners of the “matrix” or “grid” type with at least 3 burner rows (N=3);
- WHRUs comprising steam generators, hot water/oil heaters and process stream heaters, e.g., TGUs, CDUs, etc.

This PTS is written for systems which use DCS for control and monitoring and safety PLC or solid state / magnetic core type Instrumented Protective Functions. This PTS shall be used as the basis for the design of control systems, IPFs, and control and safeguarding narratives.

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 the PETRONAS or managed by a Group company, and to Contractors and Manufacturers/Suppliers nominated by them.

This PTS is intended for use in oil refineries, chemical plants, gas plants, oil and gas production facilities, and in supply/marketing installations. When PTS are applied, a Management of Change (MOC) process should be implemented. This is of particular importance when existing facilities are to be modified.

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 document 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 document as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that 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 **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant, authorised to act for, and on behalf of, the.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Controller output In this PTS the controller output is defined as % opening of the valve or damper, irrespective of whether the controller is direct or reverse acting, i.e., 0 % = fully closed; 100 % = fully open.

1.4 ABBREVIATIONS

AFT	Adiabatic Flame Temperature
AIT	Auto Ignition Temperature
ATO	Automatic Take Over (from TEG to Fresh Air)
CDU	Crude Distilling Unit
DCS	Distributed Control System
FD	Forced Draught
GT	Gas Turbine
HRU	Heat Recovery Unit
IPF	Instrumented Protective Function (=safeguarding by instrumentation)
PLC	Programmable Logic Controller
PTO	Planned Take Over (from fresh air to TEG or vice versa).
TEG	Turbine Exhaust Gases
TGU	Thermal Gasoil Unit
TSO	Tight Shut Off
WHRU	Waste Heat Recovery Unit
Safety PLC	TUV SIL Certified PLC

1.5 CROSS-REFERENCES

Where cross-references to other parts of this PTS are made, the referenced section number is shown in brackets. Other documents referenced in this PTS are listed in (8).

2. GENERAL

The relatively high oxygen content in gas turbine exhaust gases (up to 16 %) allows those gases to be used as “combustion air” for burners in steam generators or process heaters. Such units are usually referred to as Waste Heat Recovery Units (WHRUs) as they make use of the “waste” heat in the Turbine Exhaust Gas (TEG). The burners typically are in-line “duct” burners, and are used to increase the duty of the WHRU by increasing the temperature of the TEG.

Three installations are considered in this PTS. The design of the control systems shall be in line with the functional descriptions as given in the relevant sections (3), (4) and (5).

Co-fired GT-WHRU systems without fresh air back-up (without bypass stack); see (3)

The GT and WHRU can only operate simultaneously, i.e., if the GT is shut down or trips offline, the WHRU is also tripped and vice versa. These systems are usually applied when continuous availability of the GT is not required.

Co-fired GT-WHRU systems without fresh air back-up (with bypass stack); see (4)

In an installation with a bypass stack, GT stand-alone operation is possible by separating the WHRU from the GT and diverting the TEG to the bypass stack.

Co-fired GT-WHRU systems with fresh air back-up and bypass stack; see (5)

In this installation, the WHRU can be operated either on TEG, or with auxiliary fresh air if the GT is not in operation. A bypass stack and dampers are provided in the flue gas ducting of the gas turbine, upstream of the tie-ins from the FD fan.

The bypass stack provides stand-alone operation of the GT. Forced draught fans and an auxiliary firing system provides stand-alone operation of the WHRU.

A 'take over' system is installed, which allows switching from TEG to fresh air and vice versa, without interrupting the operation of the WHRU or GT. Normal operation of the WHRU on a combination of TEG and fresh air is not covered in this PTS.

3. FUNCTIONAL DESCRIPTION OF GT - WHRU WITHOUT BYPASS STACK

3.1 BURNER CONTROL

3.1.1 General

The burner load is controlled by a fuel gas flow controller (FRC-1) that acts on a master signal, e.g., the required steam pressure/flow or coil outlet temperature.

The minimum fuel gas flow during normal operation is established by an adjustable mechanical minimum stop on the fuel gas control valve(s). This stop is set to give stable flames with all individual rows (sometimes referred to as "runners") of the burner section in operation.

The maximum burner load is limited by the correct sizing of the fuel gas control valves. The maximum fuel gas flow to the burners is limited by the maximum firebox temperature; see PTS 30.75.10.31 for more details. If burner capacity is sufficient to allow the maximum firebox temperature to be exceeded by more than 50 °C, a maximum firebox temperature controller shall be installed. If the firebox temperature increases above the set point of TRC-1, the high selector will limit the fuel gas flow to the burners.

3.1.2 Single burner system

Reference is made to Figure 1.

If the required burner turn-down is 10:1 or less, the burner section shall be considered as a single burner system.

The burner system may comprise of one or more individual rows. Each individual row is equipped with its own ignition burner and flame detector. The flame detectors shall be installed so that they can detect both the ignition flames and the main flames.

All rows are started and operated simultaneously. If the flame of one row fails, the fuel gas to that row is tripped. If more than 40 % of the installed rows are tripped, the entire burner section is tripped.

If TSO valves have to be tested without shutting down the auxiliary firing, two parallel common TSO valves shall be equipped, complete with block valves, vents and pressure gauges.

3.1.3 Multiple burner system

Reference is made to Figure 2.

If the required burner turn-down is more than 10:1, the burner section can consist of multiple (usually two) burner sections.

Each burner section can have multiple burner rows and is treated as a single burner system, similar to the system described in (3.1.2).

Each burner section is equipped with a fuel gas pressure control valve. The individual pressure controllers are controlled via the total fuel flow controller, which in turn is governed by the master controller. In this way, all runners are operated on equal loads, irrespective of the number of runners in operation.

One burner section shall be assigned as primary section (meaning that it is the first to be started and the last to be stopped). The primary section shall be equipped with a low-pressure trip (set slightly above the minimum stop pressure). This low-pressure trip automatically switches off the secondary section. In addition, the primary section shall have a high-pressure alarm, notifying the operator that the secondary burner section should be started.

3.2 START-UP SEQUENCE

3.2.1 Start of GT and WHRU

When general GT or WHRU trip signals are healthy, the GT can be started. When the GT is running, the burners can be started. The WHRU is purged automatically with TEG at low temperature and therefore no dedicated purge system is required.

In single burner systems (3.1.2) only two (common) burner start buttons are installed: one to start the ignition burners and one to start the main burners. In multiple burner systems (3.1.3), each main burner section has its own main burner start button.

3.2.2 Start of ignition burners

Although each burner row is equipped with a dedicated ignition burner, there is no requirement for individual ignition burner TSO valves. The small amount of ignition gas, mixed with the TEG gases, can never form an explosive mixture, so individual TSO valves are not required. When the ignition burner start button is pressed, all ignition burners are started simultaneously.

The ignition sparks are stopped 5 s after the ignition burner is started, as sparks may interfere with the flame detection. Ignition of main burners can proceed as long as at least 60 % of the flames are detected.

3.2.3 Start of auxiliary burners

The burner should be started on approximately 30 % of design capacity to ensure proper start-up over the entire burner row. This can be accomplished by giving the fuel gas flow controller a fixed output before start-up. The valve position required for approximately 30 % flow shall be confirmed by a proximity switch (the switch shall detect that the valve is not opened more than required).

Note: Start-up at 30 % load is only required for single burner systems and for primary burner sections in multiple burner systems.

To prevent excessively drastic load changes in the WHRU, the burner load has to be reduced to 10 % (set with the mechanical minimum stop) directly after start-up (5 s after start of the main burners). Thereafter, the operator is allowed access to the fuel gas flow controller and he can switch it to automatic.

When the main burner start button is activated, the individual runner TSO valves on which ignition flames are detected are opened, and after 5 s the common ignition TSO valve is closed.

The fuel gas controller is set from its start position (approximately 30 %) to its minimum position (approximately 10 %) 5 s after starting.

If an individual runner start fails, it can be re-started by activating the ignition burner start and main burner start buttons. The same start sequence is followed again.

If the burner section is tripped, e.g., in the event of flame failure on more than 40 % of the runners, the common TSO valve and all runner TSO valves are closed, and the vent valves in the both the main and ignition burner fuel lines are opened. Upon starting, the vent valves are closed again, i.e., the vent acts as a bleed in a 'double block and bleed' system.

3.2.4 Shut down of burners

Burners can be shut down automatically (if the process does not require the burners to be in operation) or via a manual switch. Individual runners can only be stopped via a manual valve, upstream of the burner TSO valve. When more than 40 % of the burners are tripped, all burners will trip.

In a multiple burner system, the secondary burner section is automatically switched off if the fuel gas pressure in the primary section reaches a low value.

If a burner shuts down or stops (whether initiated manually or via the safeguarding system), the fuel gas control valve is set in its start position, all TSO valves in the main burner and ignition burner fuel gas lines are closed, and both vent TSO valves are opened.