

DEP SPECIFICATION

INSTRUMENTATION CONTROL AND PROTECTION FOR FIRED EQUIPMENT

DEP 32.24.20.44-Gen.

February 2012

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DESIGN AND ENGINEERING PRACTICE

DEM1



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PART I INTRODUCTION AND GENERAL

1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for control systems and instrumented protective functions for fired equipment.

This DEP replaces DEP 32.24.20.30-Gen., DEP 32.24.20.33-Gen., DEP 32.24.20.38-Gen. and DEP 32.24.20.42-Gen. that were in use up to 2011.

This DEP outlines the minimum requirements in relation to controls and safeguarding which are applicable to all fired equipment with the exception of the sulphur recovery Claus reactors and SCOT furnaces. It also contains a flow chart which enables the user to select and adopt the appropriate international/national codes and standards on basis of the configuration of the fired equipment and its intended geographical location and application.

Process side control of fired equipment is not covered in this DEP.

Parts II - VI of this DEP are based on various national and international codes/standards and recommended practices which cover specifications on control, instrumentation and protective functions for fired equipment. These include API RP 556, NFPA 85, EN 746-2, EN 12952-8 and API RP 14C (Appendix A.6)/ ISO 10418 (Appendix B.8). These sections amend, supplement and delete various clauses of these international codes and standards.

All clauses of API RP 556, NFPA 85, EN 746-2, EN 12952-8 and API RP 14C (Appendix A.6)/ISO 10418 (Appendix B.8) not modified by this DEP remain valid as written.

This DEP is written for systems which use either Distributed Control Systems (DCS) or Programmable Logic Controller (PLC) for control and monitoring and a safety PLC or solid state/magnetic core type instrumented protective function.

This DEP Specification is mainly intended to be used for new equipments. When improvements of existing systems are required, local circumstances and economic factors may require different solutions.

This DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual DEM 1 – Application of Technical Standards.

This is a revision of the DEP of the same number dated February 2011; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall 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 could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP 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 it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

Conflicts and deviations with respect to requirements and recommendations as mentioned in this DEP shall be tracked as a controlled record by the Contractor and shall be reported back to the Principal throughout the project and are subject to approval by the Principal.

1.3.2 Specific definitions

Term	Definition
Automatic Burner Start	An automatic burner start involves start-up of the burner via push buttons (or an automatic sequence), automatically operating the burner TSO valves as well as flame detection.
Fired Equipment	Covers a range of combustion equipment such as heaters, boilers and incinerators.
High Air-Side Pressure Drop Burner	Burner which has high air-side pressure drop (> 50 mm wc or 2 in wc) and not capable of natural draft operation.
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.
Low Air-Side Pressure Drop Burner	Burner which has low air-side pressure drop (< 50 mm wc or 2 in wc) and capable of natural draft operation.
Manual Burner Start	A manual burner start involves the operator manually igniting the ignition or pilot burner, opening the burner cock and observing flame ignition.
Safety PLC	A PLC complying with the requirements of DEP 32.80.10.10-Gen. as logic solver for IPFs.
Trial for Ignition Time	Maximum allowable time during which unburned fuel can be admitted into a heater/boiler without creating a risk of an explosion due to delayed ignition.

1.3.3 Abbreviations

Term	Definition
CSC	Car-Seal Closed
ESD	Emergency Shut Down
HAZOP	Hazards and Operability Study
HEMP	Hazards and Effects Management Process
HRSG	Heat Recovery Steam Generator
IPF	Instrumented Protective Function
PLC	Programmable Logic Controller
RMS	Root mean square, also known as the quadratic mean.
SIL	Safety Integrity Level
TDL	Tunable Diode Laser (instrument to measure average CO or O ₂ in a laser beam through the firebox)
TFIT	Trial For Ignition Time
TSOV	Tight Shut Off Valve
UPS	Uninterruptible Power Supply
VPS	Valve Proving System

1.4 CROSS-REFERENCES

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

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated February 2011. The following are the main, non-editorial changes.

Old section	New section	Change
1.1	1.1	Moved a statement previously embedded in section (1.5) which describes the origin of this DEP to this section. Included references to API RP 14C and ISO 10418 as additional codes/standards whereby supplements/ amendments to these codes would be addressed in PART VII of this DEP.
1.3.1	1.3.1	Removed note under SHALL [PS] definition since derogation guidelines are already addressed in the Control Framework.
1.3.2	1.3.2	Changed “low pressure drop” and “high pressure drop” burners to “low air-side pressure drop” and “high air-side pressure drop” burners so as to provide better clarity on burner type definition. Made adjustment to these terms throughout the DEP text.
1.3.2	1.3.2	Added to the list a definition for “Trial For Ignition Time”. Deleted “Ultra Low NOx Burner” from the list as this term no longer can be found within the DEP text.

Old section	New section	Change
1.3.3	1.3.3	Deleted "DCS" from the list of abbreviations as this term no longer can be found within the DEP text. Added new terms "ESD" and "TFIT" to the list.
2	2	Revised decision tree to provide better clarity on type of control and safeguarding codes/standards to be applied for fired equipment operated in USA as versus other regions, Added additional footnotes to address special circumstances.
3	3	Changed all occurrences of the term "DCS" within this section to "control system" so as to take into account locations which do not have/utilize DCS – Distributed Control System.
3.1	3.1	Added API RP 14C and ISO 10418 to the list of codes/standards mentioned in paragraph 1.
3.2	3.2.1	Re-categorized the introductory paragraphs of section 3.2 under a new section 3.2.1. All subsequent section numberings in 3.2 have been adjusted to accommodate for the addition of this new section.
3.2.2	3.2.3	Added specific criteria for application of the positioning combustion control system on packaged units.
3.2.2	3.2.3	Changed "air/fuel lead-lag control" to "air/fuel double ratio lead-lag (cross limiting) control" to provide better clarity on preferred control scheme.
3.2.3 Para 1	3.2.4 Para 1	Rephrased paragraph 1 to provide better clarity on draft requirement at the arch.
3.2.3 & 3.4.6	3.2.4 & 3.4.6	Added a requirement for the stack/flue gas damper minimum stop to be lockable once set in position so as to prevent unauthorized adjustment.
3.3	3.3.1	Re-categorized the introductory paragraphs of section 3.3 under a new section 3.3.1. All subsequent section numberings in 3.3 have been adjusted to accommodate for the addition of this new section.
3.3.1 Para 6	3.3.2 Para 6	Revised clause to provide better clarity on location of main burner pressure measurement/indication.
3.3.1 Para 7	3.3.2 Para 7	Revised SHALL [PS] statement to provide better clarity on requirement.
3.3.1 Para 9	3.3.2 Para 9 & 10	Clarified implementation requirements for the disarming of the main burner fuel pressure trip during start up. Added a SHALL [PS] requirement associated with this function.
3.3.1 Para 12	3.3.2 Para 13	Clarified SHALL [PS] requirement with respect to firebox purging.
3.3.2 Para 2	3.3.3 Para 2	Revised SHALL [PS] statement to provide clarity on requirements of process side protection for the different types of heater services.
3.3.2 Para 3	3.3.3 Para 3	Deleted SHALL [PS] clause.
3.3.2 Para 5	3.3.3 Para 5	Revised clause to include its relevance to immersed fire/exhaust gas tube heaters.

Old section	New section	Change
3.3.3	3.3.4	Revised text in this section to provide clarity on requirements with respect to purge air flow and purge time for forced and balanced draft systems under different start-up scenarios.
3.3.4	3.3.5.1	Re-categorized the introductory paragraphs of section 3.3.5 under a new section 3.3.5.1. All subsequent section numberings in 3.3.5 have been adjusted to accommodate for the addition of this new section.
3.3.4 n)	3.3.5.1 n,o)	Fireside safety trips – Re-classified high-high firebox pressure as two different types of trips/time delays –one which will be measured at the arch and another at the floor.
3.3.4	3.3.5.1	Clarified that time delay between detection and trip activation shall include delay caused by transmitter filter timer.
3.3.4	3.3.5.1	Process side safety trips – Added and categorized process side safety trips in accordance to the different types of heaters – general process heaters, ethylene cracking furnaces, steam methane reformer furnaces and others.
3.3.4	3.3.5.1	Provided explanation for the preferred use of the minimum firing trip function for upsets associated with high temperature ethylene cracking furnaces. Changed ramp down timer for minimum firing trip to 30 s to be in line with the current timer settings as reflected in the standard logic diagrams as per the annexes within the DEP informative document. Clarified the condition under which a minimum firing trip will shut off any waste gas to a heater.
3.4.4 Para 2	3.3.5.1 Para 5	Revised and moved SHALL [PS] clause from section 3.4.4 paragraph 2 to section 3.3.5.1 paragraph 5.
3.3.4.1 Para 1	3.3.5.2 Para 1	Revised SHALL [PS] clause to provide better clarity on flame detection trip requirement for burners.
3.3.4.1 Para 2		Deleted SHALL [PS] clause.
3.3.4.4	3.3.5.5	Added a new paragraph to provide details of an alternative protection scheme (to low combustion air flow trip) which may be applied on combustion control schemes utilizing mechanical linkages.
3.3.4.5	3.3.5.6	Added a statement to address requirement for combustion control schemes utilizing mechanical linkage.
3.3.4.7	3.3.5.8 and 3.3.5.9	Split old section 3.3.4.7 into two different sections 3.3.5.8 and 3.3.5.9 covering high firebox arch pressure trip for induced/balanced draft heaters and high firebox floor pressure trip for heaters with low air-side pressure drop burners, respectively.
3.3.4.7	3.3.5.8	Provided rationale behind requirement for high firebox arch pressure trip for induced/balanced draft heaters.
3.3.4.7	3.3.5.9	Revised high firebox floor pressure trip for staged fuel, low air-side pressure drop burner set ups to a SHALL [PS] requirement. Provided clarity on trip criteria as well as implementation requirements.

Old section	New section	Change
3.3.4.8	3.3.5.10	Moved text in old section 3.3.4.8 to a newly created section 3.3.5.10 in lieu of old section 3.3.4.7 splitting up into two sections 3.3.5.8 and 3.3.5.9. Revised/updated functionality of the manual ESD trip switch.
3.4.1	3.4.1	Modified clause c) of a pilot's requirement as a safety device.
3.4.4	3.4.4	Revised allowable stroking time for TSOVs to 5 seconds to account for degradation of TSOVs over time.
3.4.4 2 nd bullet	3.4.4 2 nd bullet	Revised text on selected architectural arrangement for systems firing dirty fuel gases so as to provide better clarity on location of manual block valves for TSOV.
3.4.5 Para 2	3.4.5 Para 2	Revised statement to reflect the correct person responsible for fuel mal distribution calculations.
4	PART II	Updated this section to reflect consistent clause numbering in accordance with the most recent official version of API RP 556 (April 2011).
4.3.4.10	PART II 3.4.10	Updated Table 1 to reflect corrections made to the trip actions on occurrence of low combustion air flow. Revised Notes 5 and 9 to address applicability to all staged fuel, low air-side pressure drop burners
5	PART III	Updated this section to reflect consistent clause numbering in accordance with the most recent official version of NFPA 85 (2011).
5.8.8.5.8.2.6	PART III 8.8.5.8.2.6	Relaxed the maximum allowable ignition time for HRSG duct burner igniters from 5 sec to 15 sec.
6	PART IV	Revised section to include additional amendments/supplements to multiple clauses within EN 746-2: clauses 5.2.1.3, 5.2.1.11, 5.2.1.15, 5.2.2.4, 5.2.3.3, 5.2.6.1, 5.3.1.1, 5.7.1, 5.7.2, 5.7.3.3, 5.7.3.5, 6 and 7.2.
7	PART V	Revised section to include additional amendments/supplements to multiple clauses within EN 12952-8: clauses 4.3.3-7, 5.1.1, 5.1.3, 5.3, 6.3.6, 6.4.2 and 6.5.5-8.
NA	PART VI	Added a new section covering amendments/supplements to API RP 14C Appendix A.6 (March 2007) and ISO 10418 Appendix B.8 (2003).
8	PART VII	Added DEP 30.75.10.31-Gen.and ISO 10418 to the list of Standards which are made reference to in this DEP.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the Administrator at standards@shell.com, using the DEP Feedback Form. The DEP Feedback Form can be found on the main page of "DEPs on the Web", available through the Global Technical Standards web portal <http://swwww.shell.com/standards> and on the main page of the DEPs DVD-ROM.

1.7 GUIDANCE FOR USE

A bullet (●) shown in the margin of various clauses in both this DEP and/or the external standard indicates that further decisions or information are to be provided by the Contractor and/or the Principal. These decisions/information shall be indicated directly on the relevant data/requisition sheet where provisions are made for them. Otherwise, they shall be indicated on the data/requisition sheet(s) under the heading "Additional Requirements" or stated in the purchase order.

1.8 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

2. SELECTION MATRIX

This DEP is intended to cover instrumentation control and protection requirements for a range of fired equipment purchased by the Principal. Depending upon the configuration of the equipment to be built (process heaters versus boilers, fuel gas versus fuel oil or combination firing, etc) and the intended geographical location of the equipment (USA versus other regions, offshore versus onshore facilities), Figure 1 below provides guidance to the appropriate industry codes/standards to be adopted in conjunction with the minimum requirements as outlined in (3).

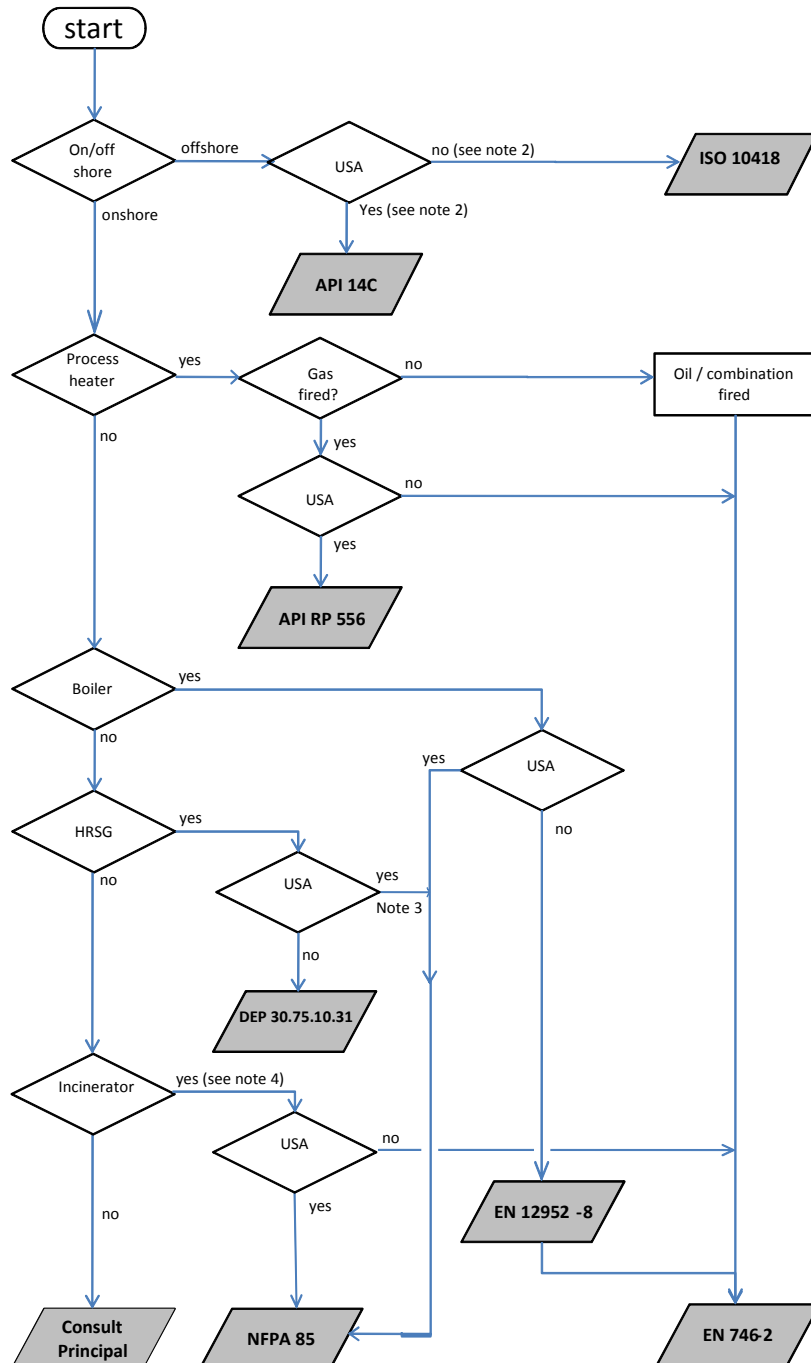


Figure 1: Decision tree on use of applicable industry codes/standards

- NOTE:
1. Some countries have nationally recognized codes that dictate the design, construction, installation, operation, and maintenance of fired equipment. The requirements of the DEP shall be followed within these "Codes in Effect". Where differences exist between the DEP and the "Codes in Effect", a discussion with the Authority Having Jurisdiction shall be held presenting Shell's operational history and process safeguarding philosophy (IPS, bow-ties, HAZOP, etc.), with the intent of obtaining a variance to the "Codes in Effect". For packaged equipment, the Contractor shall ensure that all local (the final installation of the equipment) "Codes in Effect" are met by the packaged equipment Manufacturer/Supplier.
 2. Although written for fired/exhaust heated equipment on offshore production platforms, API RP 14C/ISO 10418 may also be applied on similarly configured fired/exhaust heated components for specific onshore facilities (e.g., onshore tight gas sites).
 3. DEP 30.75.10.31-Gen. should also be used in conjunction with NFPA 85 Section 8.
 4. NFPA 85 or EN 746-2, together with (3) of this DEP, shall be applied selectively in the definition of the control and protection requirements for thermal incinerators.

- The Principal shall be consulted on the approach to be adopted for thermal incinerators.

3. MINIMUM REQUIREMENTS

3.1 GENERAL REQUIREMENTS

Clauses in API RP 556, NFPA 85, EN 746-2, EN 12952-8 and API RP 14C (Appendix A.6/ ISO 10418 (Appendix B.8) which are not mentioned in this DEP, shall remain valid as written.

Where there are conflicts between the requirements outlined in this DEP and the international codes and standards, the requirements in this DEP take precedence.

In all designs for combustion control and protection of fired equipment the following basic requirements shall be met:

- The design of the Safety Instrumented System shall consider the effect of single component failures and include provision for testing to identify dangerous faults, if test intervals are shorter than the planned turn-around (refer to DEP 32.80.10.10-Gen.).
- All safeguarding systems (IPFs) shall be designed as per DEP 32.80.10.10-Gen.
- The requirement for a local control panel shall be specified by the Principal.
If a local control panel is specified, it shall incorporate all devices required for local start-up.

3.2 FIRED EQUIPMENT CONTROL – BASIC PHILOSOPHY AND PRINCIPLES

3.2.1 General

The primary purpose of a combustion control system is to maintain a stable process output control (e.g. process outlet temperature, steam pressure) by regulating the fuel flow to the burners. Where a constant fuel gas quality is to be expected (e.g., only natural gas), the primary control may be on fuel pressure.

Secondary purposes include the control of air excess level (e.g., air/fuel ratio) and fire box pressure (application dependent).

3.2.2 Load control

The output of the process controller shall be cascaded to the main fuel flow controller. For systems that fire fuel gas of constant quality (e.g., natural gas) the output of the process controller may be cascaded to a fuel pressure controller.

Minimum burner load shall be ensured by either:

- Maintaining a minimum opening on the fuel control valve (typically for systems with up to 2 burners), or
- A dedicated active minimum pressure controller, which guarantees a minimum burner load, independent of the number of burners in operation (for systems having greater than 2 burners). If the master signal would drive the required fuel flow down to a level where the fuel pressure would come too close to the flame stability limit, the active minimum pressure controller shall take over.

Similarly, maximum burner load and over firing protection shall be ensured by a dedicated maximum pressure controller.

These minimum and maximum burner load controllers shall be configured in the control system. In case anticipated fuel gas quality variations may result in fluctuations to heater duty in excess of $\pm 15\%$, the fuel gas flow measurement shall be corrected for changes in quality. Such corrections may be based on gas density measurement and/or heating value, depending on the anticipated fuel gas compositions.

Minimum burner load control shall be made active during the start-up sequence as defined in the installation-specific procedures and control narrative in consideration of the defined start-up fuel load for the burner(s) and start-up position of the main fuel control valve(s).

Load control for natural draft systems shall have active low oxygen/high CO and low draught constraints on fuel flow.

3.2.3 Combustion air control

Combustion air shall be uniformly distributed to all burners. With air manifold systems, facilities for monitoring and adjusting airflow shall be provided. For small packaged units, the combustion air may be controlled in parallel to the fuel through the use of a robust mechanical linkage (positioning control system), provided that these packaged units satisfy the following characteristics:

1. Firing capacity ≤ 6 MW (20 MMBtu/hr)
2. Firing of a single fuel with constant quality and constant supply pressure
3. Fuel and air is controlled individually per burner

For all other forced and balanced draft systems, air/fuel double ratio lead-lag (cross limiting) control shall be applied. This should either be manually set by the panel operator, or automatically set by a closed loop oxygen controller. Limits should be set to the range over which the air/fuel ratio may be adjusted, in order to prevent settings that correspond to substantial sub-stoichiometric combustion. To ensure that excess air is always maintained during load changes, the control signals should be interconnected through the control system selectors.

For a multiple-burner system equipped with individual burner flame detection and fuel shut off capabilities, it will be necessary to isolate airflow to an individual burner which is tripped on loss of proof of flame. Alternatively, the air/fuel ratio control can be automatically adjusted such as to disregard air which is supplied to the tripped burner. When 50 % or more burners are tripped, the burners are tripped to a minimum firing mode and air to all burners shall be restored.

When a burner is tripped, the oxygen trim controller, if used, shall be switched to a manual mode and held at its last output value. The oxygen controller mode change shall be alarmed to the operator.

For natural draft fired equipment, the presence of sufficient oxygen for combustion shall be assured by maintaining a negative pressure at the arch in combination with a percentage opening of the burner air registers at the chosen fuel load (performed manually by the operator), and shall be verified by an online oxygen analyzer at the arch. Oxygen measurement shall be indicated on a local panel and in control room.

Where common air plenums with air control dampers or common jackshaft arrangements are provided (individual air registers connected by common shaft and manipulated by single actuator), oxygen levels at the arch may be controlled automatically. This will require CO-TDL measurement as a constraint or the use of multiple O₂ analysers.

- The requirement for automatic O₂ control shall be specified by the Principal.

3.2.4 Draft control

For natural draft and forced draft heaters, the draft generated by the stack and the firebox shall be sufficient to achieve a draft of at least 2.5 mm WC (0.1 inch WC) at the arch over the full load range of the heater. This draft shall be maintained by adjusting the stack damper. Draft indication shall be provided in the control room. Local draft gauges shall be provided to monitor draft at the floor and arch levels. Draft gauges upstream and downstream of the stack damper should also be provided.

Firebox pressure can be controlled by automating the stack damper. When the fired equipment has an induced draft fan, the firebox pressure shall be controlled by adjusting the induced draft damper or the ID fan speed.

Where an automatic damper actuator is used, it shall be equipped with a positioner bypass switch and manual means of setting the damper position. On instrument air supply failure, the actuator shall stay put in its last position, with a tendency to fail open. Except for the stack (bypass) damper on a balanced draft heater, there shall be a minimum stop which

shall be set based on approximately 25 % design flue gas flow. This minimum stop shall be adjustable to allow optimizing of setting during initial operation. Once set in position, the minimum stop shall be locked to prevent any unauthorized adjustment.

- For systems without ID fans, the requirement for automatic draft control shall be specified by the Principal.

3.3 FIRED EQUIPMENT SAFETY – BASIC PHILOSOPHY AND PRINCIPLES

3.3.1 General

The selection and performance requirements of the safety systems shall be determined from a Hazards and Effects Management Process or HAZOP study.

Some packaged fired equipment such as boilers or auxiliary glycol heaters may be offered complete with combustion controls and protective instrument systems. In general, the manufacturers of such systems follow the applicable code in effect such as NFPA, CGA/CSA or API. It is not the intent to fully replace each of these systems with new components and systems as would be developed through direct use of this and other related Shell documents. Each application, however, shall be evaluated in terms of compliance with the basic philosophy and principles for fired equipment safety as herein described.

Unless otherwise governed by local authority requirements, the decision to start the fired equipment manually or automatically shall be based on whether the maximum allowable time (during which unburned fuel can be admitted without creating the risk of an explosion) may be too short to safely rely on human intervention. Heaters that are intermittently operated (e.g., regeneration gas heaters) shall also be automatically started.

- The Principal shall approve the decision for manual or automatic ignition and start up.

3.3.2 Fireside protection

The following outlines the basic philosophy and principles for fireside protection:

Burners shall be properly sized, adjusted, tested and maintained to ensure safe combustion over the full operating range of conditions expected for the fuel, combustion air and process conditions.

Overfire protection shall be provided through a combination of fuel control valve sizing and control limits, in addition a high pressure trip may be required.

Start-up of the first burners shall be achieved via the use of minimum fuel load control, which provides the primary measure for flameout protection and subsequent formation of an unsafe fuel mixture.

The minimum fuel load control shall be complemented by either proven continuous pilots or direct flame monitoring of the main burners. An exemption may be made for large heaters with multiple burners such as ethylene cracking heaters or hydrogen manufacturing heaters.

The main burner pressure downstream of the fuel control valve shall be indicated in the control system.

The heater SHALL [PS] be equipped with a safeguarding system that automatically trips the main fuel(s) of all, or of each individual burner in case of a flame failure. Identification of such flame failure may be direct (by means of flame detection) or indirect (by means of a combination of high and low fuel pressure trips, high firebox-floor pressure trips, etc.) depending on the type of application.

Minimum airflow protection shall be required for forced or balanced draft combustion systems with no provision for trip to natural draft. Upon loss of airflow, the firing shall automatically trip.

Fireside protective systems shall be active at the time of light off of the first burner as defined by the project's start-up sequence. For low air-side pressure drop burners with long

Trial-for-Ignition-Time (TFIT), an exemption may be made to activate the main fuel pressure trips only after a time delay not exceeding 10 minutes in order to allow for light off of first few burners and stabilization of fuel header pressure.

Where pilots are used, these shall be armed prior to introducing fuel to the main burners. If pilots are tripped anytime during the timed override of the main fuel pressure trips, an automatic total fuel trip SHALL [PS] be required.

The instrument air supply to the instrumentation shall be monitored and alarmed upon detection of low pressure.

- On forced draft installations, protection against substoichiometric combustion shall be accomplished via an air/fuel ratio trip or equivalent as approved by the Principal.

The firebox SHALL [PS] be purged before ignition. Alternatively for natural draft heaters, a gas test can be carried out each time before lighting any ignition or pilot flame. Purging requirements may be exempted for ethylene cracking furnaces or steam methane reformer furnaces following any process related trips, provided the furnace is relighted while firebox temperature remains above 750°C (1400°F).

3.3.3 Process side protection

The following outlines the basic philosophy and principles for process side protection.

All fired heaters SHALL [PS] be provided with tube-side overheating protection using dedicated IPFs. This shall be achieved for most heaters by ensuring adequate feed flow through the heater passes. For specialty heaters such as the ethylene cracker furnaces or the steam methane reformer furnaces, additional tube side overheating protection barriers such as high steam temperature, high flue gas temperature or low steam-to-carbon ratio shall be required. Tube-side overheating protection shall be active for all operating conditions including start up. For specific operating modes that may occur on a regular basis, alternate IPFs shall be applied, for example the application of a low nitrogen flow trip (on steam methane reformer furnaces during start up).

The use of a time-delayed trip is an acceptable method to cover flow surges, particularly if the standby pump is equipped with an autostart. The duration of the time delay, however, shall be minimized to avoid damage/coking of the tubes.

A high process outlet temperature trip shall be applied to prevent serious overheating of process tubes or, in certain cases, to protect downstream equipment. Such trip may involve a trip to minimum firing, rather than a total fuel trip.

The primary means of providing tube side protection for boilers and immersed fire/exhaust gas tube heaters shall be to ensure an adequate liquid level in the steam drum or fired vessel together with a sufficient liquid hold-up below the low-level trip. When liquid levels in the steam drum or fired vessel are below the low-level, fuel SHALL [PS] be tripped automatically.

A high stack temperature alarm shall be provided on process heaters (as an indication of a possible tube failure).

3.3.4 Pre-ignition purging

For natural draft style heaters, steam purging shall be used. Steam purge shall be for a period not less than 15 minutes or three-firebox volume changes whichever is greater.

If steam is not available or equipment sensitive to moisture is in place, alternate methods of purging shall be agreed to by the Principal. In these cases, the atmosphere inside the enclosure must be checked for the presence of combustibles as per defined operating procedure and at an adequate number of locations. For forced or balanced draft heaters and boilers, purging with the combustion air fan shall be used. The purge air flow shall be equal to the minimum airflow during normal operation (air flow at minimum stop and no less than 25 % of design air flow).

- A higher purge air flow rate may be allowed subject to approval by the Principal.

The purge time as part of a cold start-up or following a low-combustion airflow trip shall be for a period not less than five minutes or five-firebox volume changes,

The purge time as part of a hot start up (e.g., after a trip not related to low combustion air flow) shall be for a minimum duration of 5 minutes.

A heater trip shall not result in an automatic increase of the air flow to the heater or boiler.

3.3.5 Safety protection trips

3.3.5.1 General

The following summarizes the minimum requirements for safety trips in process heaters and boilers (where applicable).

Fireside safety trips (Required time delays between detection and trip activation are indicated in []). Such delay shall include any transmitter filter timer):

- a) Loss of burner flame detection [max 2 s]
- b) Low-low pilot gas pressure [1 s]
- c) High-high pilot gas pressure [1-3 s]
- d) Loss of pilot flame detection [1-3 s]
- e) Low-low burner fuel pressure [1 s]
- f) High-high burner fuel pressure [1-3 s]*
- g) High-high fuel gas KO drum level [5 s]
- h) Low-low atomizing steam/oil differential pressure [1-3 s]
- i) High-high atomizing steam/oil differential pressure [1-3 s]
- j) Low atomizing steam pressure [1-3 s]
- k) Low-low combustion air flow [5 s]
- l) Loss of ID or FD fans (FD/ID fans running trips) [5 s]
- m) Low-low air/fuel ratio [10 s]*
- n) High-high firebox arch pressure (low-low draft) trip as per (3.3.5.8) [10 s]
- o) High-high firebox floor pressure (low-low draft) trip as per (3.3.5.9) [0 s]
- p) Manual heater/boiler ESD trip (local panel and control room) [0 s]

Process-side safety trips:

General process heaters:

- a) Low-low process flow (per pass) (applicable to all furnaces with individual pass control)
- b) Low-low process flow (total) (applicable to all furnaces with no individual pass control)
- c) Liquid feed low-low flow (applicable only to hydro processing heaters with no individual pass control)*
- d) Recycle/Fresh gas low-low flow (applicable only to hydro processing heaters with no individual pass control)
- e) High-high heater common outlet temperature*

Ethylene cracking furnaces:

- f) Low-low feed header pressure downstream feed supply valves*
- g) Low-low process flow (total) (alternative to (f))*
- h) High-high superheater steam outlet temperature (applicable only for units where