Thermatrix Inc.
System Design Criteria Document

Flameless Thermal Oxidizer System

For

Lyondell Equistar
Newtown Square, Pennsylvania

January 24, 2003

RELEASE FOR CUSTOMER APPROVAL
YOUR P. O. # 4400380679LY
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REVISION SUMMARY

Doc. No.	Revision	Date	Description

1 Purpose

This document formally establishes the design and performance requirements for the supply of a Thermatrix flameless thermal oxidizer system (FTO) consisting of one (1) ES-100 oxidizer to the Lyondell Equistar, Newtown Square, PA to treat volatile organic compound (VOC) emissions.

2 References

Process Specification Form, dated April 23, 2002

Thermatrix Proposal 02302, dated May 6, 2002

Thermatrix Proposal 02302FB, Rev. 1, dated October 7, 2002

Lyondell Purchase Order No. 4400380679LY dated December 11, 2002

3 Project Background

The purpose of this project is to design and build an ES-100 FTO system. The system will thermally treat volatile organic compound (VOCs) emissions generated from a pilot plant in the Lyondell Equistar Newtown Square, PA site. VOCs include propane, propylene, methanol, propylene oxide, and others. The system will be located indoors in a Class I, Division 2, Group D electrical area classification.

4 Project Scope

Thermatrix will be responsible for the following project activities:

- Project management including site meetings.
- Crating and preparation for shipment.
- Pre-assembly and mounting of fume and air trains.
- Pre-wiring of control panel and pre-ship functional check.
- Programmable logic controller programming.
- Wiring of mounted instruments, valves and motors to control panel.

Lyondell will be responsible for the following project activities:

- Shipping to jobsite (arranged by Thermatrix and reimbursed by Buyer).
- Unloading and temporary storage.
- Site preparation including civil and foundation preparation.
- Installation of oxidizer system skid on foundation.
- Installation of oxidizer vessel on skid.
- Emissions or performance testing.

5 Equipment Supply Scope

Thermatrix is to design and provide all the components for a thermal oxidation system to be installed at the Lyondell Equistar Newtown Square, PA. Site. The scope is depicted on the Thermatrix piping and instrumentation diagrams (P&ID) 4172-P40-01, Rev. A. The Thermatrix FTO will consist of the following equipment:

- ES Oxidizer with preheaters, refractory, thermowells, thermocouples, and ceramic media;
- Dilution Air Blower with Inlet Filter, a spare second blower is to be provided;
- Control Panel with PLC controls, pre-wiring of panels with pre-ship wiring functional check;
- Power Panel with motor starter and heater power controllers, pre-wiring of panels with pre-ship wiring functional check;
- Stack extending 35 feet from the skid base;
- Piping, Valving, Instrumentation;
- Deflagration Arrester with thermocouple;
- Spare oxidizer thermowell with thermocouple;
- Structural Skid mounted system.

Lyondell will supply the following equipment:

- Ladder and platform for access to stack sampling ports.

6 Process Description

VOC fumes, nitrogen, carbon dioxide, and water vapor are emitted from a pilot plant. The "Hydrocarbon Vent Stream" is piped to the FTO system. The fume stream is combined with dilution air and is sent to the oxidizer under positive pressure.

The Thermatrix flameless oxidation process is based on a patented matrix that enhances the oxidation process. The matrix is a carefully designed volume of inert ceramic media selected for its thermal properties. Equipment and instrument tag numbers may be found on Piping and Instrumentation Drawing 4172-P40-01. The design flow rates for the thermal oxidation system are shown on Process Flow Diagram 4172-P30-01.

The tie point for the fume collection system is at the edge of the Thermatrix system skid. The fume enters the ES-100 skid through an air operated block valve and the flow is indicated with a rotameter. The fume is directed to the bottom of the oxidizer. Dilution air is required to maintain the proper operating temperature of the oxidization zone as well as to keep the operating limit of the system below the LFL. This is automatically accomplished by maintaining a constant volume dilution airflow through the system.

A blower is used to supply this dilution air. The flow rate of air to the oxidizer is measured to provide local indication. An air-actuated block valve is opened when the blower is energized.

The oxidizer shell is fabricated of carbon steel and lined with a refractory blanket that reduces the external skin temperature suitable for the electrical area classification. The oxidizer has three internal vertical protection tubes that house the heating elements. A single vertical thermowell in the bed is also provided. The oxidizer contains randomly packed ceramic saddles that fill the oxidizer from the bottom to 12 inches above the top of the protection tubes. During startup, the cold ceramic media is heated using the electrically controlled heaters. The heaters operate during the run mode to enhance low BTU fume streams. For the "Normal Case" basis the heaters are expected to operate at partial capacity as needed. For the "Maximum Case" basis the heaters will be idling.

The gas mixture enters a nozzle on the bottom of the oxidizer and flows upward through the media. The oxidation reaction takes place at the heated region of the ceramic bed. The oxidation occurs in an 8 to 12 inch zone and the temperature rises from the inlet temperature to the full operating temperature. Hydrocarbons are oxidized to carbon dioxide gas and water vapor. Nitrogen and excess oxygen are also present in the reaction products. The oxidation reaction generates heat, which is transferred and stored in the media. The hot media then radiates heat back to the incoming gas mixture and sustains the oxidation reaction. Above the reaction zone, the temperature of the media is at the operating temperature. The upward flowing gas emerges from the media and into the oxidizer headspace, which is lined with refractory blanket. A 12-inch nozzle exhausts the reaction products into a refractory lined stack that vents to atmosphere.

7 Design Basis and Performance Criteria

7.1 Process Stream Design Basis

Lyondell supplied stream flow and composition data (Process Specification Form dated April 23, 2002) provides the following instantaneous maximum design basis for the Newtown Square, PA site thermal oxidizer system:

Flow rate	Units	Normal Fume	Maximum Fume
Flow	SCFM	1.6	2.0
Temperature	°C	10 - 30	10 – 30
Relative Humidity	%	1.5	0
Pressure (tie-point)	IWG	24	30
Major components			
Oxygen	lb/hr	0.48	0.42
Nitrogen	lb/hr	3.74	2.33
Carbon dioxide	lb/hr	0.02	0.004
Propane	lb/hr	4.5	10.0
Propylene	lb/hr	1.14	1.3
Methanol	lb/hr	0.004	0.03
Propylene oxide	lb/hr	0.0001	0.0001
Hydrogen	lb/hr	0.01	0.00

The "Maximum Fume" listed above is the highest permissible safe fume loading for the thermal oxidizer. Total oxidizer capacity to safely treat other chemical mixtures is dependent on the composite physical and chemical properties of the mixtures. Thermatrix does not authorize the processing of other fume mixtures or of mixtures which exceed the loading of the "Maximum Fume" case without thorough Thermatrix review and written approval.

7.1.1 Performance Criteria

The oxidation system is guaranteed to destroy 99.99% of the Volatile Organic Compounds (VOC) in the incoming fume stream or 1 ppmv per VOC in the oxidizer exhaust, whichever is less restrictive.

7.1.2 Other

Equipment provided by Thermatrix is warranted to be free of defects in materials or workmanship, under normal and proper use, for a period of 12 months from initial operation of the product, or 18 months after shipment, or 18 months from notice of readiness to ship, whichever first occurs.

Lyondell Equistar will be responsible for stack sampling to verify the system performance meets the specifications.

The stack will be provided with two sampling ports (6-inch min.) with no access platforms to the ports. Lyondell Equistar will be responsible for the regulatory mandated operational stack sampling and analysis.

Client Name/Location: Lyondell Equistar, Newtown Square, PA. **Project No: 4172**	**Description** (use attachments if necessary)
1. Scope of Project	
1.1 Equipment Configuration Associated with P.O.	
1.1.1 PFD (Process Flow Diagram)	Process Stream Table Rev. A, Project 4172
1.1.2 P&ID (Piping and Instrumentation Diagram)	Dwgs. 4172-P40-01, Rev. A
1.2 Type of controls: PLC, DCS, or I/O only	PLC
1.3 Responsibility for Controls Programming: TMX or Client	TMX
1.4 Responsibility for Electrical motor control: TMX or Client	TMX
1.5 Responsibility for Lighting: TMX or Client	Lyondell
1.6 Communications (Phones, Radios, Intercoms, etc.)	Not Provided by TMX
1.7 Safety Showers	Designed, supplied and installed by Lyondell
1.8 Fire Protection Plan	By Lyondell
1.9 Emission Monitoring Requirements	TBD by Lyondell
1.10 Civil – foundations and curbing	TMX will supply load diagrams including stack support load. Lyondell will provide foundation engineering, design, installation, and stack support engineering, design, and installation.
1.11 Type Of Heat Tracing: Steam Or Electric	Not Provided by TMX
1.12 Responsibility For Heat Tracing And Insulation	Not Provided by TMX
1.13 Engineering Documentation	
1.13.1 Definition of approval documents	SDCD, P&ID, PFD, General Arrangement
1.13.2 Number of document iteration cycles	1
1.13.3 Electrical design requirements	Electrical one-line drawing
1.14 HAZOP	Not Included by Lyondell Request
1.15 Overall Project Schedule	TMX will provide and maintain project schedule
2.0 **Fume Data**	
2.1 General Fume Characteristics	
2.1.1 Source description	See Process Specification Form dated April 23, 2002. Supplied by Lyondell.
2.1.2 Capability to treat Explosive Group B gases	No. The system is not designed for a Group B composite mixture. The Normal Case contains a maximum of 0.01 lbs/hr hydrogen but this does not result in a composite group B gas feed to the FTO. There is no hydrogen in the Maximum Design case.

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2.1.3 Halogenated gases present	No
2.1.4 Sulfonated gases present	No
2.1.5 Nitrogenated gases present	Nitrogen
2.1.6 Free acids present	No
2.1.7 Carrier gas	Nitrogen
2.1.8 Oxygen concentration	6% mole fraction, per Process Stream Design Basis
2.1.9 Relative humidity	0 - 2%
2.2 Flow Rate & Composition vs. Time	Detailed in Process Stream Design Basis
2.3 Supply Pressure and Motive Force	Detailed in Process Stream Design Basis
2.4 Tie Point Location, Line Size, Connection Type	Per TMX P&IDs and General Arrangement drawing.
3.0 Tie Point Definition & Criteria *Quantity available is stipulated where there are limitations; if not stipulated, design requirement will be stipulated.*	
3.1 Electric Power	
3.1.1 Control Voltage	120 vac, 1 phase, 60 Hz, 20amp
3.1.2 Lighting Voltage	Not applicable
3.1.3 Voltage Available for Large Power Loads (e.g., motors)	480 volts, 3 phase, 60 Hz, 100amp
3.1.4 Electrical Area Classification	Class I, Division 2, Group D
3.1.5 Tie Point Location	Lyondell to provide power wiring to TMX control panels. TMX to provide single line drawing and wiring diagram.
3.2 Fuel Gas	Not applicable
3.3 Water	Not applicable
3.4 Instrument/Plant air	
3.4.1 Quantity Available	5 SCFM continuous required
3.4.2 Dew Point	(-30°F)
3.4.3 Pressure	80 psig
3.4.4 Tie Point Location, Line Size, Connection Type	Lyondell to field route and connect to TMX Tie Point #3 per TMX P&IDs and General Arrangement drawing.
3.5 Controls	
3.5.1 Location of Man-Machine Interface (panel at FTO or at remote location)	Panel on FTO control panel. PLC shall be Allen Bradley
3.5.2 Location of Controllers (panel at FTO or at remote location)	Control panel – Locate HOA switches in front of control panel in skid

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3.5.3 Shared Signals (remote indication)	Not applicable
3.5.4 Client Control Interface	Not applicable
3.5.5 Tie Point Location	Not applicable
3.5.6 Remote Communications	Not applicable
3.6 Caustic Supply	Not applicable
3.7 Steam Supply	Not applicable
3.8 Liquid Blowdown	Not applicable
3.9 Vent Stack	
3.9.1 Stack Discharge Elevation	Extends 35 feet from the skid base
3.9.2 Minimum Stack Discharge Velocity	TMX standard
3.9.3 Maximum Stack Surface Temperature	392 °F Maximum
3.9.4 Required Sample Port Connections (no., size, orientation, location on stack)	2 @ 90° apart, 1" NPT 3000# Couplings, location selected by TMX
3.9.5 Tie Point Location, Line Size, Connection Type	Vent Stack is within TMX scope. Lyondell to support stack.
3.10 Other Customer Supplied Interfaces	Not applicable
4.0 Performance Data	
4.1 Emissions Performance Data	
4.1.1 DRE	
4.1.1.1 High VOC destruction required (99.99%)	99.99% VOC destruction or 1 ppm_v per VOC in the oxidizer exhaust, whichever is less restrictive.
4.2 Operating Performance Data	
4.2.1 Desired Turn-up and turn-down	None
5.0 Materials Requirements	
5.1 Equipment/Instrumentation Component Grade	
5.1.1 Chemical/Refinery Grade	TMX standard
5.2 Materials of Construction Preferences *These may be defined in Design Specs section; but should be summarized here*	
5.2.1 Fume Piping, Valves, Instruments, Specialties	TMX standard
5.2.2 Oxidizer Components	TMX standard
5.2.3 Dilution Air Piping, Valves, Instruments, Specialties	TMX standard
5.2.4 Dilution Air Blower	TMX standard
5.2.5 Vent Stack	TMX standard

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5.2.6 Flame arrester	TMX standard
5.2.7 Dilution Air Heater	TMX standard
6.0 **Project Specifications**	
6.1 Meteorology & Site Conditions	
6.1.1 Wind Speed	Lyondell to supply
6.1.2 Prevailing Wind Direction	Lyondell to supply
6.1.3 Average Temperature	Lyondell to supply
6.1.4 Extreme Low Temperature	Lyondell to supply
6.1.5 Winter Dry Bulb (minimum 99%)	Lyondell to supply
6.1.6 Summer Dry Bulb (maximum 99%)	Lyondell to supply
6.1.7 Average Rainfall	Lyondell to supply
6.1.8 Design Snow Loading	Lyondell to supply
6.2 Seismic	Seismic Zone Factor Design 0
6.3 Elevation Above Sea Level	Lyondell to supply
6.4 Design Specs (client vs. TMX; attach client's if applicable)	
6.4.1 Piping	TMX standard
6.4.2 Mechanical	TMX standard
6.4.3 Electrical	TMX standard
6.4.4 Instrumentation	TMX standard
6.4.5 Layout	TMX standard
6.4.6 Structural	TMX standard
6.4.7 Painting and Coatings	TMX standard
6.4.8 Noise	TMX standard
7.0 **Client Preferences and Special Requirements**	
7.1 Space Requirements	See General Arrangement Drawings
7.2 Preferred Suppliers	
7.2.1 Equipment	None
7.2.2 Instrumentation	None
7.2.3 Controls	None
7.2.4 Electrical	None
7.2.5 Valves	None

Client Name/Location: Lyondell Equistar, Newtown Square, PA. **Project No: 4172**	**Description** (use attachments if necessary)
7.3 System Assembly & Testing	
7.3.1 Pre-Assembly(air blower; piping; oxidizer)	Pre-assembly and mounting of fume and air trains by TMX
7.3.2 On-site assembly	Installation of Oxidizer vessel on skid and stack by Lyondell
7.3.3 Testing Location and Scope	Pre-wiring of control panel and pre-ship functional check by TMX. Emissions or performance testing by Lyondell.
7.3.4 Transportation Size Limitations	All components can be shipped per DOT regulations.
7.4 Drawing Conventions	
7.4.1 Drawing Numbers	TMX numbering system
7.4.2 Equipment & Instrument Tag Numbering	TMX numbering system
7.4.3 Drawing Symbols	TMX numbering system
7.4.4 Dimensions (English, metric, mixed metric)	English, °F
8.0 Level of Redundancy	
8.1 Major Equipment	Non-installed spare Blower and FTO Thermowell /Thermocouple
8.2 Instrumentation & Control	Per TMX P&ID
9.0 Process Control Methodology	
9.1 System Interlocks/Switches	Per TMX P&ID