Attachment Nº D

Roche Ireland incinerator

Introduction.

Overview of System.

The Roche Ireland incinerator may be considered to comprises five distinct parts.

1. VOC fume collection from production plant process vents.
2. Destruction of VOC fumes by direct fired thermal incineration.
3. Odorous fume collection from the waste water treatment plant (WWTP) aeration cells, and destruction/removal of the odour using the incinerator.
4. Waste solvent incineration.
5. Waste heat recovery and steam generation for plant use.

Objectives of the Project.

1. **To achieve compliance with Irish air pollution control legislation** Roche Ireland is required under the conditions of its Integrated Pollution Control (IPC) Licence to reduce licensed emissions of volatile organic compounds (VOC's which basically in our case are solvent fumes) from the manufacturing plant process ventilation stacks.
2. **Reduce odour releases from Waste Water Treatment Plant aeration basins.**
3. **Minimise offsite waste solvent disposal** by providing on-site disposal capability.
4. **Energy recovery:** the combustion of VOC fume requires a lot of energy to maintain the 1100°C combustion temperature as appropriate. The incinerator

requires a supplementary fuel and/or waste solvents can be used. Energy recovery from the hot combustion gases makes good economic sense, and is also a requirement of the European Union Directive on hazardous waste incineration.

VOC Fume Collection System.

Production Plants.

All in-plant process vents that can contain VOC or other vapours or gases at concentrations in excess of the BATNEEC and/or IPC licence emissions limits have been connected to new process ventilation headers. These new process vent headers will feed the VOC fume or gasses to the incinerator system.
The new process vent headers are of stainless steel construction, and are rated for working pressures of up to 10 Bar gauge or 16 Bar gauge depending on the pipeline internal diameter. The design of the new vent header systems, from a safety point of view, is based on the German Trbf 100 (technical regulations for flammable liquids) standard.

A typical in-plant process vent system now comprises three separate process vent headers, each designed for a particular venting application.

1. **VOC rich fume header :** the rich header system is designed to process VOC rich emissions from mainly reaction vessels, storage tanks, filter systems and centrifuges. Safety of the system is assured by the prevention of a flammable atmosphere within the vent header by exclusion of oxygen. Rich headers have been equipped with continuous oxygen monitoring. Oxygen ingress to the header system is minimised by nitrogen inerting all of the equipment systems connected to the header, and also by operating the header at all times under a small positive pressure of about 50 mBar gauge. Should the oxygen level in any rich header rise above 50% of the MOC (minimum oxygen concentration to support combustion) then automatic injection of nitrogen to the header will occur to correct the situation. Knockout collection pots have been provided to collect any liquid which may condense within a vent header. Venting rates of equipment connected to the header will be limited and controlled automatically where necessary, mostly on reaction vessels, so as not to exceed the design flow-rate of any individual header system. The maximum vent flow-rate from any individual reaction vessel will be limited to 300 Nm^3/hr by a control valve installed in the vent pipeline.

2. **Vacuum equipment vent header :** a separate vent header system has now been provided for equipment that operates under vacuum, for example product dryers. Oxygen ingress is always a possibility where equipment is operating under vacuum, and inerting by nitrogen injection may not be practical where a large in-leakage might occur. Consequently a flammable atmosphere might be present at some time. The basis of safety for the vacuum system header, following the Trbf 100 standard, is to design the header piping to withstand and contain any internal fire or explosion. Header pipelines up to and including 200 mm internal diameter are rated for a 10 Bar gauge operating pressure and larger diameter header pipelines carry a 16 Bar gauge pressure rating. Additional detonation flame arrestors have also been installed at the vacuum pump exhaust outlets to prevent propagation of any explosion or fire into any plant equipment system.
   A P. and I.D. of the plant waste gas collection system connection to the incinerator is provided.

3. **Lean header system :** this header system collects air streams which contain levels of contaminants at concentrations below the BATNEEC emission limits. These mainly result from local air extraction systems at, for example, solvent drum or acid carboy handling stations. Air collected from these points is drawn through mainly GRP header piping and exhausted through the existing roof mounted exhaust process ventilation stacks.

3. Hydraulic Flame Arrestors.

How they work:

There are two hydraulic flame arrestors installed within the scope of air emissions reduction project, one to receive process vent gases from the combined 04 Mofetil/Mibefradil plants and the second to receive process vent gases from the combined 05/06/07/07MP plant areas. They are one of the main safety devices associated with the transfer of flammable vapours to an incinerator system. Both are installed outside of and adjacent to their respective plant areas.

- The purpose of the hydraulic flame arrestor is to protect the plant area and its equipment from any possible propagation of a flame back into the plant from the external gas/vapour transfer piping to the incinerator. The hydraulic flame arrestor will prevent either a deflagration (flame speed less than speed of sound) or a detonation (flame speed greater than the speed of sound) from passing through and entering the in-plant header systems.

- The hydraulic flame arrestors are horizontally mounted pressure rated vessels, in our case of stainless steel construction. There is a water level maintained in the bottom of the flame arrestor, it should be about one third full. This water level is very important ensure to the proper operation of the hydraulic flame arrestor. Vent gases from the plant areas are fed into the hydraulic flame arrestor through horizontally inserted sparge pipes, each with a series of holes drilled on the underside along the full length. The vapour or gas exits from underneath the sparge pipes and rises through the water to enter the head space above the water surface. From here it is drawn through a control valve into the main transfer pipe to the incinerator by the variable speed waste gas fans located down in the incinerator area. It should be noted that these fans are the only means of extracting gas or vapour from the plant process ventilation systems. The speed of the fans is regulated by the incinerator Siemens plc control system to maintain slight positive pressures in both the hydraulic flame arrestor head space and the in-plant process vent headers.
- There is a maximum acceptable gas or vapour flow-rate to the hydraulic flame arrestors. The principle of operation requires that the VOC vapour must rise through the liquid as discrete bubbles (in fact hydraulic flame arrestors are often referred to as bubbler tanks). If there is excess vapour flow-rate then a continuous rising vapour plume may form within the water level and this could provide a pathway for a flame to propagate back into an in-plant header. Each plant header system therefore has automatic high flow measurement, and controls and interlocks to prevent excessive flow. In the unlikely event that these controls fail to prevent an excessive flow then the header will be automatically isolated from the hydraulic flame arrestor and the excess flow will be allowed to blow off through an emergency vent located above the plant roof level.
- The water in the hydraulic flame arrestor should be maintained at or above 10°C. There is a water temperature control loop, and heating is achieved by steam injection.
- The correct water level within the hydraulic flame arrestor must be maintained at all times. There is a level control loop provided. To avoid a build-up of contaminants in the water there is a continuous drain off or blow-down through the level control valve on the bottom outlet, about 1 litre/hour is the design. This is sent to the process drain system.

- The pH of the water is monitored and automatic addition of caustic will be carried out to neutralise any acidic condition.
- Temperature switches are fitted in the head space of the hydraulic flame arrestor to detect a high temperature in the unlikely event of a fire in the main transfer piping to the incinerator. Activation of these temperature switches will result in immediate shutdown of the incinerator and isolation of the hydraulic flame arrestor.

5. Liquid Wastes.

5.1 Waste Solvent Storage.

Waste solvents from the production plant areas are transferred from the individual plant area waste solvent tanks, T0739-T0 and T0412-T0 to one of two 80,000 litre bulk storage tanks in the Solvent recovery plant area. Tank T1834-T0 is designated for non-chlorinated waste solvent storage. T1835-T0 is designated for chlorinated waste solvent storage. Assay tanks, T1834-T1 and T1835-T1 are provided for the preparation and assay of batches of waste solvent feed to the incinerator. Tanks are provided with level measurement to indicate the volume, and hence mass, of the waste solvents to be incinerated, and sample points are provided to take representative samples for chemical analysis.

The waste solvent transfer pumps and valves are operated using the plant DCS system.

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02523	90731451	+49 2151-899-240	schneider@keu.de	19. August 2005

Our project no: 90731451

Dear Sirs,

please find attached our quotation no. 90731451 regarding the +/-10% estimate for the Stand-by Thermal Oxidiser Unit for Roche Ireland Ltd.

best regards

KEU GmbH

Reinhard Schneider

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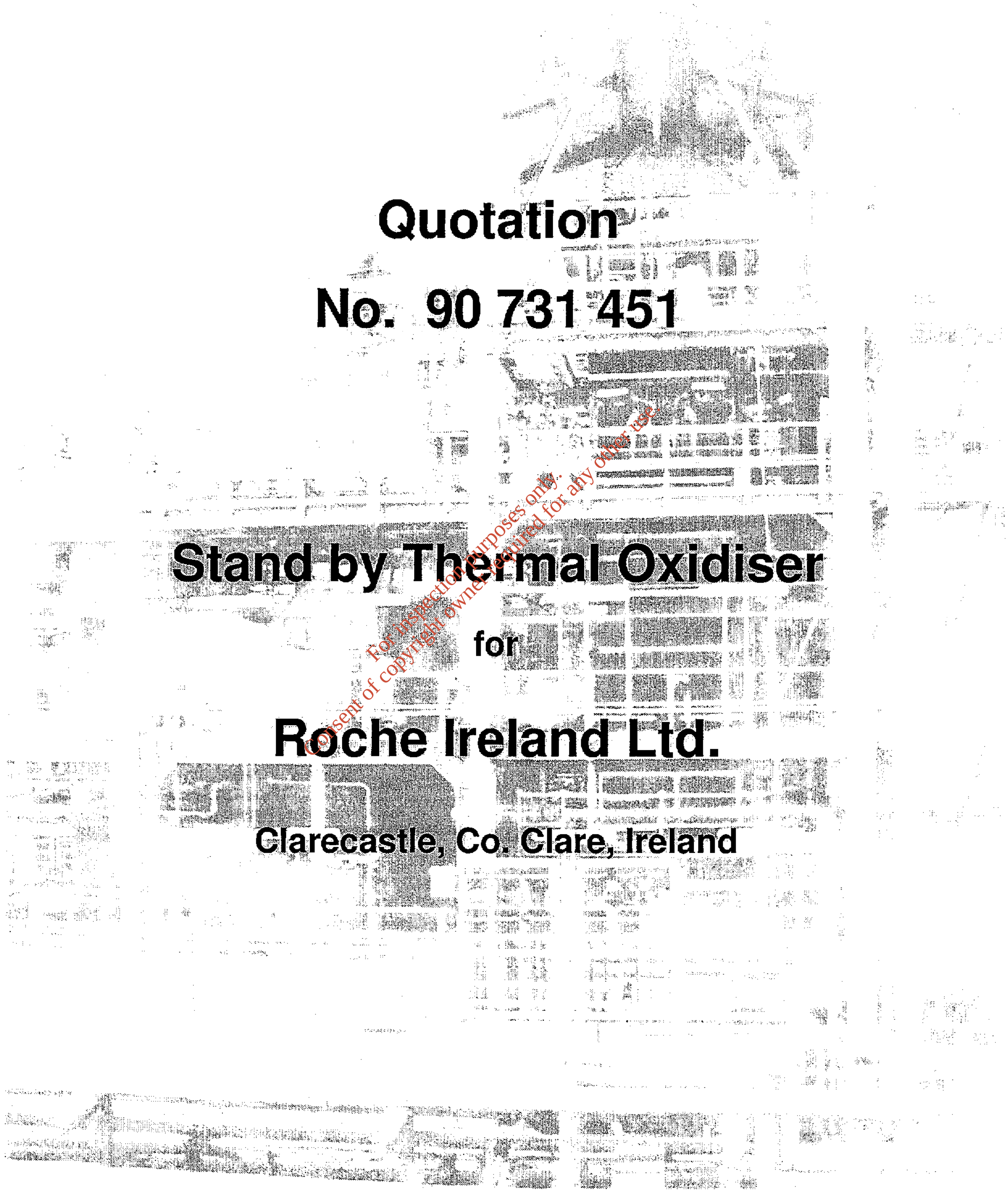

Quotation

No. 90 731 451

Stand by Thermal Oxidiser

for

Roche Ireland Ltd.

Clarecastle, Co. Clare, Ireland

Your contact for sales, process engineering and project planning:

Reinhard Schneider

phone: +49 2151 899 240 fax: +49 2151 899 111 email: schneider@keu.de

Content

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I. Technical Part

A. BASE OF PROPOSAL

Base of this proposal are:

- your bid inquiry no. 02523 dated September, 14th 2004
- the technical clarifications afterwards incl. the HAZOP
- the basic engineering documents attached

B. PROCESS DESCRIPTION

The quoted thermal oxidiser system is designed to treat the two different waste gas streams with its variing composition and consists basically of following process steps:

- Supply lines with fittings and flame arresters
- Combustor and reaction chamber
- SNCR – Thermal DeNOx
- Flue gas quench
- Flue gas scrubber
- ID-fan
- Plume suppression

The unit is designed as an outdoor installation in a non-ex area.

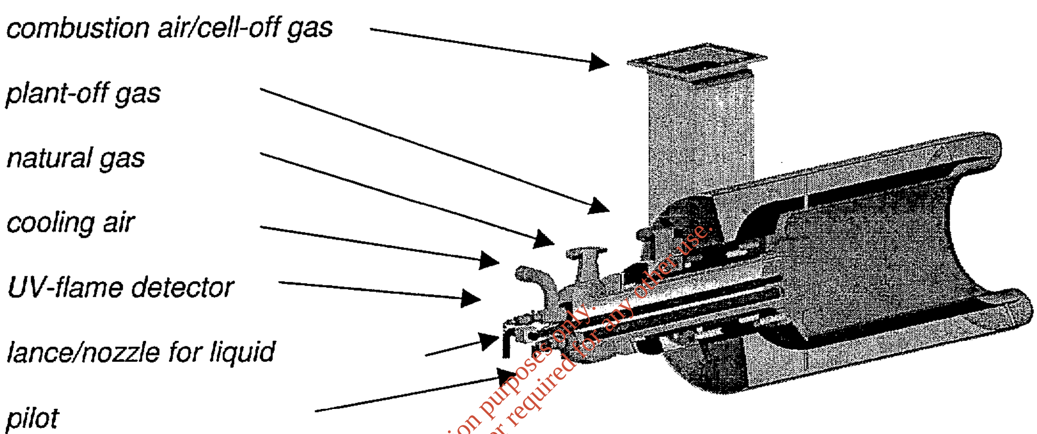
Supply Lines - Safety:

The plant-off gas is classified into Explosive Zone 0. As the combustion process with its flame is a continuous ignition source, the production side has to be protected with three independent safety devices from this ignition source. This is done by one static flame filter for the waste gas, which is designed as detonation arrester, one (existing) liquid flame arrestor and one dynamic flame barrier. Also the equipment for the plant off gas line – especially the blower – is designed and suitable for Ex-Zone 0 streams.
The explosivity class of the solvents possibly present in the waste gas is II B3, which means an MESG (Maximum Experimental Safe Gap) ≥ 0.65 mm. Therefore the flame arresters are designed for IIB3-solvents and are equipped with filter gaps of 0.5 mm.
The cell-off gas is classified into Explosive Zone 2, one static flame arrestor – designed as detonation arrestor - is provided.

Combustion Process

The key part of the system is the KEU-Combustor, starting the whole incineration process. The Combustor is a multi-purpose burner system. It is is constructed as one compact unit consisting of burner and combustion chamber. The waste streams are thoroughly mixed with the combustion air and the support fuel and are then combusted in a high-turbulence vortex flow. The advantages are:

- Equal temperature level across the section of flame
- Low formation of NOx
- High destruction efficiency at lowest possible temperature level



Picture 1: KEU Combustor

This design performs an optimized combustion process regarding the important three „T"-factors: **T**emperature, **T**ime and **T**urbulence. The result is a complete reaction, which means a complete destruction of the VOC's and chlorinated hydrocarbons. The resulting products (referring to the chlorine) of this process is HCl and according to the Deacon-equilibrium also a small amount Cl_2., but no intermediate products, which could form Dioxins.

Regarding those three **T**'s the following values are base for the design:

max. volume flow	$\dot{V}_n$	9,000	m_n^3/h
temperature	T	1,100	°C
pressure	p	-50	mbar

This gives an actual volume flow $\dot{V}_a$ of:

$$\dot{V}_a = \dot{V}_n \frac{273.15 + T}{273.15} \frac{1.013}{p} = 13.22\ m_a^3/s$$

The design of the reaction chamber with the dimensions mentioned below gives a free volume of app. 26.5 m³ in the reaction chamber. That leads to a residence time of two second at maximum operating conditions before the DeNOx-stage. This residence time together with the operating temperature and the turbulence ensures a complete reaction even liquid solvents containing chlorinated hydrocarbons would be injected.

For the start-up of the unit is heated up with combustion air (ambient air) and support fuel (natural gas) up to operating temperature, then it is allowed to switch on the waste gases PLANT OFF GAS and CELL OFF GAS.
The CELL OFF GAS with its oxygen content is used as combustion air. It is - together with ambient air – suctioned in into the tangential inlet of the Combustor. The frequency-controlled ID-fan provides the required negative pressure in the reaction chamber.
This constant negative pressure ensures stable conditions for the reaction itself and prevents back flow to the header systems. As the whole oxidiser unit is operating with underpressure, any leackage can not lead to unreacted or hot flue gas emissions.
The PLANT OFF GAS is fed into the organ-set of the combustor. The PLANT OFF GAS supply line is equipped with a Zone-0-fan, certified for this application.

The combustion process itself is generally controlled by the temperature of the reaction chamber. On the one side support fuel provides the minimum temperature in case of no VOCs coming with the waste gas, on the other side additional combustion air provides the necessary oxygen for a complete reaction and keeps the reaction temperature within its limits in case of high VOC-loading of the waste gas.

Due to the flue gas dew points, the inner refractory lining together with the outer insolation is designed to provide a metal shell temperature of > 150 °C under all ambient conditions.

<u>*DeNOx-system:*</u>

Downstream the reaction chamber the flue gas directly enters the DeNOx-chamber. The DeNOx-stage works according the SNCR-process (**S**elective **N**on **C**atalytic **R**eduction). This SNCR follows generally the reaction:

$$NO_x + NH_3 \xrightarrow{DeNOx-temperature} N_2 + H_2O$$

and works at the so-called DeNOx-temperature, which means the temperature window between 950 – 1000 °C. Too low temperatures (< 950 °C) cause the so-called NH_3-slip, which means that remaining unconverted ammonia will be emitted or results in ammonia salt by HCl. Too high temperatures (> 1,000 °C) will cause to much oxidation of the agent NH_3 leading to higher NO_x formation. Coming with an temperature of 1100 °C out of the reaction chamber, the flue gas is first cooled down to the DeNOx-temperature by ambient air, before the DeNOx-agent is injected.

The NOx-concentration is reduced below the required emission limit by the addition of ammonia-water into the flue gas. The correct amount of ammonia water is calculated based on the NO-value in the raw gas, the NOx-value in the clean gas and the flue gas mass-flow.

The DeNOx-chamber provides the adiabatic residence time for this process.
Some more detailed equations of this process are:

$$6NO + 4NH_3 \xrightarrow{950-1000°C} 5N_2 + 6H_2O$$
$$6NO_2 + 8NH_3 \xrightarrow{950-1000°C} 7N_2 + 12H_2O$$
$$4NO + O_2 + 4NH_3 \xrightarrow{950-1000°C} 4N_2 + 6H_2O$$
$$2NO_2 + O_2 + 4NH_3 \xrightarrow{950-1000°C} 3N_2 + 6H_2O$$

The DeNOx-agent used here is an urea-solution, as it's available on site. This gives the required ammonia according:

$$H_2N - CO - NH_2 \ + \ H_2O \longrightarrow \ 2NH_3 \ + \ CO_2$$

Flue gas treatment:

Generally, the quality of the flue gas requires a quenching stage and an absorption stage.

This principle of flue gas cleaning is extended by integrating a gas cooling and condensation step. This process technological principle of additional gas cooling down to app. 45 °C leads to:

- a substantial reduction of the flue gas quantity
- considerable reduction of water consumption
- together with the clean gas reheater a plume free operation

High-Temperature Quench S1702-H1:

The flue gas out of the DeNOx-chamber is quenched down from the app. 1000 °C to almost the saturation temperature in a jet scrubbing quench S1702-H1 (cooling through water evaporation). The saturation temperature is depending on the gas throughput, the inlet temperature and water content in the inlet gas.

The flue gas enters the quench from the top and is sprayed, in parallel flow, with the uncooled circulation liquid. Depending on the water evaporation, the flue gas cools down to a limiting cooling temperature. At the same time a large part of the HCl is absorbed at the droplet surfaces. Aerosol formation classes like SO_3 (H_2SO_4- aerosols) are growing together (heterogeneous condensation).

The inlet area of the quench can stand a continuous thermal load up to 1200°C via a rinsing collar. The rinsing collar is made of a material which is highly heat resistant (Haynes 556; max. surface temperature 1250°C).

In the case of the quench, circulation water is fed tangentially in the area of the rinsing collar behind the rinsing collar. As a result of the impulse through the tangential feeding of the water, a rotating liquid ring is produced. As a result of this, the cleaning water runs down the wall as a even film that is resistant to dirt and thus leads to a protection of the next part of the quench equipment in steel rubberised design. The tangential jets are located in the liquid ring and are therefore always protected. A jet level with flat spray jets is arranged under the rinsing collar. These jets are located in the nozzle behind the protective liquid wall film. A continuous spray area is formed at the collection point beneath the droplet levels which meet here because of the collision of the droplets, and this leads to the pre- quenching process. This pre-quenching is sufficient for adequate cooling of the remaining gas flow in the case of emergency but with a considerably reduced gas quantity. These two first jet levels (tangential rinsing collar and flat spray jets) are necessary for the protection of the equipment and are therefore also supplied during emergency operation. On account of the over-dimension of the rinsing jets, smooth running is possible even if a jet breaks down because of clogging.

The following third jet level consists of the main scrubber jets which, in the same way as the flat spray jets in the jet nozzle, are also safely protected at an angle of 60° behind the wall film. Here, in the same way as with the flat spray jet system where the jets meet beneath this point, there is also an even distribution of the droplets over the cross section of the equipment. The possibility of the droplets reaching the wall is thereby reduced.

Tank S1702-S1:

This quench stage is equipped of course with a tank S1702-S1 and recirculation pumps S1702-P1/2 (duty, stand-by). The water loss due to evaporation and blow down minus the condensed amount of water will be balanced by level-control with softened water.

Scrubber system S1702-S1:

The saturated flue gas out of the quench exhausts into the scrubber column including a packed bed and a mist separator. The scrubber column is set on top of the tank. The flue gas enters at the bottom and flows through the packed bed, while the scrubbing liquid is fed in at the top of the packed bed and flows in cascades over the bulk material in counterflow. The remaining contaminants (mainly acid gases) are removed and neutralised to salts, chiefly by the means of NaOH for the HCl (controlled by the pH-value).

The salt concentration in the scrubbing liquid is limited by the water blowdown, controlled by the conductivity of the scrubber liquid. To avoid excessive droplet carry over a mist separator including water wash is installed at the tower outlet.

Analog to the existing system there is a plate heat exchanger S1702-H2 to cool down the scrubbing liquid for the column. This decreases the flue gas flow by condensing water vapour and therefore to total water vapour carried out of the system.

Reheater C1702-H1, ID-fan C1702-E1:

Downstream the scubber column the ID-fan leads the flue gas towards the stack. The design of the ID-fan covers the increads clean gas flow in case of no cooling water available.

Downstream finally the heat exchanger C1702-H1 reheats the flue gas, using steam. This reheater together with the scrubber-liquid subcooler S1702-H2 provides a plume-free operation.

C. Design Datas

1. Waste Gases

a) Plant Off Gas

• Flowrate, max.	2500	m_n^3/h
• Pressure at battery limit	-38	mbar
• Temperature at battery limit	ambient	
• Composition:		
O_2:	0 – 21	vol-%
H_2O:	saturated	
N_2:	balance	
VOC's with max:	HCl: 196	kg/hr
	N: 10	kg/hr
	CV: 2,200	kW

b) Cell Off Gas

• Flowrate, max.	750	m_n^3/h
• Pressure at battery limit	-1	bar g
• Temperature at battery limit	ambient	
• Composition: air	100	vol-%

2. Utilities

Utilities required by the system:

- Natural gas – as support fuel
- instrument air, min. 5 bar g – for pneumatic actuators
- electricity – for blowers, pumps and field instrumentation
- caustic – for neutralisation
- softened water – for quench/scrubber system
- emergency water – for quench/scrubber system
- steam – for clean gas reheating
- compressed air – for atomizing
- urea – for DeNOx-purpose
- process water – for purging urea line
- cooling water – for the heat exchanger

3. Process Datas

For the process datas and the different utility-consumptions please refer to the table on the flow-sheet and the utility-list attached.

D. PROCESS WARRANTY

1. Emissions

KEU guarantees that the quoted oxidiser system attains in an odourless combustion process at least the relevant emission criterias, given in the specification and summarised below:

Emission limits for release to air (daily average):

VOC	≤ 10	mg / m_n^3
HCl	≤ 10	mg / m_n^3
CO	< 50	mg / m_n^3
NO_x	< 200	mg / m_n^3

The values are based on 11 vol-% oxygen and dry flue gas during normal operation.

2. Noise

Noise level will not exceed 80 dB(A) sound pressure level, measured at 1 m in any direction from the individual equipment, during normal operation.

E. Scope Of Supply And Specification

1. Engineering and Documentation

a) Process Design Engineering

Includes verification of process flowsheets and material balances, complete heat balances across the system and specification of operation parameters for all of the equipment items. Includes also four meetings in Clarecastle during the project-execution (e.g. kick-off, review-meeting general, review/coordination control system, erection coordination).

b) Equipment Design Engineering

Includes detailed engineering for each major equipment component in the system. Also includes preparation of specifications for those equipment items which will be purchased from subcontract vendors or fabricators.

c) Electrical Design and Instrumentation Engineering

This part of the engineering provides all information to Roche, which is necessary for designing and adding the control system, programming the software and doing the cabling from the junction boxes to the control cabinets. Examples for all mentioned documents are attached. Documentation will be in englisch language, in detail consisting of:

- Measuring and control loop list

contains all tag no. and short descriptions of engaged measuring devices as an overview

- Measuring and control loop

Detail informations for all measuring and control loops, regarding process informations, mechanincal and pipework informations and engaged devices

- Signal list

List of all inputs and outputs and there destinations to PLC, fail safe PLC or DCS. This list will give the quantity structure for the programmable logic controller

- Electrical motor list

List of all electrical consumer e.g. electrical motors, electrical preheater etc.

- Functional description

A verbal description of the used plant functions.

- Field equipment list

List of field equipment includes: type, fabricator, auxilary power, type of input, type of output etc.

- Switching function and alarm text

Detailed descriptions about each single switchpoint and there use in plant function

- cause – effect diagram

A matrix diagram showing how in plant sensors co-operate with in plant actors.

- List of set points and limit values

A list of all set point values and limit values used in the plant

- controlschema

Schematic diagram how the close control loops will work and what's the specific field parameters

- specification sheets

Specification sheets for each field instrument used in the plant

- functional logics

Functional logic diagramm for the fail safe part of the logic.

- example screenshots

screen shots of other DCS screens used for equivalent plants and later on hand scetches to help the DCS people to create the DCS sreens.

- loop diagrams

showing each instrument loop from field device up to field junction box.

d) *Structural Engineering*

Includes design of the structural steel as shown in the layout, incl. all required supports and platforms to provide access, provision of all necessary structural calculations.

e) *Piping design*

Includes the piping design acc. RIRL piping specification where applicable, otherwise KEU-standard as shown on the P&ID's (e.g. scrubber piping).

f) *Drafting and Computer Aided Design Work*

Includes preparation of all drawings, preparation of a library of CAD drawings which can be utilized as the master drawings for the plant to enable easy modifications at a later date, and preparation of as-built drawings after the plant has been completed.
The system used is Microstation, able to convert into and from AUTOCAD-format (up to AUTOCAD 2000). KEU will provide a 3D-model, done also with Microstation.

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2. Combustion System

a) *Combustor type: NK-A 08*

designed as stepless adjustable reaction burner with inner cylinder of material 1.4828

including
- mixing nozzle of material 1.4828
- air circulation cylinder of material 1.4541
- outer cylinder of material 1.4541
- tangential air inlet flange of material 1.4541

incl. twist control butterfly valve and frame

b) *Organ Set*

to burn natural gas and the PLANT OFF GAS

with following accessories
- combi-organ for natural gas and cooling/ignition air
- organ for the PLANT OFF GAS, proven for flashback free operation
- pilot incl. electrical ignition device
- UV flame detector
- sight glass

c) *Reaction Chamber H1707-H1*

The reaction chamber with its refractory lining is designed for a operating temperature of app. 1100 -1200 °C. The max. allowed continuous operating temperature for the material is 1200 °C. Because of the acid dew point of the flue gas the inner refractory lining together with the outer insulation is designed for a shell temperature above 180°C (app. 200 – 250).

Comprising:
- chamber incl. refractory lining and outer insulation
- connection joints for measurements (temperature, pressure)
- sight glasses
- manhole

The refractory lining consists of:
- app. 125 mm Andalusit-bricks A63 C or equal
- app. 115 mm insulating refractory bricks ASTM 23 or equal
- app. 110 mm insulating plates Casi-Super 1000 or equal

d) Supply Line For Plant Off Gas

Design Data:

Flow rate design	2500	m_n^3/h
Temperature	20	°C
Classification	Zone 0	IIB3
Material for piping and fittings	stainless steel 1.4571	equal to 316 L
Line size	DN 250	(10 ")

Supply line incl. flange connections, compensators, sealing, fittings, holdings etc. mainly consisting of:

- 2 safety shut off valves with actuators
- 1 manual valve
- 1 flow measurement
- 1 Detonation flame arrestors (e.g. DA-SB-T-500/250-IIB3 or equal), designed acc. EN 12874

Housing , cover	stainless steel	1.4408
Gasket	PTFE	
Flame arrestor unit:		
Enclosing cage	stainless steel	1.4408
Flame filter discs	stainless steel	1.4571
Width of gap	0,5	mm
temperature sensor	W-BYI-5	

- 1 differencial pressure transmitters (around the flame arrestor)
- 1 Zone 0 – fan E1705-E1

to be installed in the plant off gas line, fna for transprotation of explosive atmospheres zone 0 temperature class T3, with EC-type examination acc. directive 94/9/EC, certificate no. IBExU98 ATEX 2030 X

medium to be handled	plant off gas	
capacity	2,500	mn^3/h
temperature inlet	max. 30	°C
total pressure difference	45	mbar
power at shaft, max.	~ 10	kW
required rated motor power	15	kW
impeller rotation speed	max. 3753	rpm

housing design:

material	SS 1.4571 / A316
baseframe	housing bolted on baseframe
design	gastight; shock pressure jproof 10 barg at 100°C
front cover sealing	gastight with PTFE-cord
welding	in- and outside continous welded, outside bracings skip welded

impeller design:

material	1.4571
blade design	backwards curved

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welding	blades are continuously welded to impeller shroud and back disk
balancing	Q 2.5 according to ISO 1940
shaft bearing	grease lubricated antifriction bearings incl. provisions for vibration monitoring, M 10 and temperature monitoring M12x1
belt drive	incl. belts, pulleys and guard acc. UVV, guard in SS

explosion protection acc guide line 94/9/EC and per prEN 12874
flame arrestors suction side: EV/VS-T-3-0.5-400/250
flame arrestors discharge side: EV/VD-3-0.5-400/250

e) Supply Line Make-up Air

Design Data:

Flow rate max.	900	m_n^3/h
Material for piping and fittings	carbon steel	
Size	DN 200	(8")

Supply line incl. flange connections, sealing, fittings, holdings consisting of:

- 1 inlet strainer
- 1 control valve

f) Supply Line For Combustion Air (incl. cell off gas)

Design Data:

Flow rate	max. 5000	m_n^3/h
Temperature	ambient	°C
Material for piping and fittings	CS / SS	

Supply line incl. flange connections, compensators, sealing, fittings, holdings consisting of:

Combustion air:
- 1 inlet strainer/silencer
- 1 control valve
- 2 flow measurements (Anubar with pressure transmitter)
- 1 differential pressure measurement (to combustor)

Cell off gas:
- 2 safety shut off valves with actuators
- 2 manual valves
- 1 Detonation flame arrestors (e.g. DA-SB-T-700/350-IIB3 or equal), designed acc. EN 12874

Housing , cover	stainless steel	1.4408
Gasket	PTFE	
Flame arrestor unit:		
Enclosing cage	stainless steel	1.4408
Flame filter discs	stainless steel	1.4571
Width of gap	0,5	mm
temperature sensor	W-BYI-5	

- 1 differencial pressure transmitters (around the flame arrestor)

g) Supply Line For Natural Gas

designed acc. the relevant regulations for Natural gas (LHV = 37.5 MJ/mn³, inlet pressure 0.5 bar g) installed to a fitting group consisting of:

Main gas:
- ball valves
- flow measurement
- pressure switches
- pressure transmitter
- test-burner (bunsenburner)
- manometers incl. shut-off valve
- shut off valves (double block and bleed incl. bubbler)
- control valve

branch to pilot:
- pressure controller
- manometer incl. shut-off valve
- pressure switch
- double block valves

incl. flange connections, compensators, sealing, fittings, holdings

h) Supply Line For Cooling Air

designed for ambient air, consisting of:

- inlet strainer/silencer
- pressure switch
- manual valves

incl. flange connections, compensators, sealing, fittings, holdings

i) Supply Line For Instrument Air

designed for instrument air for the pneumatic actuators installed to a fitting group consisting of:

- ball valve
- pressure indicator
- pressure switch
- manual valves

incl. flange connections, compensators, sealing, fittings, holdings

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3. DeNOx-stage

a) *DeNOx-Chamber*

The DeNOx-chamber is the continuing reaction chamber H1707-H1as described above, providing additional required residence time.

b) *Supply Line Cooling Air*

Design Data:		
Flow rate max.	2000	m_n^3/h
Material for piping and fittings	carbon steel	
Size	DN 200	(8 ")

Supply line incl. flange connections, sealing, fittings, holdings consisting of:

- 1 inlet strainer
- 1 flow measurement
- 1 control valve

c) *Supply Line For Urea*

to feed in the urea solution into the DeNOx-chamber, supply line incl. flange connections, compensators, sealing, fittings, holdings consisting of:

- 2 ball valves
- 1 manometer incl. shut-off valve
- 1 pressure switch
- 1 flow measurement
- 1 control valve
- connection for process water with automated valve and check valve for purging

d) *Supply Line For Compressed Air*

designed for pressure air for atomizing the urea, installed to a fitting group consisting of:

- ball valves
- manometer incl. shut-off valve
- solenoid valve
- pressure switch
- manual valves

incl. flange connections, compensators, sealing, fittings, holdings

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4. Quench-/ Scrubbing System

a) Flue Gas Quench S1702-H1

In the quench the gases are cooled down to saturation temperature by spraying with scrubbing liquid.
The quench includes following connections:

- Gas inlet
- Gas outlet to liquid tank S1702-S1
- all nozzles in the three levels (tangential, saturation and motive nozzles)
- connections for pH- and conductivity-measurement

Design:

Flue gas flow		11,000	mn³/h
Operating temperature inlet, max.		1200	°C
Materials	rinsing collar	Haynes 556 alloy	
	Nozzles	HC4 / PP	
	Equipment	FRP Derakane 411-300	Momentum
Design data		+/- 0.1 bar	90°C

b) Scrubber Column S1702-S1 with tank S1702-S1

The second stage of the scrubber system is the a packed bed absorber, set on top of the tank S1702-S1.
In the absorber the gases are sprayed countercurrent with scrubbing liquid. The absorber tower is equipped with a polypropylene packing support, a packing section filled with polypropylene packing rings, a polypropylene scrubbing liquid distributor and a mist separator including water wash. The column is constructed of FRP with a vinylester inliner.
The scrubber with the tank includes following connections:

- Pump (tank)
- Overflow (tank)
- Drain (tank)
- make-up water (tank)
- Demister water wash feed
- pH- and conductivity-return piping
- differential pressure measurement
- Level measurement (tank)
- manholes DN 600
- Gas outlet
- temperature measurements

c) Scrubber Liquid Pump S1702-P1/2

Two polypropylene scrubbing liquid recirculation pumps (duty – stand-by) for the quench and packed tower.

Make	Wernert	or equal
Type NETO	150-125-315	
Capacity	270 m³/h	45 mLH
Motor (ABB)	55	KW

d) *Supply Line For Caustic*

designed for caustic, installed to a fitting group consisting of:

- ball valves
- check valve
- pressure switch
- control valve

incl. flange connections, compensators, sealing, fittings, holdings

e) *Recirculation Piping*

Connecting scrubbing liquid recirculation/feed piping to quench and absorber including blowdown piping constructed of FRP.

f) *Heat Exchanger S1702-H2*

Plate type heat exchanger to cool down the scrubber liquid

Type	Plate Heat Exchanger	
Make	Alfa Lavel	or equal
Flows:		
Scrubber liquid	120	m³/h
Cooling water	~330	m³/h
Temperature, max.	100	°C
Pressure, max.	10	barg
MOC	titanium	
Capacity	~ 5200	kW

g) *Supply Line For Softened Water*

to provide fresh water for the quench and scrubber system

Supply line incl. flange connections, compensators, sealing, fittings, holdings consisting of:

- ball valves
- control valve for level control
- solenoid valve for demistor

h) Supply System For Emergency Water

to provide emergency water for the scrubber system.

Supply line incl. flange connections, compensators, sealing, fittings, holdings consisting of:
- ball valves
- check valves
- pressure switch
- manometer
- actuated valve

5. Plant Accessories

a) ID-fan C1702-E1

to be installed in the clean gas line. A centrifugal blower with coupling and common baseframe, grease lubricated antifriction bearings and electric motor drive. The ID-fan is designed for VFD-operation.

medium to be handled	clean gas	
capacity	20,000	mn³/h
temperature inlet	max. 80	°C
total pressure difference	90	mbar
power at shaft, max.	~ 85	kW
required rated motor power	110	kW
impeller rotation speed	max. 3576	rpm

housing design:

material	CS, rubber lined
baseframe design	housing mounted on baseframe
design	gastight; 95 °C / 0.25 barg
with	inspection/cleaning access and condensate drain fitting

impeller design:

material	Hastelloy C 4, with intake strengthening disk
blades	welded at both sides continuously to impeller shroud and back disk
balancing	Q 2.5 according to ISO 1940
coupling	standard elastic coupling (FLENDER N-EUPEX), incl. guard in CS
shaft bearing	grease lubricated antifriction bearings incl. provisions for vibration monitoring, M 10 and temperature monitoring M12x1

b) Steel Structure / Platforms

Complete frame work incl. stairs and platforms with guard-rails where necessary, to provide access to the relevant equipment and/or instrumentation.
Material: carbon steel galvanised.

The amount of structural steel included in this quotation is shown and based on the lay-out drwg. attached.

c) Insulation / personnel protection

Includes insulation or personnel protection for relevant equipment and piping, where accessible and/or necessary.
Max. surface temperature: 40 K above ambient temperature

d) Painting – Surface treatment

As we didn't receive a painting specification, we allowed for the KEU-standard painting as follows:

- carbon steel equipment/piping, which will be insulated: sandblasted SA 2.5, one layer primer (min. 45 µm to min. 70 µm, depending on temperature)
- carbon steel equipment/piping, which will not be insulated: sandblasted SA 2.5, one layer primer, two layers top coat (total 240 µm)
- stainless steel equipment/piping: no painting
- plastic equipment/piping: no painting

6. Electric / Instrumentation / Automation

As agreed, we allowed for all field equipment and field instrumentation to be wired up to field junction boxes as well as the supply and installation of the main cable trays inside our footprint, up to battery limit.

7. Erection

a) *Mechanical Erection*

The offer includes the mechanical erection of the specified scope for the thermal Oxidiser unit including:

- Construction management
- Coordination and monitoring of progress on site
- Quality and safety monitoring of construction
- Unpacking
- Site installation (scaffolds, crane, etc.)
- Test and inspections (e.g. examination, pressure tests, etc.)

RIRL to provide:

- Offices for construction personnel incl. infrastructure like phone, fax, etc.
- Areas for parking and construction equipment during construction
- Water and power during construction

b) *Electrical Installation*

The offer includes the installation of all field instrumentation and wiring to local junction boxes incl. required cable trays within the footprint.
Wiring from JB to control-cabinets and motor-cabling to be done by RIRL.

8. Commissioning, Start-up and Training

As RIRL supplies the control system itself, the commissioning work is jointly executed with the RIRL-personnel responsible for the control system and the electric installation. Nevertheless, KEU should be the technical leader of the commisioning and start-up phase.

The **commissioning** of the unit shall follow the erection, chiefly consisting of:

- loop checks
- checking of all utilities
- testing and pre-adjusting of valves, butterfly-valves etc.
- testing of blowers
- Calibration air flows
- testing and adjusting of instruments
- combustor and burner pre-adjustment
- testing safety devices
- testing alarm devices
- start up (ignition) tests burner with natural gas
- heating up/curing the reaction chamber
- cooling down and inspection of the refractory
- restart burner and optimising automatic heat up ramps
- reheating and optimising controllers while hot operation with natural gas and ambient air
- training of the operation personnel

The following **start-up** of the unit includes:

- connection of the waste gases
- optimizing of the system, incl. the waste gas related controllers

For the allowed period for commissioning and start-up please refer to the schedule attached.

F. BATTERY LIMITS, SCOPE OF SUPPLY

The covered scope of supply described herein is generally shown and located within the footprint of the lay-out drawing attached. All equipment and the interconnecting piping internal is included, all external this footprint is excluded.
Regarding the piping, tie-ins resp. hand-overs are at the North-West corner of the footprint, details and dimensions also shown on the drawing.

Delivery Exclusions

Not included in our quotation are following positions:

- Foundation works, civil works, all buildings
- Utilities, Power supply
- Pipework to thermal oxidiser battery limit / external pipes lines with fittings etc.
- Wiring from field junction boxes to control cabinets
- MCC's, motor cables
- Control system
- Trace heating
- NOx-measurement (at stack)
- Temporary facilities
- Official emission checks

G. REGULATIONS TO BE OBSERVED

- EN 676, Automatic forced draught burners for gaseous fuels
- EN 746-2, Industrial themoprocessing Equipment; Safety requirements for combustion fuel handling systems
- PED – European pressure equipment directive
- KEU standards for incineration plants
- ANSI standard for piping as per pipe spec.
- All relevant EN-rules or guidelines
- TRbF- and VBF- Rules
- VDE-Rules

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H. PROJECT REALISATION

1. Project Organisation

One project manager from KEU will be defined and responsible for the whole project. This project manager is mainly the contact person to the customer and organises the processes with the different departments and suppliers.

For the duration of procurement and site-activities a project site engineer will be installed.
If within KEU's scope, for the assembly on site the head of the site office is defined latest 4 weeks before start of assembly. This supervisor on site will be also responsible for the safety on site.

2. Quality System

KEU GmbH has established and applies a quality system for Development, Design, Engineering, Installation, Start-up, Servicing of Plants for Energy Recovery and Environmental Technology. An audit was performed, Report No. 3092 Proof has been furnished that the requirements according to DIN EN ISO 9001 are fulfilled.

All relevant equipment will be provided with CE-Certificate.

3. Communication And Reporting

All communications will be done via the responsible project manager at KEU in English.
All documents and correspondence will be numbered. A document number and reporting system will be used for all communications and documents.
The process progress will be documented schematic with a time schedule once a month.

II. Commercial Part

A. PRICES / PRICE BREAKDOWN

Based on current rates material prices the +/-10% estimate is as follows:

Standby Fume Incinerator	***EURO***	***2,390,000.-***

B. PRICE / TERMS / VALIDITY OF QUOTATION

CIP RIRL Clarecastle, Ireland - Incoterms 2000,
Prices exclude value-added tax (VAT) and any levies and other fees in force in the country of destination related to this project including delegation of personnel

C. TERMS OF PAYMENT

For pricing we assumed cost-covering payments:

30 % with order placement
50 % at notification that goods are ready for dispatch
10 % after erection, latest 3 month after the second installment
10 % after start-up, latest 5 month after the second installment

All payments within 30 days after receipt of invoice, net.

D. DELIVERY TIME

Please refer to the time-schedule attached.

E. CONTRACTORS'S LIABILITY FOR DEFECTS

Claims of the Purchaser based on defects are subject to a limitation period of 24 months after the delivery date. All parts or services where a Defect becomes apparent within the limitation period shall, at the discretion of the Contractor, be repared, replaced or provided again free of charge. The Purchaser shall notify Defects to the Contractor in writing and without undue delay and the Contractor shall first be given the opportunity to supplement its performance within a reasonable period of time. After acceptance/ handing over of the delivery item the right of the Purchaser to withdraw from a contract is excluded.

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Contractor's warranty does not cover damages when due to abrasive and/or corrosive substances or other bad influence by substances not foreseen in the contract. Contractor's liability for proved financial losses due to delay shall be limited to the amount of 5% of the agreed order value, deducting a penalty possibly agreed.

Unless otherwise stipulated above and hereinafter the Contractor shall not be liable for consequential or indirect damages or losses such as but not limited to loss of profit, loss of power, loss of use, costs of capital or costs connected with interruption of operation due to delay, poor workmanship, torts or any other legal ground. The limitation of Contractor's liability shall not apply if such damages are caused wilfully or by gross negligence of the proprietor/ executive body and/or senior staff and in the case of mandatory liability, e.g. under the Product Liability Act, in the case of intent, gross negligence, injury of life, body or health. To the extent that the Purchaser has a valid claim for damages according to this article, it shall be time-barred upon expiration of the limitation period applicable to defects as mentioned above. In the case of claims for damages under the Product Liability Act, the statutory provisions governing limitation periods shall apply.

F. GENERAL QUOTATION CONDITIONS

All other terms and conditions not specifically mentioned herein shall be as per the GENERAL CONDITIONS FOR THE SUPPLY OF PRODUCTS AND SERVICES recommended by the Zentralverband Elektrotechnik- und Elektronikindustrie e.V. (ZVEI), Frankfurt/M. / Germany, published under: (www.gah-ag.de/service). Specific clauses in the quotation take precedence over the relevant clauses in the General Conditions.

G. VALIDITY OF QUOTATION

Budget price is based on the engineering carried out as well as labour-rates and material-cost. An estimate for a project execution in late 2006 or in 2007 is not possible.

We are convinced, that we came close to the final solution based on your requirements. If you have further questions please do not hesitate to contact us.

Best regards

KEU GmbH

- van de Loo - - Schneider –

III. Appendices

Please find the following documents as attachments:

- PFD, drwg.-no. 05308871 rev. E
- Lay-out and 3D-model
- KEU-comments to RIRL-PID's
- Utilities / tie-ins
- Equipment list
- Pipe list
- Inline-instrument list
- Functional description
- Heat-up procedure
- Signal list
- Control schema
- Measuring and control loop list
- Field equipment list
- Electrical motor list
- Project schedule