Laser in Situ Online Gas Analysis System

Application Guide

for the Petrochemical Industry

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Foreword

The results of the China Instrument Manufacturers Association survey reveals three major challenges with conventional gas analysis systems used in the petrochemical industry:

(1) The sampling and pretreatment systems barely meet technical requirements, are easily damaged and need significant maintenance, oversight and repair.

(2) The systems are generally unable to compensate for the data error introduced by background gas cross interference, dust, and window contamination.

(3) The response time is slow, and generally cannot meet the industry's real time control requirement.

These limitations of conventional online gas analysis systems have become bottlenecks in the petrochemical industry's process control automation. It has also limited the development and application of online gas analysis systems.

TAI's LGA-3500 in-situ laser online gas analysis system series solves these problems. Our products usually do not require a sampling or pretreatment system, and when they do, the requirements are much simpler. Our products measure the gas in situ, have high measurement precision, and have a short response time. The benefits include greater convenience and flexibility for production optimization, gas recycling, safety control, and environmental protection.

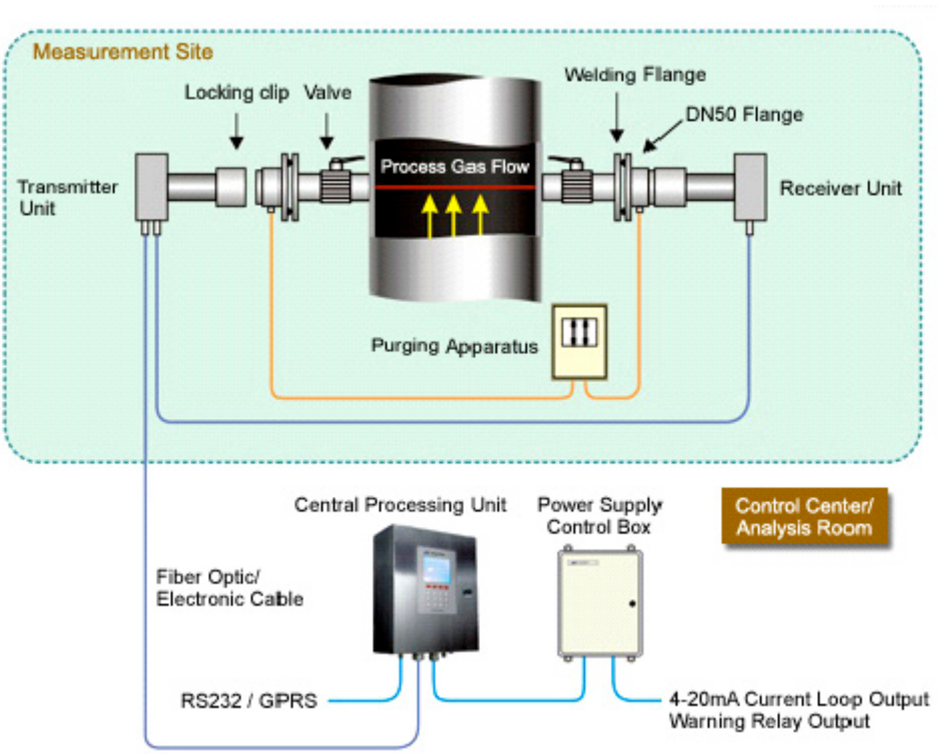
TAI's LGA-3500 Laser In-Situ Online Gas Analysis System has the following features and benefits:

- ✓ No sampling or pretreatment system, easy to operate
- ✓ High measurement precision
- ✓ Quick response
- ✓ High dependability
- ✓ Easy to calibrate and maintain
- ✓ Low operational and maintenance costs to the user

1. Introduction

1.1 System Configuration

A Laser in-situ online gas analysis system comprises of a transmitter, a receiver and a central processing unit. The transmitter launches a laser beam across the diameter of the industry flue or conduit under test onto the receiver placed at the other end. The resulting electrical signal is then sent to the central processing unit and analyzed to yield the gas concentration information.



Main P

✧ **Transmitter**

Components: laser launching device, optical assembly, transmitter unit box and etc.

Function: generates and launches a collimated modulated laser beam across the gas environment under test and onto the receiver.

✧ **Receiver**

Components: opto-electronic sensor, optical assembly, signal amplifier, receiver unit box and etc.

Function: collects the laser beam from the transmitter, converts the light intensity into electric signal and sends it real-time to the central processing unit.

✧ **Connecting Unit**

Components: valve, welding flange, instrument flange and etc.

Function: mounts the transmitter and receiver units onto the industry flues/conduits under test.

- **Central Processing Unit**

  Components: power supply board, signal processing board, user interface board, central processing unit case, and etc.

  Function: processes the spectral signal from the Receiver, performs display, data communications and operation management.

- **Purging Apparatus**

  Components: precision filter, decompression valve, flowmeter, case, and etc.

  Function: blows clean industry gases such as N2 into the connecting unit to form a air wall before the optical window that prevents process gas flow from contaminating it.

- **Calibration Unit**

  Componenets: Calibration tube, needle valve, and etc

  Function: Used for calibration.

- **GPRS wireless communication system**

  Components: GPRS module, control circuit, case, and etc.

  Function: enables online data analysis, remote diagnosis, instrument management, and remote software upgrade.

1.2 Gas Species

Regular gas species and their measurement indicators

Gas	Lower Limit	Rang	Highest Pressure	Highest Temperature
O_2	0.01% Vol.	0-1% Vol., 0-100% Vol.	10 bar abs.	1500□
CO	40 ppm	0-8000 ppm, 0-100% Vol.	2 bar abs.	1300□
CO_2	20 ppm	0-2000 ppm，0-100% Vol.	2 bar abs.	1500□
H_2O	0.03 ppm	0-3 ppm, 0-70% Vol.	2 bar abs.	1500□
H_2S	2 ppm	0-200 ppm,0-30% Vol.	2 bar abs.	400□
HF	0.01 ppm	0-1 ppm,0-1000 ppm	3 bar abs.	600□
HCl	0.01 ppm	0-7 ppm,0-8000 ppm	2 bar abs.	500□
HCN	0.2 ppm	0-20 ppm,0-1% Vol.	2 bar abs.	500□
NH_3	0.1 ppm	0-10 ppm,0-1% Vol.	2 bar abs.	500□
CH_4	10 ppm	0-200 ppm, 0-10% Vol.	5 bar abs.	500□
C_2H_2	0.1 ppm	0-10 ppm，0-70% Vol.	-	-
C_2H_4	1.0 ppm	0-100 ppm，0-70% Vol.	-	-

Note: Specific ranges can be custom made.

1.3 Technical Specifications

Technical Features	Optical path length (OPL)	≤ 12m
	Response time	< 1s
	Linear accuracy	≤ ± 1% FS
	Span drift	≤ ± 1% FS (within a maintenance interval)
	Zero drift	Negligible
	Warm-up time	< 1hour
	Maintenance interval	< 4 times/year (no replacement parts)
	Calibration interval	<4 times/year
Input & Output Signal	Analogue output	4~20mA current loop, 500Ω Max, isolated
	Digital output	RS232/GPRS
	Relay alarm	3-Channel (Relay Specification: 220V, 0.5A)
	Analogue Input	4-20mA environment gas temperature, pressure input (optional)
Operation conditions	Environment temperature	-20□—50□ (adjustable upon customer request)
	Protection class	Transmitter/ Receiver: IP65
	Power supply	220 VAC, 50Hz, <30W
	Purging gas	N_2, etc.
Installation	Mounting method	Use DN50/PN2.5 flanges to install transmitter and receiver
Dimension and Weigh	Transmitter/Receiver Unit	260×200×150mm, 10kg
	Connecting Unit	385×150×160mm, 10kg
	Central processing unit	400×320×170mm, 10kg

Note: Specific indicators can be adjusted.

1.4 Models

（1）Standard Model

□Applicable scope: The temperature and pressure is in the measurement range, as well as the dust concentration is lower than $80g/m^3$.

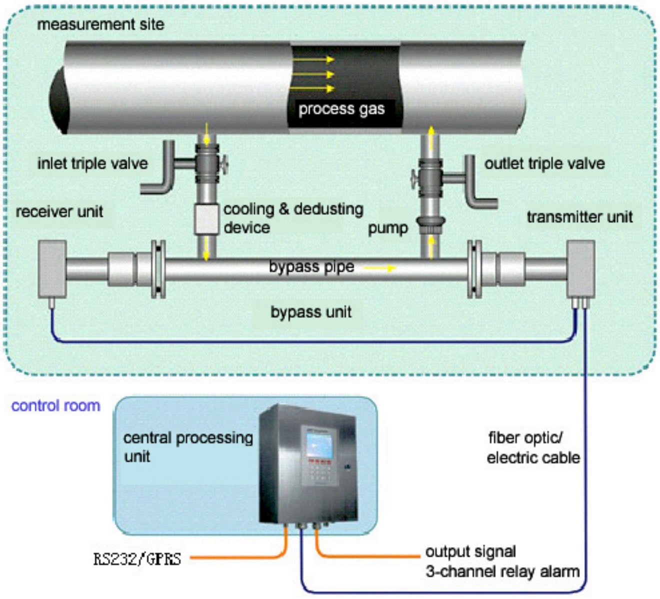
□Configuration: Mainly comprises of the transmitter unit, receiver unit, central processing unit, connecting unit, purging apparatus and the calibration unit.

□Features: The receiver unit and the transmitter unit can be directly installed onto the gas flow flue under test, and realizes in situ measurement and analysis.

（2）Bypass Model

□Applicable scope: Dust, temperature and pressure all exceeds the standard model's range. The customer's field installation requirement will not allow opening holes in multiple locations while several gas species needs monitoring.

□Configuration: As depicted in the figure, a bypass unit is added. The bypass unit comprises of feed gas pipe, gas pretreatment system, electric ball valve, electric pump, bypass measurement pipe, calibration gas inlet and off gas pipe. The configuration may vary from application to application.



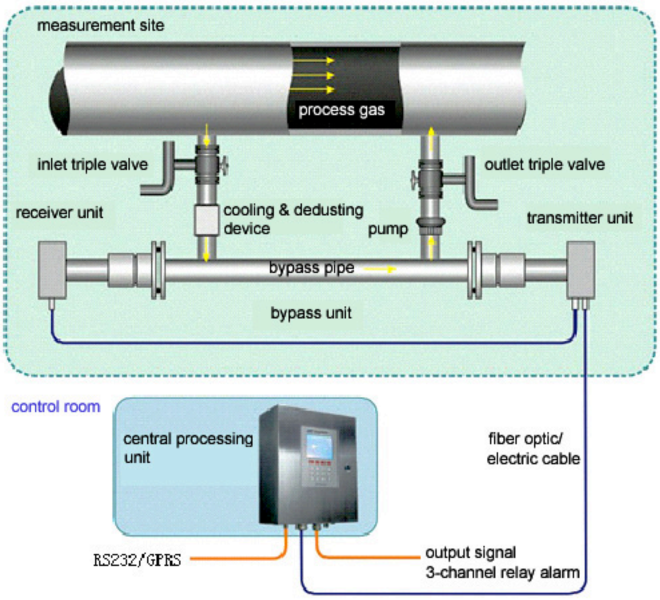
□Features: The bypass unit extracts the gas from the process flue. After cooling, de-pressurization, dust removal, and other simple pretreatments, the gas enters the bypass measurement pipe where the gas is analyzed. By using the special bypass unit invented by TAI, quality field measurements can be achieved.

（3）Fiber Model

□Applicable scope：The fiber system is suggested when it is not suitable to put the diode laser in-situ, due to operational constraints, or for situations when monitoring the same gas at multiple points,

□Configuration: Different from the standard model and the bypass model, the diode laser is put in the central processing unit, and the laser is transmitted to the receiver unit via the fiber.

□Features: Resistance to electromagnetic interference is very high; thee central processing unit can be put in better

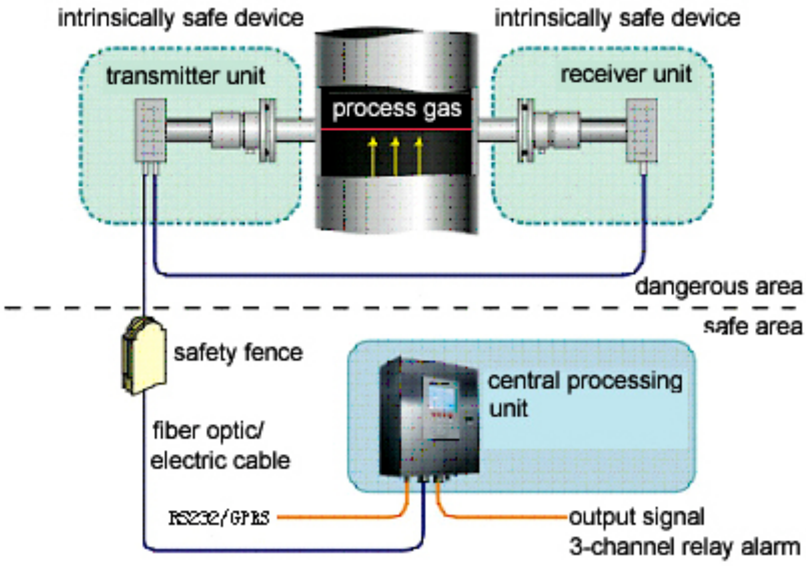


environments, thus increasing its ability to work effectively in poor environments.

Using the fiber model, TAI can construct distributed fiber laser in situ online gas analysis system, measuring gas at different locations. In the distributed fiber laser in situ online gas analysis system, several monitoring points share one central processing unit and laser, thus greatly reducing the cost. Compared to traditional gas analysis system, the system configuration is more flexible, and the price point is better in most customer applications.

（4）Anti-explosion Model

Applicable scope：TAI provides intrinsically safe and positive pressure anti-explosion models, which meet or exceed all anti-explosion requirements. Use the intrinsically safe cables with relative small distributed capacity and distributed inductance in dangerous areas. The positive pressure anti-explosion model's central processing unit can be installed in dangerous areas, thus adopts positive pressure anti-explosion design.



Configuration: All electrical wiring between the transmitter unit and the receiver unit is intrinsically safe. During the installation, a safety fence with limited current and pressure to the cable is added between the central processing unit and the transmitter unit.

Features:　Applicable to all situations requiring anti-explosion units.

2. Technical Principle

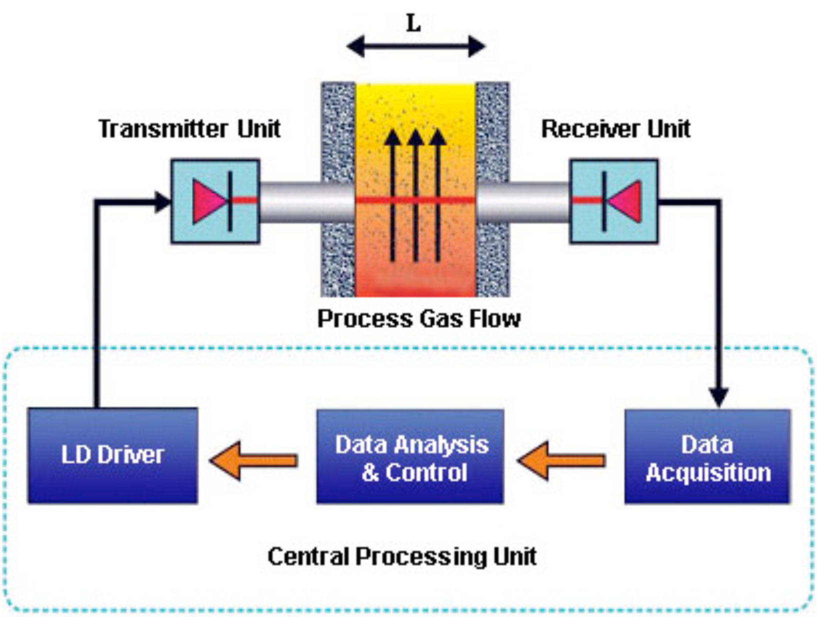
2.1 Brief Introduction of DLAS

TAI's Laser in-Situ Online Gas Analysis Systems are based on TAI's proprietary Diode Laser Absorption Spectroscopy (DLAS) technology.

Focused Photonics, Inc. (TAI) is a major leader in DLAS analysis instruments and systems. It has built a complete portfolio of intellectual property in relevant areas such as quantitative laser spectrum technology, feeble signal detection, optical fiber technology, simultaneous and digital electro circuit design, micro controller technology, and software. Its analyzers have been widely installed in the metallurgy, petrochemical, environmental protection, biochemical, aeronautics and astronautics, and etc. fields.

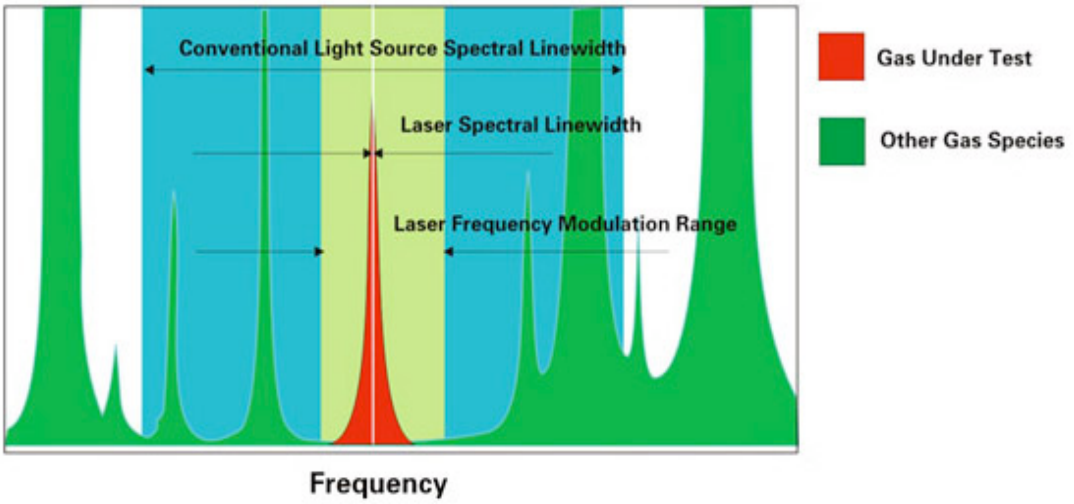
2.2 Technical Principle of DLAS

DLAS is short for Diode Laser Absorption Spectroscopy. Light from a diode laser passes through the environment under test and gets selectively absorbed. By detecting and analyzing the absorption spectrum, TAI's DLAS analyzers can measure gas concentrations, flow velocity, temperature, and etc.



The special gas analysis technology of DLAS solves three major problems in process gas analysis, cross interference of background gas, dust and window contaminations, and influence of the environment parameters of the gas under test. Thus it makes in situ online analysis possible, and avoids pretreatment.

■"Single-line" Spectroscopy Technology－no cross interference from background gas species



Schematic of "Single-line" Spectroscopy Measurement Principle

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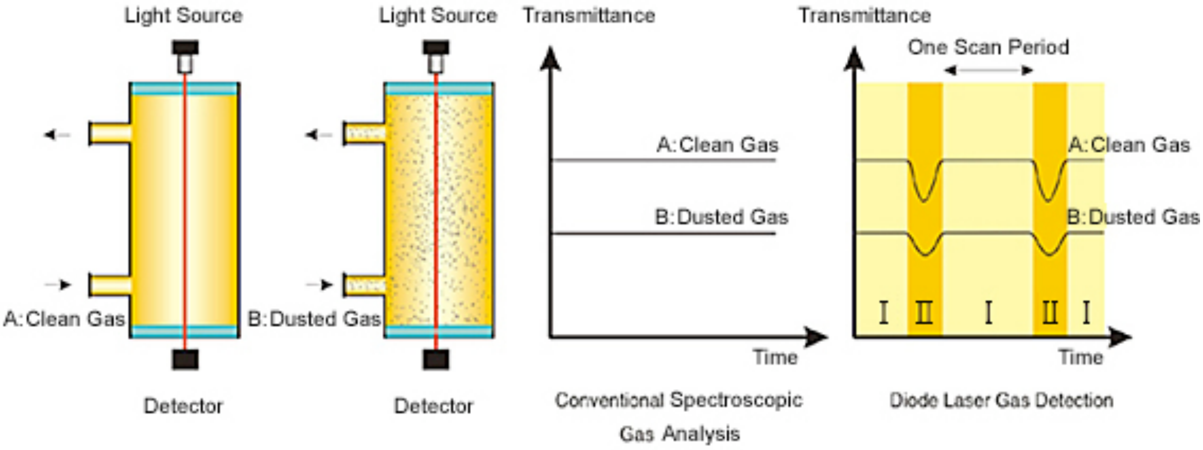
ver… om the gas under test, but also those from background gas species, and introduces cross interference. DLAS gas analyzers uses diode lasers, which have line-widths of less than 0.0001nm, or only 1/106 of that of the non-laser sources. By selecting a laser emitting near a specific absorption line of the gas under test and tuning its wavelength through changing its temperature and driving current, an absorption spectrum that only covers a single line of the gas under test can be obtained to eliminate cross interference.



Dust … Measuring量Concentration的影响

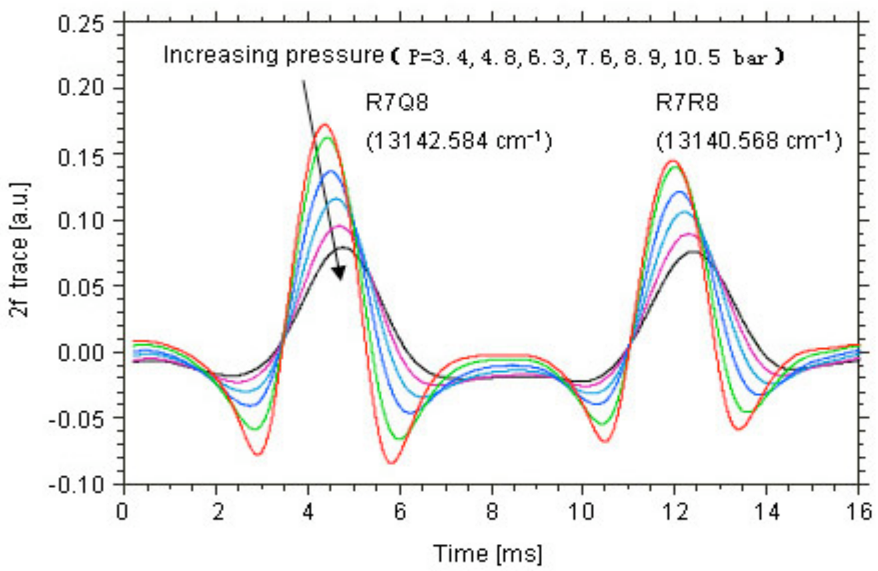
■ Laser spectral scanning technology－automatically correct for dust, water vapor and optical window contaminations

Spectroscopic gas analysis technologies in general measure light transmittance to yield the gas concentration information. Conventional gas analyzers use fixed broad-spectrum light sources and measures total light transmittance, Tgd, that also counts for absorptions and deflections caused by dust, water vapor, optical window contaminations etc., and can not differentiate the transmittance of the gas under test, Tg, and that of dust, water vapor, and optical window contaminations, Td. As a result, measured gas concentration will be higher than the real data when dust density in the environment increases.

DLAS gas analyzers use the laser spectral scanning technique. They periodically scan the gas under test with a modulation frequency range larger than the gas absorption spectral line-width such that, within one scan period, there are two distinctive areas. Area I is unaffected by the gas absorption and gives Td, whereas area II is and gives Tgd. The transmittance of the gas under test is then calculated accurately by Tg = Tgd /Td. The interference from dust and optical window contamination is, therefore, automatically screened out.

■ **Automatic compensation for the spectral line broadening—eliminates the influence of gas environment parameters (temperature and pressure) variance**

When the gas temperature and pressure change, the width and height of the measured gas absorption spectral line will change accordingly. It affects the accuracy of the measurement. By having a 4-20mA process temperature and pressure input, TAI's LGA-3500 and LGA-3000 analyzers automatically compensate for them with TAI's proprietary algorism to ensure measurement accuracy.



The evolution of absorption spectral line as a function of gas environment parameters.

2.3 Technical Advantages of DLAS

Compared to conventional analysis system, this laser online gas analysis system has the following advantages:

Item	**LGA-3500 *in situ* laser online gas analyzer**	**Conventional online gas analyzers**
Pretreatment	Not required	Required
Measurement Method	*In Situ*, continuous, real-time	Discontinuous
Gas Environment	Applicable to adverse environments such as high temperature, high pressure, high dust density, high water vapor density, high flow velocity, high corrosiveness	Only applicable to dry, dust-free gas samples with constant temperature, pressure, and flow velocity
Response Speed	Fast, only limited by instrument electronics response, less than 1 sec.	Slow, limited by gas sampling, transport, and instrument electronics response, 20+ sec.
Reliability	Average concentration along the optical path, *in Situ*, real-time; no cross interferences from other gas species, dust, and gas parameter fluctuations	Gas concentration at the tip of the sampling probe only, affected by gas influence, absorption, and leakage during gas sampling and transport; cross interferences from other gas species, dust, and gas parameter fluctuations
Continuous	Continuous	Discontinuous; not functioning during reverse purging
Dependability	No moving parts, highly reliable	Quite a lot of moving parts, low reliability
Measurement Parameters	Gas concentration, temperature, flow velocity, and etc. simultaneously	Gas concentration only
Medium Interruption	No cross interferences from background gas species; automatic correction for dust and optical window contamination	Vulnerable to background gas cross interference, unable to compensate for dust and optical window contamination
Sample Gas Discharge	None	Frequent, dangerous and pollutant
Calibration & Maintenance	Calibration: 3~4 times /year Maintenance: 4 times/year, system prompt	Calibration: 2~3 times /month Maintenance: often
Operation Cost	No spare parts, only electricity	Significant spare parts cost, ~20% of the equipment cost per year

3. Installation & Operation

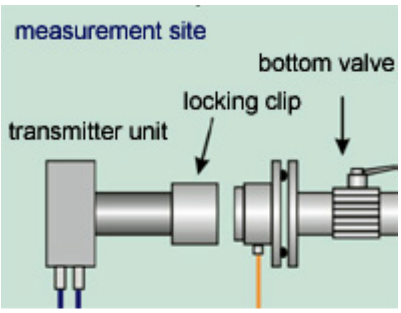
3.1 Installation

The installation is easy. Open up two round holes at the two ends of a diameter of the process gas flow flue under test, weld a DN50 flange on each side, mount a valve (optional) and an instrument flange subsequently, and then install and tighten the transmitter unit and receiver unit to the instrument flange by mounting nuts. The central processing unit is placed in an Instrument Control Center or an Analysis Room (instrument rack).

3.2 Standard Working Flow

- Keep the bottom valve open, certain frequency laser transmit from the transmitter unit to the receiver unit, when crossing the gas pipe, it attenuats as a result of absorption. Afer receiving the attenuated laser, the sensor in the receiver unit sends the signal to the central processing unit for analysis and computing the concentration of the gas under test.
- To prevent dust and other contaminations from assembling in the window, it is necessary to purge the inlet continuously with industry N_2, forming a section of N_2 curtain between the optical window and industry gas.

3.3 Calibration & Maintenance



It is easy to calibrate and maintain the system. The typical maintenance interval is 3 months.

When maintaining, first close the bottom valve (no influence to production), then screw down the locking clip, clean the optical window, and then screw up the locking lip. It is shown in the right figure.

When calibrating, first close the bottom valve (no influence to production), then screw down the locking clip, and install the transmitter and receiver unit on the calibration pipe, and inlet the calibration gas. And calibration can be finished while operating the central processing unit or PC menu.

4. Applications in Petrochemical Industry

4.1 Purposes

- Optimize production process
- Control product quality
- Control production safety

 Make sure that the off gas meets the environment protection requirement.

4.2 Typical Applications

List of typical applications:

Production Device	Monitoring Material or Locations	Gas under test	Process Purpose
Catalytic Cracking	Regenerated gas	$O_2/CO_2/CO$	Optimize production process
Ethane Cracking	Burn Off Gas	$O_2/CO_2/CO$	Master the result
	Cracking Furnace Flue	O_2	Optimize production process
	Gas Drying System	H_2O	Control product quality
	Top of De-Methane Tower	CH_4	Control product quality
Synthetic Ammonia	Half-water Gas Tank Back and Front	O_2/SO_2	Control production safety
	Desulphurizing Process	H_2S/SO_2	Optimize production process
	Middle Transform Outlet	CO	Control product quality
	Low Transform Outlet	CO	Control product quality
	Decarbonizing Outlet	CO_2	Control product quality
	Regenerated CO_2	O_2	Optimize production process
	Refinery Gas	CO/CO_2	Optimize production process
	Synthetic Recycle Gas	CH_4/NH_3	Control

			quality
	Natural Gas Hydrogen-Producing 1 section Furnace	CH4	Optimize production process
	Natural Gas Hydrogen-Producing 2 section Furnace	CH4	Optimize production process
	Heavy Oil Hydrogen-Producing carburetor	CH4	Optimize production process
Urea Synthesis	CO2CompressorInlet	O2	Optimize production process
	Outlet of De-Hydrogen Reactor	H2/O2	Optimize production process
	Recycle Gas	NH3/CO2	Control product quality
Cyclohexanone-oxime	Oxidization Material Inlet	O2/CO/CO2	Control production safety
PTA	Oxidization Off Gas Outlet	O2/CO/CO2	Control production safety
	Crystal Off Gas Outlet	O2	Control production safety
CLAUS Sulfur Recovery	Sulfur Main Pipe	H2S/O2	Optimize production process
	Acid Feed Gas	H2S/Hydrocarbon/CO2/H2O	Optimize production process
	Exhaust-heat Boiler Outlet	O2/SO2	Make sure that the off gas meets the environment protection requirement
	Claus Off Gas	H2S/SO2	Control product quality

PVC Ethane Oxychlorination	Ethane, Chlorine Feed Gas	H2O	Optimize production process
ETO	Feed Gas	O2/C2H2/CO2	Optimize production process
Phenol		O2	Control production safety
Methanol	Saturation Tower Outlet	H2O	Control product quality

4.3 Typical Cases

（1）Catalytic Cracking Gas Monitoring

The concentration measurement of CO, CO_2, and O_2 in the regenerated gas is very important for setting operation parameters in Catalytic Cracking process. It is also the basis of closed-loop control. The temperature of the flue gas is at range of 600－760□. It is mixed with solid catalyst particles. There are also much steam, even some tar and erosive gases. Thus it is very difficult to sample. First, the sampling probe erodes fast; second, sampling system is easy to be blocked. Third, the requirement of sample gas purification device is too high and too complicated. The temperature is very high, and the production device seldom stops, thus very inconvenient to repair. It can wait to be mended till the overhaul time after it is broken. So dependability and maintenance are the most important factors.

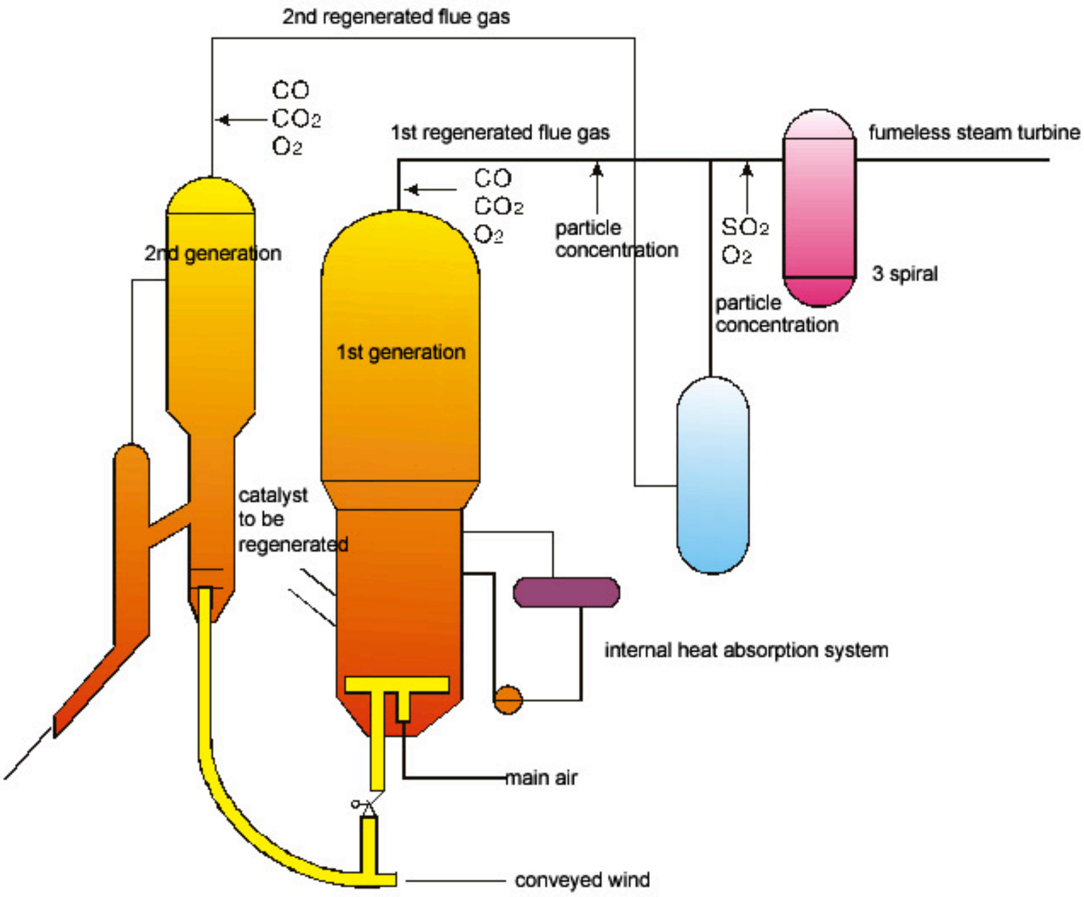


Figure 1 Catalytic Cracking Regenerated gas Process Chart

List of gas monitoring points:

Monitoring Point	Temperature (°C)	Pressure (Mpa)	Dust (mg/m^3)	Flow Rate (m^3/h)	Gas Measured	Gas Concentration
1st regenerated gas Outlet	600-720	0.1-0.28	100		CO CO2 O2	2-8% 7-15% 0.5-5%
2nd regenerated gas Outlet	650<690<720	0.15-0.19	100-260	23-34	CO CO2 O2	10-100-2000 ppm 12-14.5-15% 2-3.5-5%

（2）Gas Detection of Ethane Cracking Device

In petrochemical industry, the so called cracking means that using petroleum hydrocarbon as the raw material, taking full use of Hydrocarbon's unstable, easy to break down and have chain rupture features under high temperature, under air-isolated and high temperature (above 600°C), make the material under go many chemical reactions, such as deep decomposition. The main task of Petroleum Hydrocarbon Cracking is to produce as much ethane as possible.

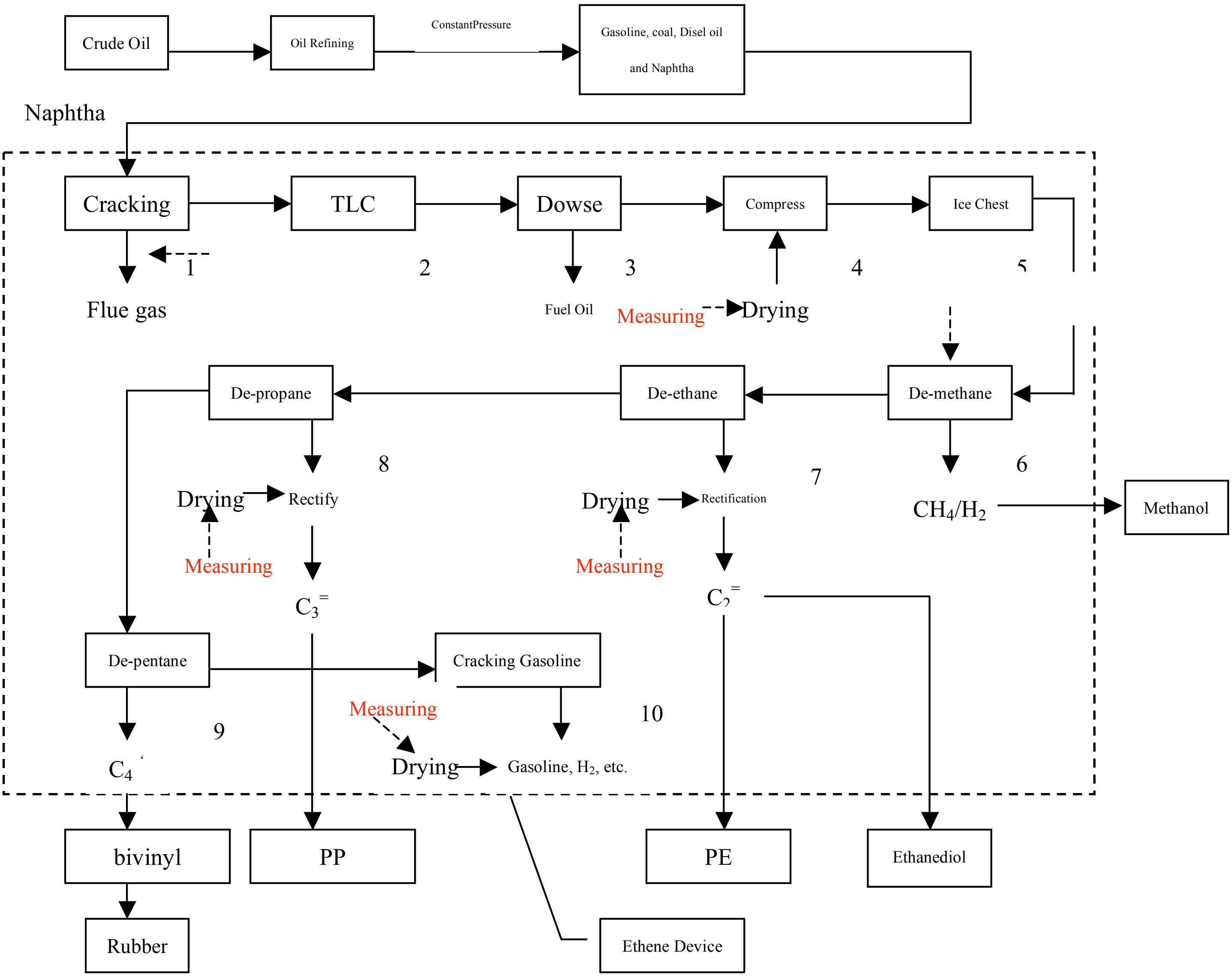


Figure 2 Ethane Cracking Process Chart

List of gas monitoring points:

Monitoring Point	Temperature(°C)	Pressure(Mpa)	Dust	Measuring Gas	Concentration
Burn Off Gas	350	0.07	Micro doses	CO/CO2	0.1%~20%
Cracking Furnace Flue Gas	900-1000	Micro Negative Pressure	No	O_2	0-20%
Compress Drying	50	2	No	H_2O	0-1000ppm
Ethane Drying		1	No	H_2O	0-1000ppm
Propane Drying		1	No	H_2O	0-1000ppm
H_2Drying			No	H_2O	0-1000ppm
Top of De-methane Tower		1	No	$CH_4/C_2H_2/\ C_2H_4$	CH_4 concentration is around 80%

（3）Synthetic Ammonia Process Gas Monitoring

Synthetic Ammonia's principle chemical reaction formula：

$$1/2N_2 + 3/2H_2 \underset{\text{Catalyst}}{\overset{\text{High Pre.\&tem.}}{\rightleftharpoons}} NH_3$$ (positive reaction, heat release)

In the early time,Synthetic Ammonia's main material is coke-oven gas, H_2 from electrolyzing the water and water gas from coke gasification, From the 1960s, it turns out that natural gas, nalpha, and heavy oil become the most popular materials.

Synthetic Ammonia takes H_2 and N_2 as raw material. H_2 is produced from coal, crude oil or natural gas. N_2 is separated from the air. Synthesis makes NH_3. Its processes mainly contains the production of feed gases, purification, and synthesis.

Ammonia is mainly used for agriculture. It can be produced to urea, ammonium acid carbonate, ammonium sulfate, ammonium borate, ammonium chloride, and ammonium phosphate, and other nitrogenous fertilizers. Ammonia is also an important raw material in chemical industry. We can use ammonia to produce nitric acid and other nitrogenous compounds.

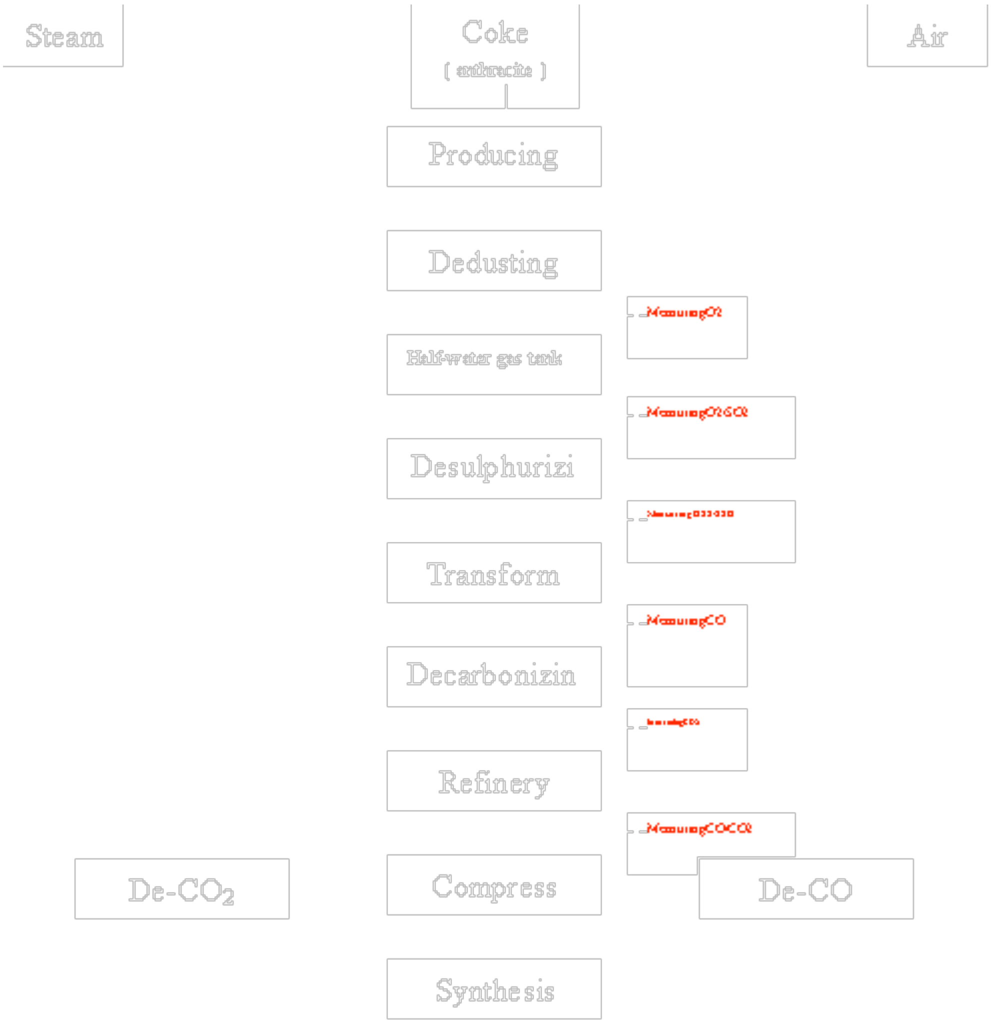


Figure 3 (Coke as the Material) Synthetic Ammonia Process Chart

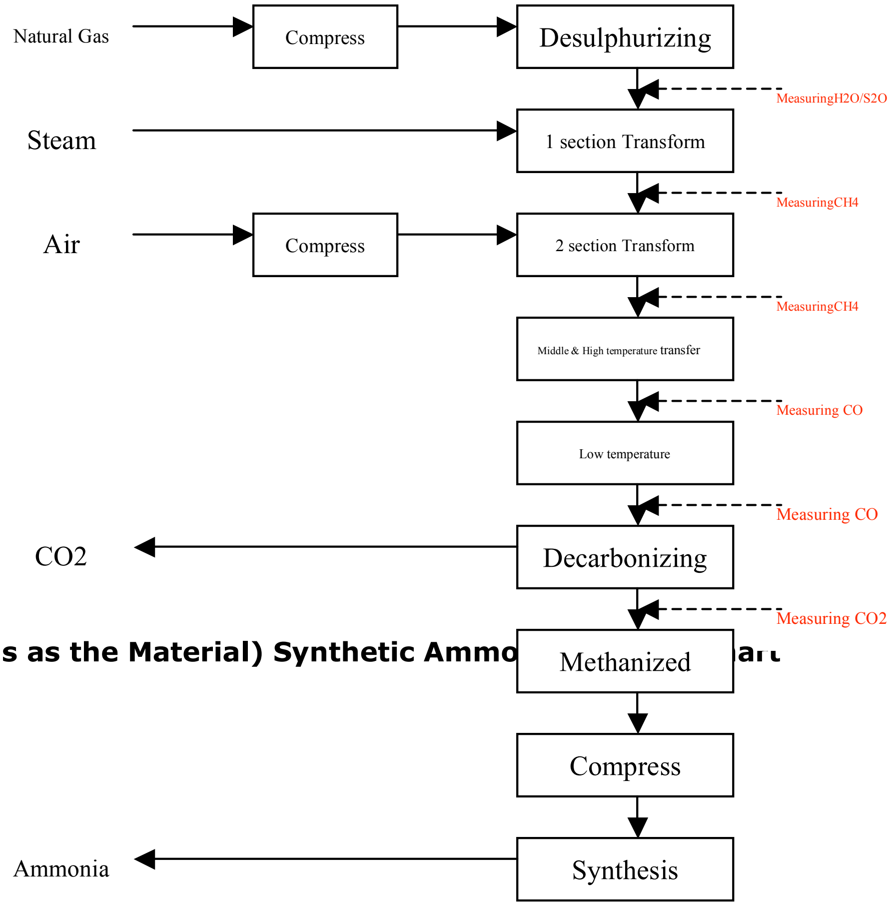


Figure 4 (Natural Gas as the Material) Synthetic Ammo… art

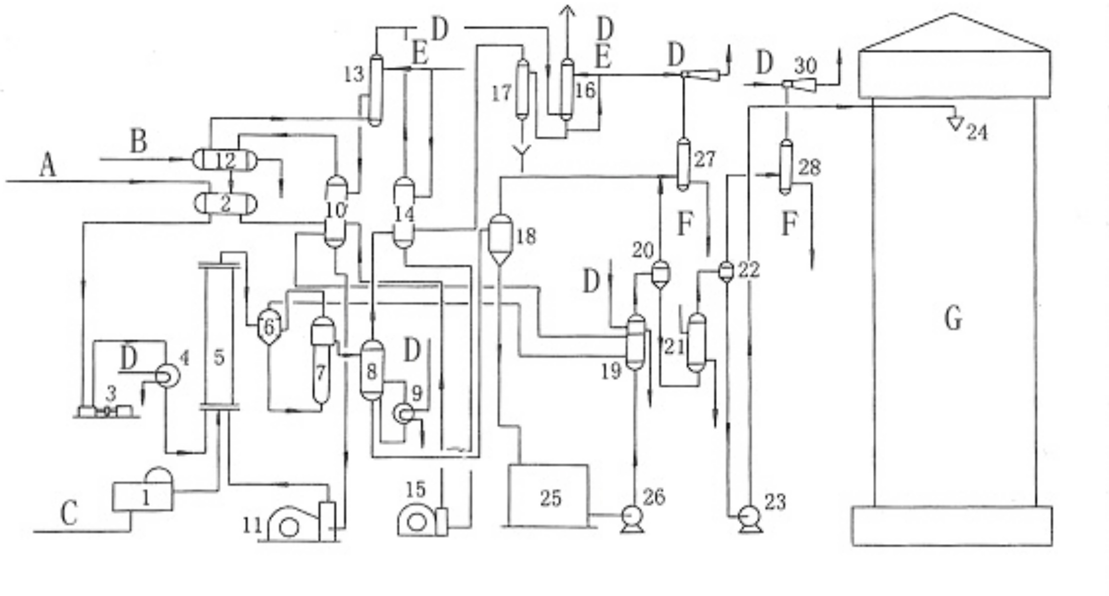
List of gas monitoring points:

Monitoring Point	Temperature(℃)	Pressure(Mpa)	Dustmg/Nm3	Measuring Gas	Concentration
Half-water Gas Tank back & front	30～256	0.04～8.4	1～2	O2 SO2	<0.5% 0～30 mg/Nm3
Desulphurizing			Micro doses	H2S/SO2	
中变 Outlet			Micro doses	CO	
低变 Outlet			Micro doses	CO	
Decarbonizing Outlet			Micro doses	CO2	
Regenerated CO2			Micro doses	O2	
Refinery Gas			Micro doses	CO/CO2	
Synthetic Recycle Gas			Micro doses	CH4/H2/NH3	
Natural Gas Hydrogen-Producing 1 section furnace	330～380	2.8～3.3	Micro doses	CH4	3～8
Natural Gas Hydrogen-Producing 2 section furnace			Micro doses	CH4	
Heavy Oil Hydrogen-Producing vaporizing furnace			Micro doses	CH4	

（4）Urea Synthesis Process Gas Analysis

Urea is synthesized under high temperature, its chemical reaction formula is $2NH_3+CO_2=CO(NH_2)_2+H_2O$.

Put CO2, liquid ammonia and aminomethane mixture into the bottom of the synthesis tower, to make urea; 62% of the CO2 may transform to urea. Process the mixed solution of urea, untransformed aminomethane, and ammonia, and separate the urine, and send it to prilling tower. Finally, pack it to be finished product.



A-liquid ammonia; B- cooling water;C-CO2; D-steam; E- condensate;F- evaporation condensate;G- prilling tower;

1-CO_2 compressor;2- liquid ammonia buffer tank;3- High pressure ammonia pump;4-liquid ammonia preheater;5- urea synthesizing tower;6- pre separator;7-1 section decomposition tower;8-2 section decomposition tower; 9-2 section decomposition heater;10-1 section absorption tower;11-1 section aminomethane pump;12- ammonia condenser;13- inactive gas abluent;14-2 section absorption tower; 15-2 section aminomethane pump; 16- off gas absorption tower; 17- desorber; 18- flash drum; 19-1 section evaporation pump; 20-1 section evaporation separator;21-2 section evaporation pump;22-2 section evaporation separator;23- melt urea pump;24- prilling spry;25- urine storage tank; 26-urine pump;27-1 section evaporative surface condenser; 28-2 section evaporative surface condenser; 289-1 section evaporation injector; 30-2 section evaporation injector

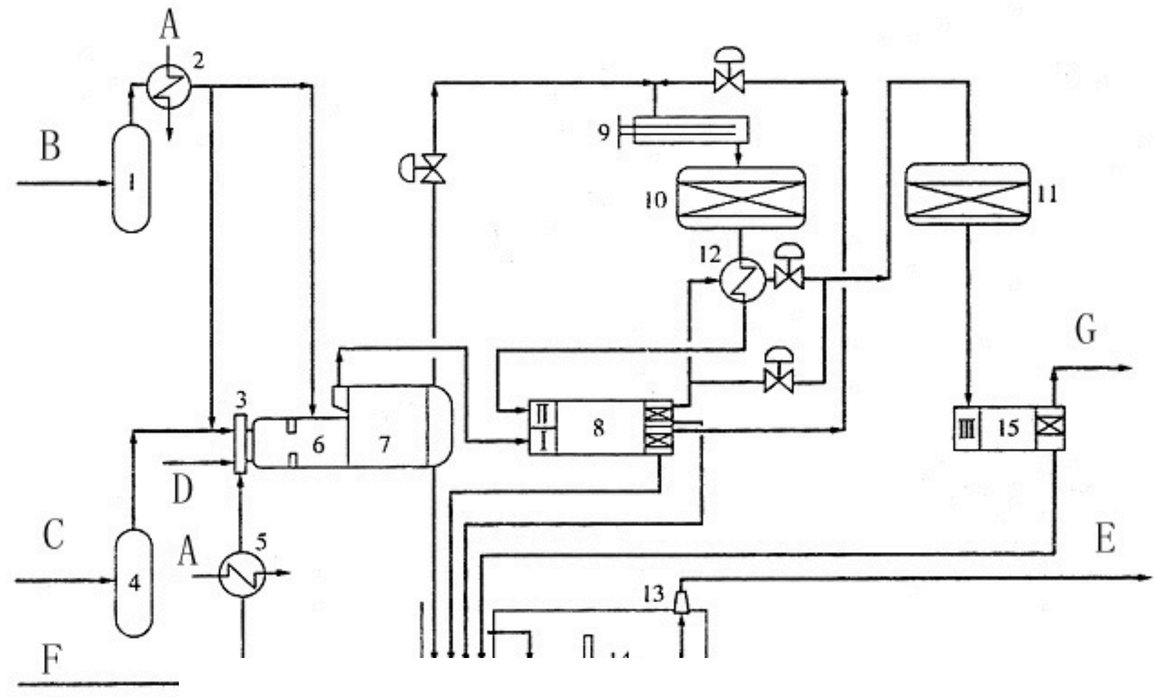
Figure 5 Aqua-solution Total Cyclic Method of Prilling Urea Process

List of gas moni

Monitoring Point	Temperature (°C)	Pressure	Dustmg/Nm3	Measuring Gas	Concentration%
CO2 Compressor Inlet	<42	<1 Mpa	No	O2	0～2
De-hydrogen Reactor Outlet	110～128	138～144 bar	Micro doses	O2	0.8～0.9
Recycle Gas			Micro doses	NH3/CO2	

（5）Application in CLAUS Sulfur Recovery Device

There is sulfur in the crude oil. After refining, sulfide will come out. It is detrimental to the environment if discharged directly, as well as to the human being. Claus Sulfur Recovery Device used a part of the H_2S process recovery.



A-steam; B- acid recycle gas; C- oil refinery acid gas; D- fuel gas; E- liquid sulfur exit device; F-air;G- off gas goes to RAR or combustion furnace
1-acid recycle gas abluent; 2-acid recycle gas pre heater; 3-main burner; 4-oil refinery acid gas delivery pot; 5-air pre heater; 6-thermal reactor (acid gas burner); 7-exhaust-heat boiler; 8-I, II class sulfur condenser; 9-electric heater; 10-1st Claus reactor; 11-2nd Claus reactor;12-gas-gas heat exchanger;13-liquid sulfur pump; 14-liquid sulfur pit;15-III class sulfur condenser

List of gas monitoring points:

Monitoring Point	Temperature (°C)	Pressure (Mpa)	Pipe Diameter (m)	Measuring Gas	Concentration %
Sulfur Main Pipe				H2S/O2	
Acid Feed Gas	40	0.065	0.5	H2S Hydrocarbon CO2 H2O	H2S：80 Hydrocarbon：2 CO2：12.5 H2O：4
Exhaust-heat Boiler Outlet	350	0.004	1	O2 SO2	O2：2 SO2：0.03
ClausOff Gas	158	0.025	0.6	H2S SO2	H2S：0.82 SO2：0.41

（6）Application during PTA Manufacturing

Most PTA manufacturers in China adopt Amoco method.

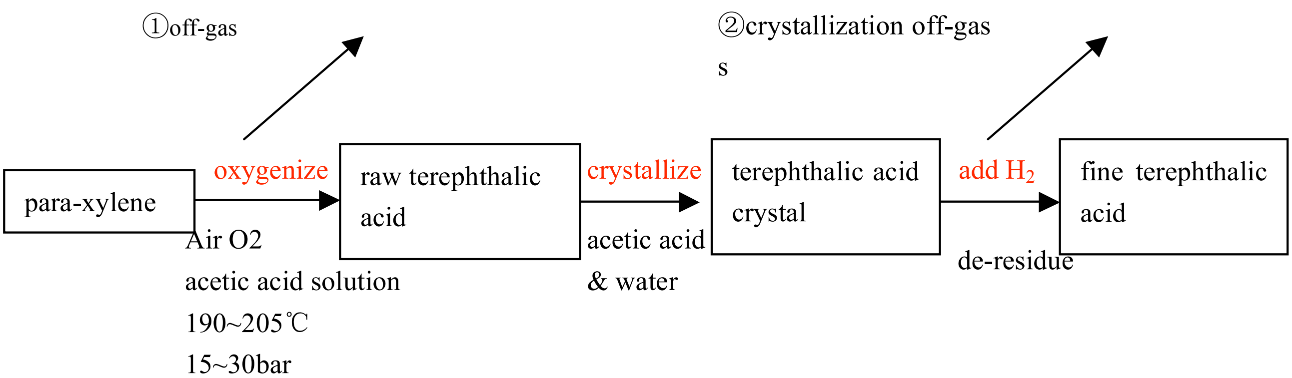


Figure 7 PTA Amoco Process Chart

Oxidization off Gas Environment:

Main Gas Components	**O_2**	**CO_2**	**CO**	Acetic Acid
Concentration Range	0~5%	0~3%	0~5%	
Concentration Typical Value	2.49%	0.73%	0.19%	0.007%
Temperature	49□			
Pressure	15bar±2bar			
Dust	No（Normally）			
Off Gas Discharge Pipe	Not key factor, it depends on the field conditions.			

Crystal off Gas Environment:

Crystal Off Gas Component	N_2	O_2	CO_2	CO	H_2O	Acetic Acid
	23.01%	0.62%	0.73%	0.19%	30.96%	44.49%
Crystal Off Gas Outlet Pressure	11.4bar					
Crystal Device Outlet Temperature	201□					

In PTA process, three gas species should be measured, O_2, CO_2 and CO. O_2 directly participates in the closed-loop control of safety production device. Now the method of 2 out of 3 samples is very popular. That means, at the same point, use three sampling and measuring systems to analyze 3 groups of data, and compare the two groups, if it exceeds the nominated range, than stop the machine according to safety control system. Usually, the O_2 Concentration is between 3.5%—9%. As for CO_2 and CO, measure a group of data at the oxidization phase, playing the role of monitoring and safety linkage.

（7）Application in Oxychlorination Method of PVC Production Process

Chlorine and Ethane, both as feed gases, the existence of water will make them produce erosive HCl gas. Neither aluminum oxide senor nor quartz-crystal resonator sensor can measure water concentration under Chlorine environment. Laser online gas analysis system is not touching, easy to install and its measurement range can reach ppm level. Thus it is very suitable for Ethane Oxychlorination process. The following figure is Ethene Oxychlorination Process Chart。

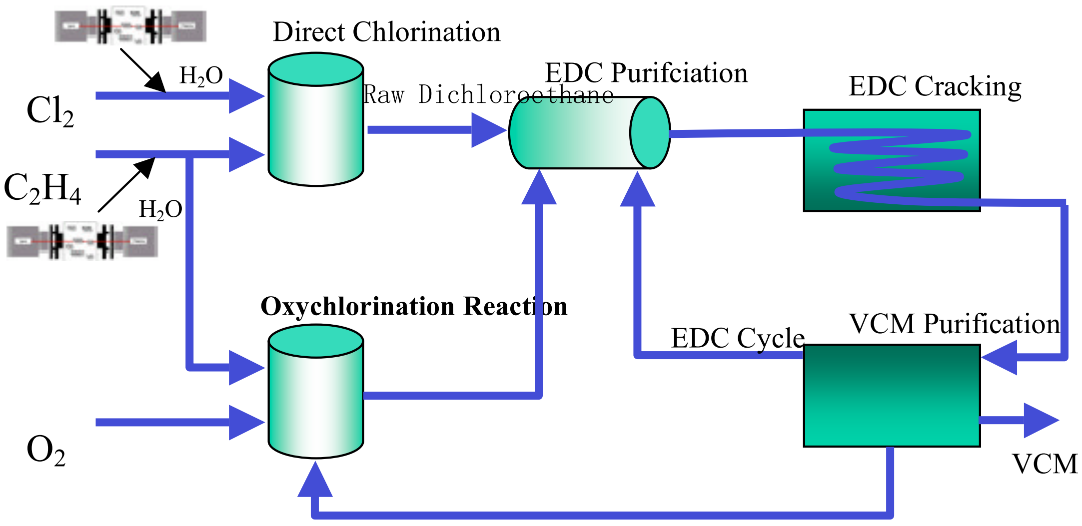


Figure 8 Ethane Oxychlorination Process

（8）Application in ETO Production Process

As the gas mixer is especially important for ETO production, it is necessary to real time analyze the feed gas and mixed gas concentrations.

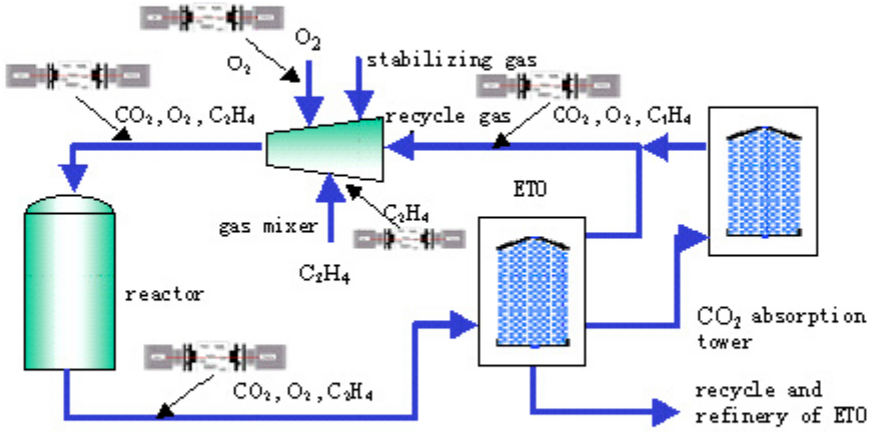


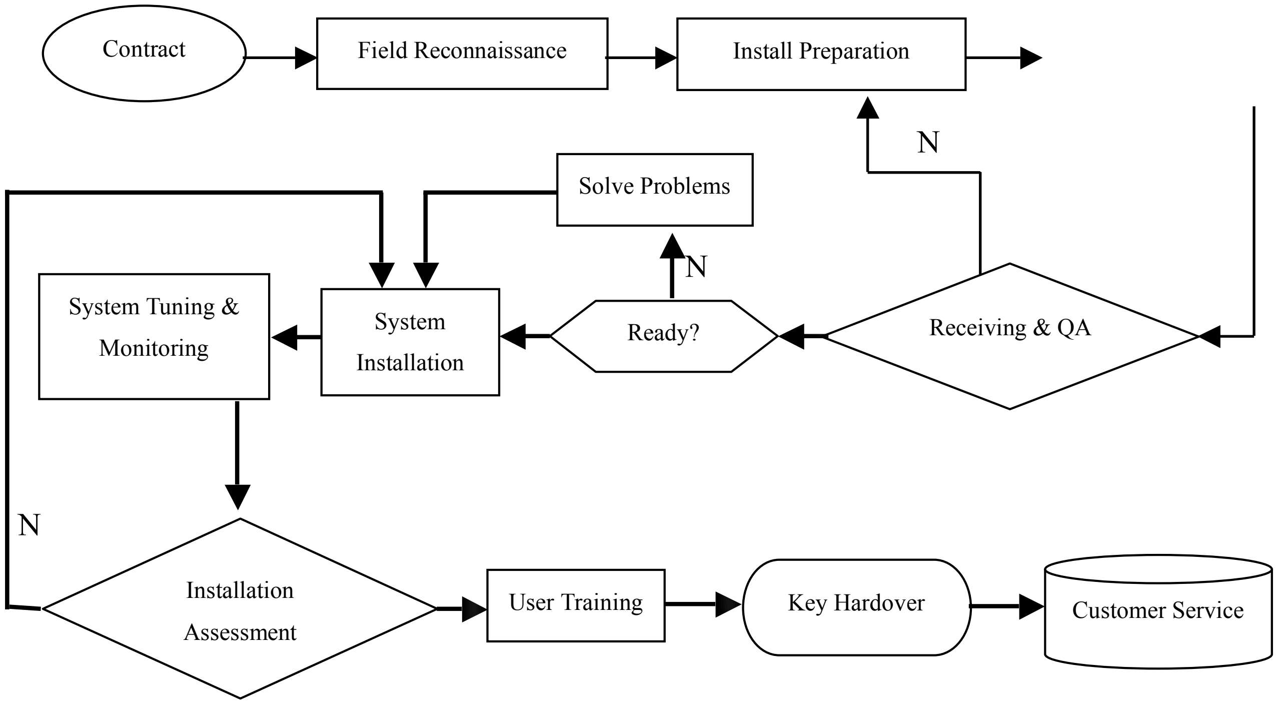
Figure 9 Ethane Oxychlorination Process Chart

5. Project Implementation & After Service

5.1 Project Flowchart

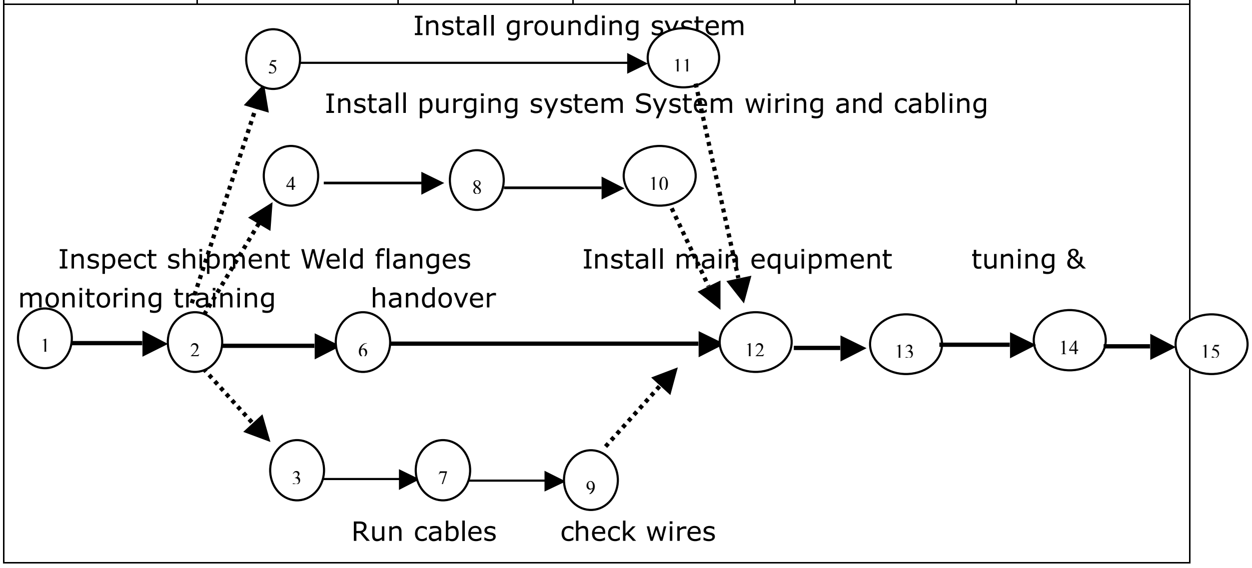
TAI takes full notice of canonical service flow being the prerequisite of any successful engineering projects. It has instituted and strictly enforced a thorough set of flow charts to ensure the best long-term interests of the customers, ranging from customer project initiation to installation to assessment and handover to after-sale services.

Packing&
Shipping


Contract
Field Reconnaissance
Install Preparation
N
Solve Problems
N
System Tuning & Monitoring
System Installation
Ready?
Receiving & QA
N
Installation Assessment
User Training
Key Hardover
Customer Service

5.2 Field Application Schedule

Day one		Day two		Day three	
AM	PM	AM	PM	AM	PM



5.3 Service

Technical Support

TAI is dedicated to providing customers with the best pre/post-sale services, and helping them to optimize their project designs to achieve the ultimate performance-to-cost ratios.