CONCLUSION

The Mercury Freedom System has been successfully tested and installed in multiple Power Plants and cement plants.
In summary, our field tests have proven that the current design of the Mercury Freedom System is fully capable ofmeeting the regulatory monitoring requirements of the Power and Cement industry. We will continue to focus on enhancing the range and sensitivity of the instruments to meet more stringent needs.

ACRONYM

CVAF – cold Vapour Atomic Fluorescence
MDL – Minimum Detectable Limit
CEMS – Continuous Emission Monitoring System
OSHA – Occupational Safety and Health Administration

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Environmental Control by Discharge Monitoring Techniques

Abstract

The importance of industrial waste water monitoring is undoubted in this age. Industrial waste water monitoring is very important to know as to check whether the quality of our water is getting better or worse. Information gathered through industrial waste water monitoring is important to many different decision makers. So it is necessary to implement an effective analyzer system that monitors the industrial waste water conditions. Industrial waste water monitoring is a system of devices which collects the data in real time and transfers it to the particular company website or environmental department/authority for analysis. Analyzer Systems generally monitors Pollutants in waste water and it is important to choose appropriate techniques that are effective and accurate and should be able to deliver significant results in any circumstance/conditions to maintain plant health and environmental protection. Major critical parameter like pH, Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) are the most common parameters which are present in the industrial waste water, and it causes significant damage to life, agriculture and economy

The continuous analysis of industrial wastewater is known to be problematic - especially when the analyzer is used as a spill monitor for heavily polluted wastewater containing a high load of particles. Thus, most operators require analyzers that enable accurate TOC measurements. But do they really get these? Common analyzers suffer from clogging and blockages due to their measuring techniques using tubes and valves. They require pretreatment and/or filtration of the sample. However any pretreatment and/or filtration will affect the analyzers measuring results. Removing particles means removing carbons and, hence, it results in inaccurate measurement. So Instead of total organic carbon measurement, the analyzer determines only some organic carbon.

Keywords

Environment Monitoring, TOC monitoring, Effluent Monitoring techniques, Efficiency monitoring of ETP Plant, Industrial wastewater, Wastewater treatment, Influent water, Upstream monitoring, Organic carbon, Organic pollution, Continuous monitoring, Online monitoring, High-pollution sample, Petrochemical, Chemical

Introduction

A clean environment is the basis for a healthy life. Whether water, soil or air – keeping the environmen clean for the protection of all creatures should be the primary responsibility of any society. In Europ alone, there are numerous laws, ordinances and administrative regulations describing the environmenta conditions needed to ensure a certain environmental standard. Instrumental analysis is a useful tool t measure the status of environmental conditions. Looking at the numbers of possible chemica contaminations (compounds), the group of organic compounds is the largest. With an estimated numbe of more than 19 million, it is impossible to detect and quantify each and every one of them. The sum parameter TOC (Total Organic Carbon) is one of the most important parameters used in man environmental applications. TOC analysis enables the determination of the sum of all organically boun carbons in the abovementioned organic compounds and is, therefore, a measure of organic pollution in matrix. The relevance of the TOC parameter becomes clear when looking at the parameter lists o various regulations in European countries: the Waste Disposal Ordinance, the Waste Technica Guidelines, the Landfill Ordinance, the Ordinance pertaining to the Recovery of Waste, the Stowin Directive, the Drinking Water Ordinance and the Wastewater Ordinance are just some that mentio TOC as a valuable parameter. TOC analysis is therefore carried out in a wide variety of environmenta matrices: from groundwater to seawater, from drinking water to wastewater, from soils to sewag sludge. The diversity in environmental applications creates many different challenges for the analytica systems being used. In addition to the different concentration ranges, TOC analysis repeatedly face different types of conditions such as salt content or number of particles.

Central Pollution Control Board vide its letter number. B-29016/04/06 PCI-1/5401,dated 05.02.201 issued directions under section 18(1)b of the water and Air Acts to the SPCB and PCC for directing 1 categories of highly polluted industries including Petrochemical industries for installation of onlin effluent quality and common emission monitoring system to help track the discharge of pollutants fro these units. The direction envisage: Installation of online effluent quality monitoring system at the outle of the identified units for the measurement parameters Flow, pH, COD,BOD,TSS & other sector specifi parameters as per guidelines provided and transmission of online data so generated to SPCB/PCC an CPCB as well. Installation of surveillance system with industrial grade IP (Internet Protocol)camera having (PAN, Tilt Zoom(PTZ) with leased line real time connection for data streaming and transmissio of the same (in case of having ZLD). Ensure regular maintenance and operation of the online system with tamper proof mechanism having facilities for online calibration.

Environmental analysis

In addition to environmental analysis, there are also application notes and information on Petrochemical industry, Chemical Industry, TOC special applications, “TOC in daily practice” and “TOC process analysis”. In many arid and semi-arid countries water is becoming an increasingly scarce resource and planners are forced to consider any sources of water which might be used economically and effectively to promote further development. At the same time, with population expanding at a high rate, the need for increased food production is apparent. The potential for irrigation to raise both agricultural productivity and the living standards of the rural poor has long been recognized. Irrigated agriculture occupies approximately 17 percent of the world's total arable land but the production from this land comprises about 34 percent of the world total. This potential is even more pronounced in arid areas, such as the Near East Region, where only 30 percent of the cultivated area is irrigated but it produces about 75 percent of the total agricultural production. In this same region, more than 50 percent of the food requirements are imported and the rate of increase in demand for food exceeds the rate of increase in agricultural production.

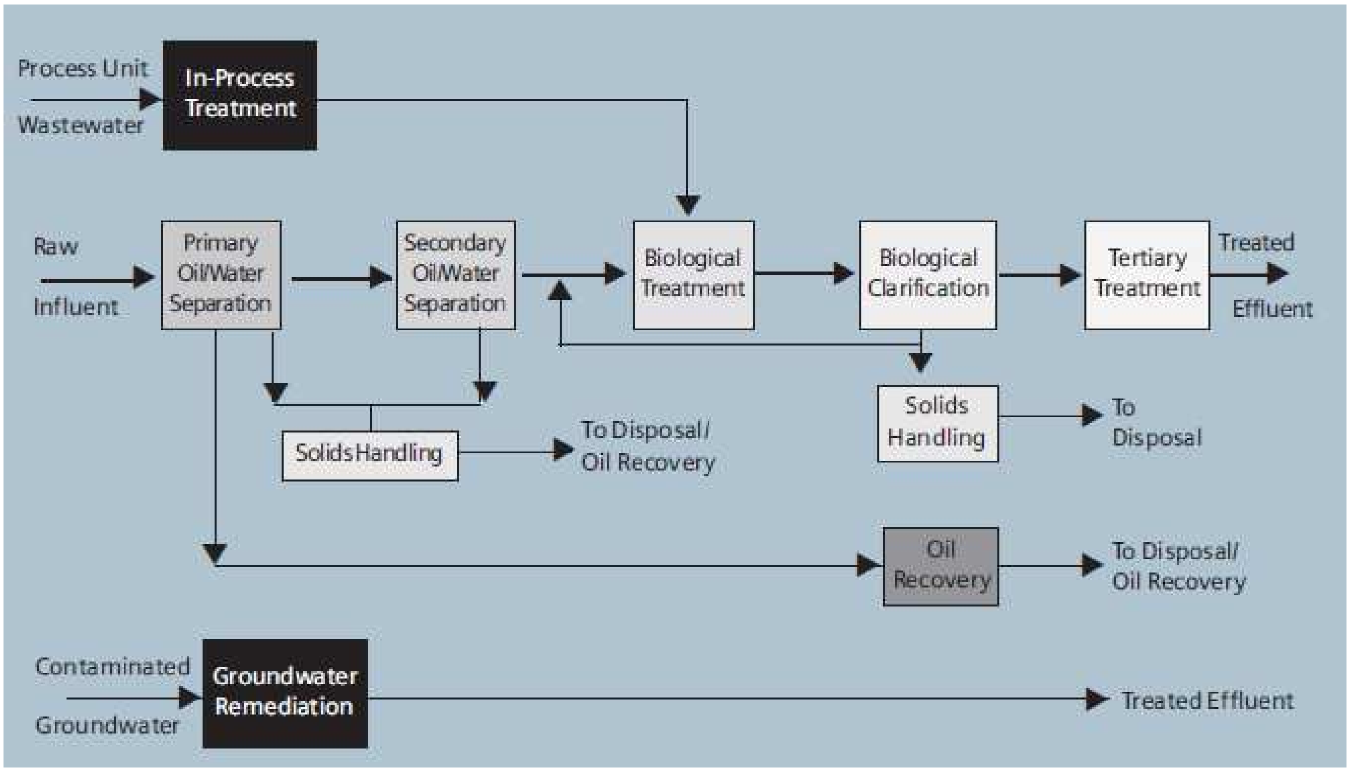
In India continuous monitoring system is heterogeneous due to the following factors: Various instrument suppliers are available to supply the analyzers/ instruments for monitoring various technologies are available for continuous monitoring of environmental parameters Data generated from these instruments are available in different format Since systems are different , platforms are different, formats are different, data collection and verification mechanism is not possible in a single platform. In order to overcome the heterogeneity of the systems, the following models of data collection and verification has been suggested in CPCB guideline. Major instrument suppliers have been asked to install and operate their control servers and software’s at CPCB, Following the polluter-pay principle all the industries were asked to submit the real-time data through instrument suppliers. Server-client software mechanism is in place, which enables CPCB to view and verify the data through remote configuration and calibration, along with the status of instrument health Instrument suppliers have also developed their own web portals where collected data can be visualized through internet.

System Validation:

The users need to frequently validate their online results with laboratory based methods. Online instrument operation will be evaluated using known buffers, traceable standards and laboratory techniques. By validating sensors and probes with known standards such as KHP (potassium hydrogen phthalate) for COD & TOC, Formazin equivalent standard for TSS &pH buffer have to be used to calculate a running variance of the measurements. When the variance is outside the set-points, this can be an indication the monitors requires calibration and services.

Effluent Monitoring in Petrochemical Refineries

Petroleum refineries are complex systems of multiple operations that depend on the type of crude refined and the desired products. For these reasons, no two refineries are alike. Depending on the size crude, products and complexity of operations, a petroleum refinery can be a large consumer of water relative to other industries and users in a given region. Within a refinery, the water network is as unique to the refinery as its processes. Refineries can generate a significant amount of wastewater that has been in contact with hydrocarbons. Wastewater can also include water rejected from boiler feed water pretreatment processes (or generated during regenerations). Wastewater can also refer to cooling tower blow downstream, or even once-through cooling water that leaves the refinery. Once-through cooling water typically does not receive any treatment before discharge. Cooling tower blow down water and wastewater from raw water treating may or may not receive treatment at the wastewater treatment plant (WWTP) before discharge. Contaminated wastewater is typically sent to either a wastewater treatment plant that is located at the facility, or it can be pretreated and sent to the local publicly owned treatment works or third-party treatment facility for further treatment.



Wastewater effluent discharge require two important measurement for loading calculation, One is Flow (millions gallons/day) and the other is concentrations (mg/L or ppm).Concentrations tells how much of a substance (i.e. mg of BOD) is present in a known volume of waste water (e.g. 1 liter). However, concentration is not the whole story since it does not tell how much (i.e. mass or weight) of a substance is going down to drain-commonly referred as loading.

TOC Measurement Technologies

(1) TOC – Optical Analysis (UV-Absorption 254nm, fluorescence, light scattering)

(2) TOC – Differential Conductivity

(3) TOC – UV-Persulphate

(4) TOC – 2-Stage Advanced Oxidation

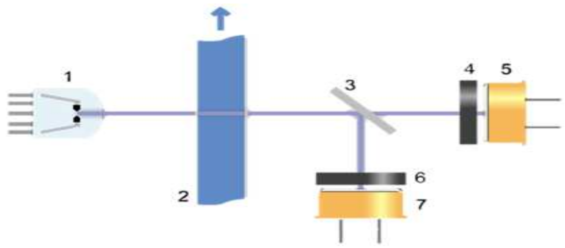
(5) TOC – Super-Critical Water Oxidation

(6) TOC – Catalytical Combustion

(7) TOC – High Temperature Combustion

TOC – Optical Analysis (UV-Absorption 254nm, fluorescence, light scattering) –

When a UV Light beam emitted by a lamp passed through Substances in liquid sample, Impurity present in sample will weaken light beam after the absorption of UV light due to presence of Impurity Intensity is measured by a detector at a wavelength of e.g. 254 nm. So it's an indirect method with correlation to TOC. The advantages of this method can be named easily: Very short response time, no reagents and low maintenance. But besides these positive aspects, it is actually not a real analytical method. It is just a parameter that has to be correlated to a standard method. This alone would not be that bad. But in reality the UV adsorption method can only see carbon double bonds. That means all substances which contain only single bonds cannot be detected. Here is a group of substances that cannot be detected with this method:



• Alcohol • Ether • Aldehyd • Alkine

• Glycerin • Ketone • Paraffin • Sugars

It is known in the market that this method is only suitable for concentration changes within otherwise known water streams. That requires that the matrix of the water is not changing, that the mixture of the compound is not changing and that only the overall concentration is changing. This is most unlikely for a real river stream! Therefore the required criteria of 100% recovery rate for all substances is not guaranteed here. The reality is far off with this method. It is obvious that such a limited analytical method is not suitable for the special conditions of river monitoring.

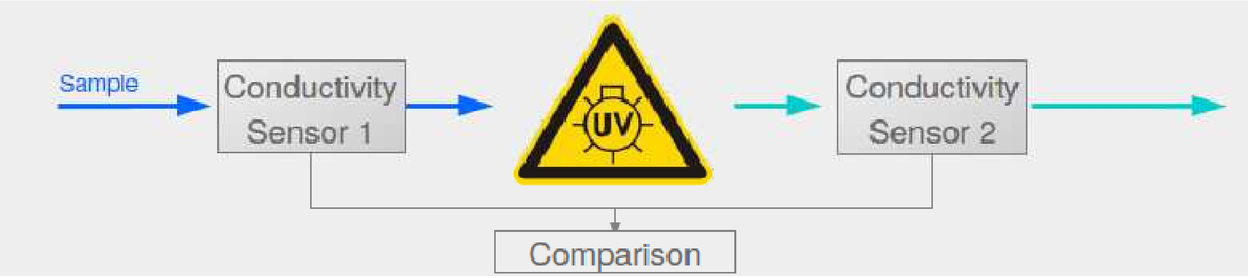
Limitations:

- Only double-bonds are absorbing UV
- Interference: Highly turbid or colored water
- Interference: Many DOC species

- Interference due to Particles
- Accuracy on real samples: +/- 30%

2. Differential Conductivity –

Common method used for pharmaceutical & ultra-pure water, Oxidation of organic carbon in a sample to carbon dioxide is carried out by UV radiation with oxidation (at e.g. 185nm) catalyst or per sulfate (According to standards USP643, EP2.2.44, ASTM D5173, conductivity USP 645). Conductivity change of water in conductivity detection cell separated from the sample with a gas permeable membrane or a gas-liquid separator is measured. The application of these methods is restricted to low polluted waters that have no suspended particles by the reason mentioned above article.



Limitations

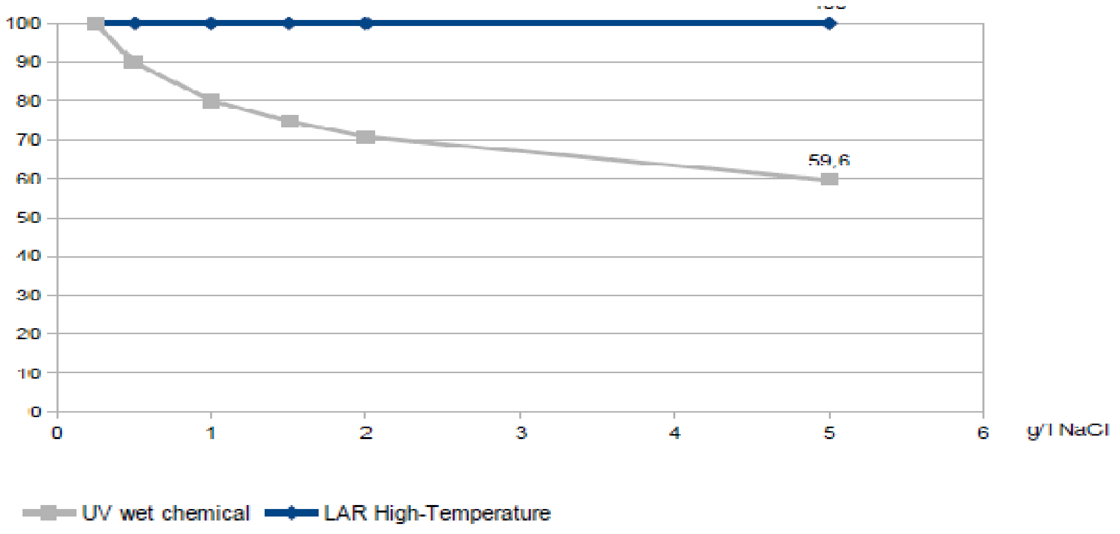
- Only clean samples without particlecontent with lowest conductivity
- Not all organics are oxidised& detected
- Some organics (e.g.chlorinated HC)produce false positives(high conductivity)
- Frequent recalibration with expensivecalibration standards required

3. UV-Persulphate Oxidation

There are two types of method, Persulphate oxidation supported with UV (Ultraviolet) irradiation activation and heated Persulphate oxidation. TC is converted to carbon dioxide in an oxidation chamber by being acidified with phosphoric acid and reacting with Persulphate in the irradiation of UV light if provided. The carbon dioxide produced in the oxidation chamber is carried with the carrier gas stream to a NDIR and concentration of carbon dioxide is measured (According to standards US-EPA 5310C, US-EPA 415-2 and DIN EN 1484:1997-08). IC, TOC and NPOC are measured by the same manner with the combustion / NDIR method mentioned above. The Persulphate oxidation / NDIR method is a rapid, precise method for the measurement of lower levels of TOC in purified water used mainly in semiconductor, pharmaceutical and power-generation industries. But since this method has some restrictions about samples which contain difficult oxidizable organic substances, suspended organic particles and salts, it is necessary to check the operational performance of the TOC analyzer beforehand when the TOC analyzer which employs this method is apply to domestic and industrial wastes, surface and saline waters and ground water. Check efficiency of oxidation with selected model compounds representative of the sample matrix as mentioned in U.S. Standard methods 5310 C or with samples containing particulates as mentioned in EPA method 9060.

Limitations

- Only for clean samples (no particles)
- Oxidation potential depends on complexity of carbon compounds
- Salt will inhibit the recovery of TOC
- Intensity of UV-light will decrease
- Limited recovery of organic substances when using UV-Persulphate oxidation
- Limited recovery of TOC in samples containing NaCl when using UV-Persulphate oxidation method e.g. 0,5% Salts: < 60 % recovery



4. 2-Stage Advanced Oxidation –

Measurement Principle

TIC detection

In first stage the sample is acidified by HCL and purged and then further passed to the measurement via NDIR detector

TOC oxidation – Step 1

Acidified sample is mixed with base sodium hydroxide and ozone (2-stage oxidation process)

Ozone and base (hydroxide ions) are forming hydroxyl radicals

Hydroxyl radicals are oxidizing the sample into carbonate and oxalate

TOC oxidation – Step 2

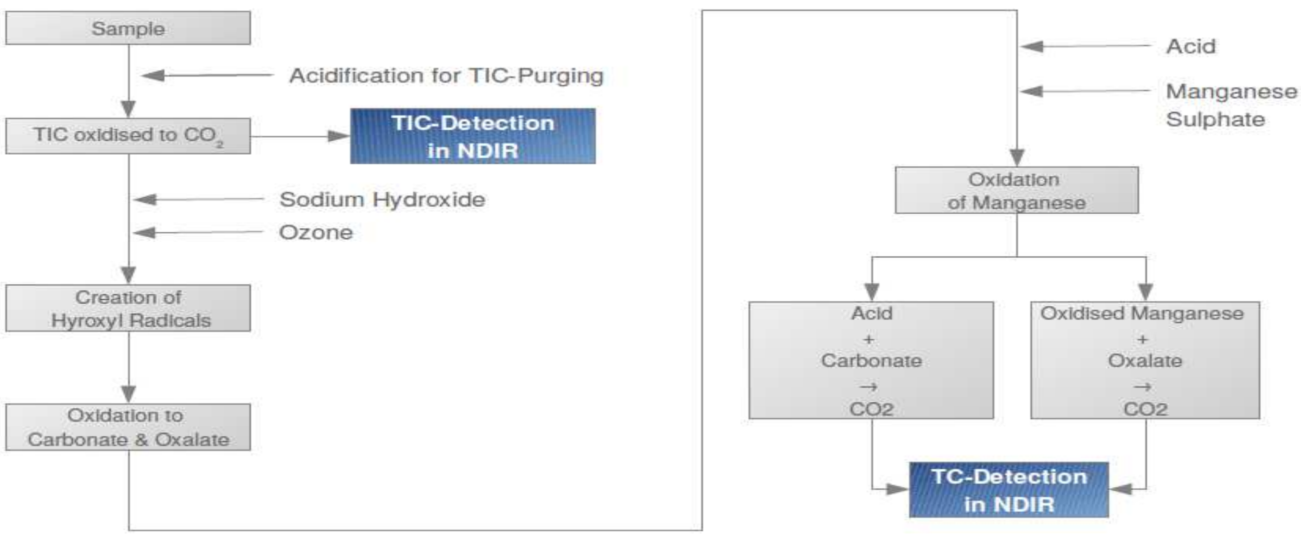
Acid and manganese sulphate are added to the sample

Ozone oxidizes manganese contained in the acid

Oxidized manganese reacts with oxalate, formed during base oxidation, to produce CO2

Simultaneously the acid reacts with carbonate, formed during base oxidation, to produce CO2

CO2 is detected via NDIR (→ TOC measurement)



✓ Used for waste and clean water applications

✓ Measurement according to standards ASTM D5173: 97(2007), DIN-EN1484, US-EPA 415.1, DIN 38409-H3 and ISO 8245

Limitations:

- Incomplete oxidation of particles
- Incomplete oxidation of some components (e.g. „ TMT15“)
- Some substances flocculate during up and down of pH-level (e.g. traces of vegetable oils)
- Cancerous ozone necessary for oxidation
- High amount of corrosive chemicals required for oxidation

5. Super-Critical Water Oxidation –

Sample & oxidant (Peroxodisulphate S2O8) are fed into isolated measurement chamber

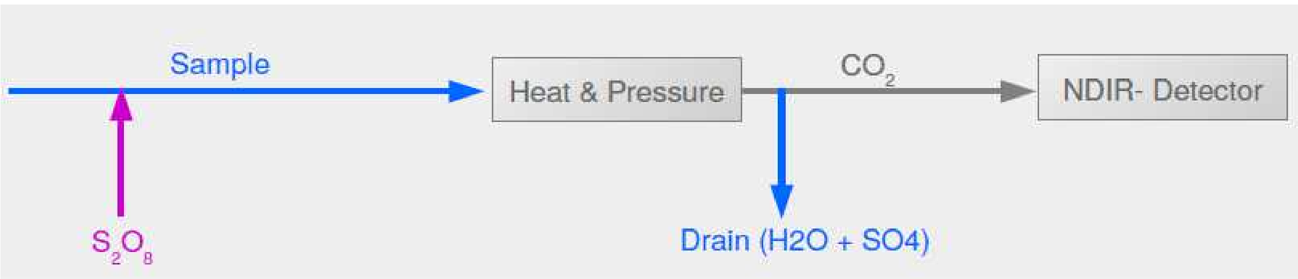
Increase of temperature to 375 °C

Increase of pressure to 215 bar

The increase in density enhances the oxidation interaction between sample and oxidant

Equation: Organics + S2O8 + heat + pressure

→ CO2 + H2O + SO4



6. Catalytical Combustion –

Removal of inorganic carbon (acidification of sample + air-purge)

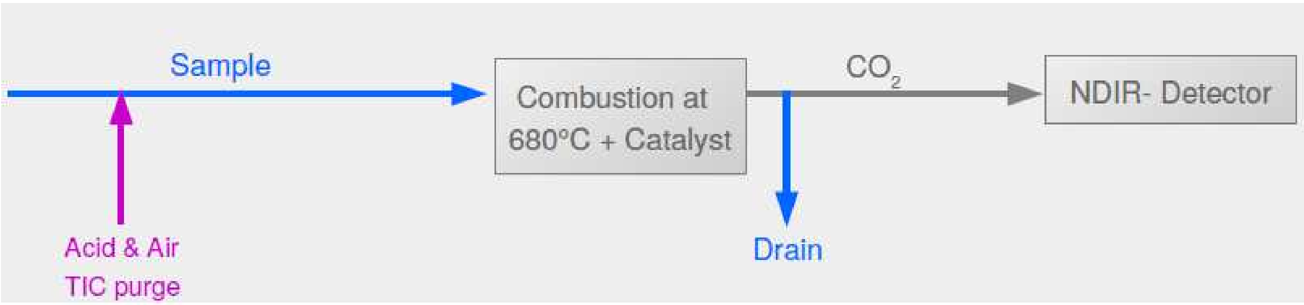
Oxidation of sample at 680 °C adding a catalyst

Conversion to CO2

Analysis of CO2 in NDIR-detector

Limitations

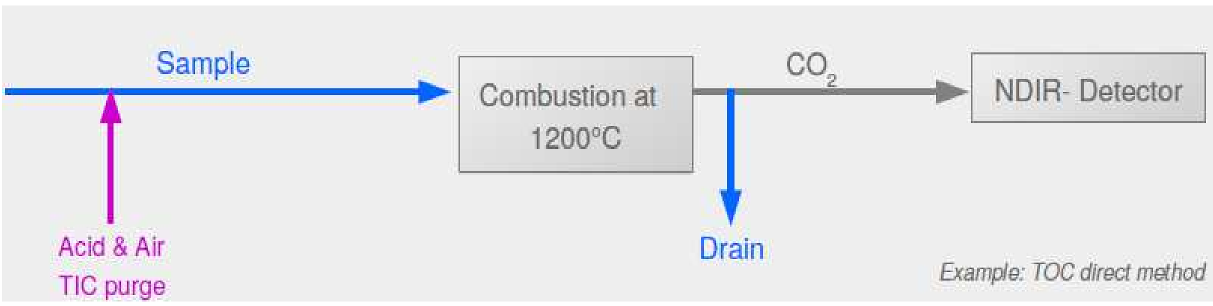
- Catalysts (expensive, high maintenance, slinking inaccuracy)
- Thin tubing’s (blockages, limited to clear water applications, „ DOC“ -measurements)
- Salty applications will harm glass reactor
- Glass reactor (frequent replacement, high maintenance)



6. High Temperature Non-Catalyst Combustion

Principle

TC is measured by injecting a portion, tens or hundreds microliter, of the sample into a heated



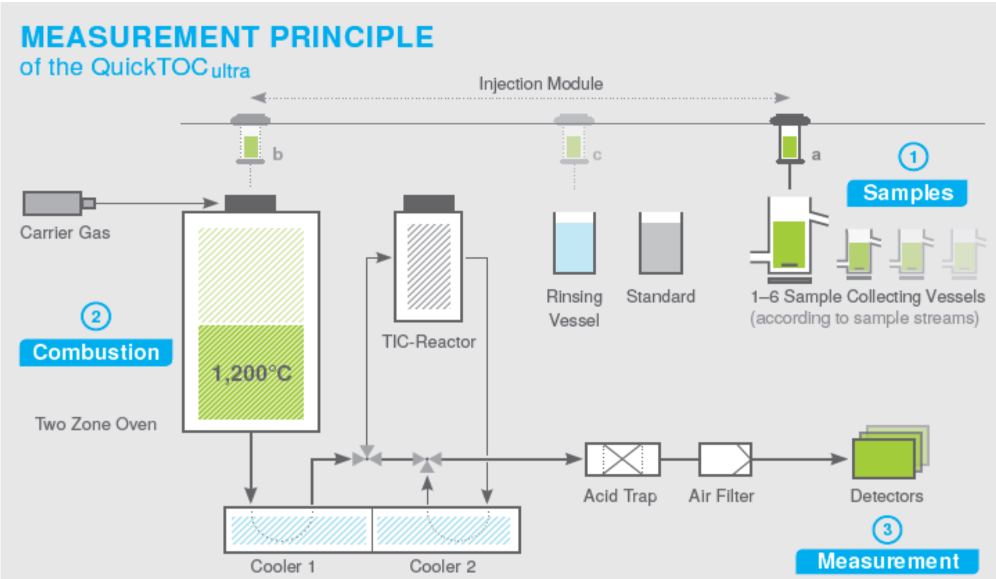
combustion

Furnace tube maintaining a temperature of 12000C without any catalyst. The water is vaporized and TC, the organic carbon and the inorganic carbon, is converted to carbon dioxide (CO2). The carbon dioxide is carried with the carrier gas stream from the combustion tube to a NDIR (non-dispersive infrared gas analyzer) and concentration of carbon dioxide is measured. The TC concentration of the sample is obtained by using the calibration curve prepared with standard solutions. IC is measured by injecting a portion of the sample into an IC reaction chamber filled with phosphoric acid solution. All IC is converted to carbon dioxide and concentration of carbon dioxide is measured with a NDIR. TOC may be obtained as the difference of TC and IC In the direct method the sample from which IC was removed previously, injected into the combustion tube and TOC (NPOC) is measured directly. The combustion / NDIR method is applicable to a wide variety of samples such as surface water, ground water, drinking water and waste water including intake water and discharged water for a waste water treatment facility. The strong points of this method are quick operation and strong oxidation capability for any kind of organic substance including suspended particulate organic substance. For an exact TOC measurement. All carbon bonds must be reliably combusted. Using a temperature of 1,200°C, LAR Process Analysers AG have developed a high temperature method which makes this possible! This temperature was chosen due to the proven fact that a complete oxidation of a sample cannot occur at temperatures below this: For example, the carbon bonds of carbonates only break fully when reaching a combustion temperature of 1,200°C. Basically, the lower temperatures deliver less exact measurement results. For this reason, to distinguish ourselves from these other methods Removal of inorganic carbon (Acidification of sample & air-purge)Oxidation of sample at 1200 °CConversion to CO2Analysis of CO2 in NDIR-Detector

The determination is in accordance to DIN EN 1484:1997-08, ISO 8245:1999-03 and EPA 415.1.The modular system offers high flexibility. When your application demands it, you can measure up to six different sample Streams with one device for example. Furthermore, it can be decided whether to build in additional detectors to determine the TNb and COD parameters alongside measuring the TOC value.

The TRUE TOC measurement takes place in less than 3 minutes. Thereby, short measurement value peaks can also be reliably shown. The maintenance service that is required is also fast: Less than 30 minutes per week are necessary. The analyzer's availability is over 98%. Moreover, all areas of the analyzer have been designed for easy maintenance: From the filter less sample extraction with the patented Flow Sampler®,(as shown below) by way of the generously measured and blockage free tubes, to the catalyst-free high temperature oven with the removable oven foot for the quick removal of salt residues.

In contrast to many other analyzers, the QuickTOCultra can handle salt concentrations up to 10 g/l. There is also an extra high salt option available that can handle up to even 300 g/l sodium chloride (NaCl). That means that even with a high salt concentration the sample does not need to be diluted. This, again, has a Positive effect on the accuracy of the measurements.



1) Sample transport via injection system
a) Extraction of sample from sample stream
b) Injection through valve
c) Rinsing of the injection needle.

2) Combustion, oxidation to CO_2

3) CO_2 concentration measurement

Advantages by using High-Temperature Combustion analyzers

- 1200 deg C furnace temperature
- No catalyst needed
- No chemicals required
- High salt up to 30% (300 g per Liter)
- Complex organics 100% oxidized
- Can handle and analyze high solids, oil and high salt samples at low maintenance
- 6 month routine maintenance intervall, more than 6 month calibration stability
- Special designed explosion proof cabinet
- Designed and manufactured in Germany

Many TOC analyzers technologies available in the market are not suitable for oily applications. Firstly, parts that come into the contact with the sample can be continuously contaminated. Secondly, oil is hydrophobic: Oil and water do no mix. Finally, Most TOC analyzers have a limited measurement range up to a maximum of 2000 mg carbon/l, which cannot be extended using dilution because this in not recommended technique for oily samples. The Quick TOC analyzer on the other hand features a relatively simple design that is better suited for the purpose maintained is reduced because the analyzer has a process controlled XY-driven robot that copies the manual laboratory methodology. This robot positions an injection port of 1200oC reactor or a Waste vessel, where the oils and greases contained in the sample are fully oxidized. Since oil tends to stick to wetted parts, most analyzers become contaminated over time, leading to so called memory effects which cause relatively clean samples to be systematically measured as too high. The great advantage of Quick TOC is that only the injection needle can become contaminated; it is cleaned with hot rinse water. However, directly and automatically after the sample injection.

Conclusion

Water is the most primitive element of all living beings. In order to keep our society green and clean and to address water pollution crisis, treatment of waste-water from industries is a necessity. The non-treated wastewater affects our environment by contaminating the water bodies like rivers, lakes etc. which will adversely affect the health life of wildlife habitat, fisheries and eventually deteriorates the quality of human society. The crisis of water scarcity can be addressed to a great extent by treating the wastewater from the industries. The initial Indian experience of real time monitoring system for reputed industries has not been very satisfactory as per CPCB. The operation need dedication and initiation both from the industry as well as supplier of the Instruments.

ACRONYMS

TOC	Total Organic Carbon
TIC	Total Inorganic Carbon
VOC	Volatile Organic Carbon
NPOC	Non-Purgeable Organic Carbon
WWTP	waste Water Treatment Plant
EPA	Environment Pollution ACT
NDIR	Non-dispersive Infrared
CPCB	Central Pollution Control Board

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BIOGRAPHIES

Nakul Jain was born in Bhopal in the year 1985. He had studied Electronics Engineering from RGPV Bhopal and Then Perused MBA in International Business in 2010 From University of Wales Institute Cardiff U.K. Having More than 7 Years of Experience in handling Liquid analyzer. Currently working as an Product Manager in Axis Solution Pvt., Ltd, Ahmedabad.

Failure Rates Estimation – Why Indian Industry should have its own database.

Mr. Mohan Limaye & Mr. Akhilesh Shah

Abstract

We have been observing the Indian Industry for past more than 5 years from Functional Safety perspective, and found that the awareness about functional Safety in general, IEC 61511 & SIL in particular is not very encouraging as of today. The authors are bringing in the issue which is facing by Indian industry for failure data, which we have been using from other countries. Aiming to make industry on one platform to create Own data base which is more relevant with Indian perspective.

Keywords:

Reliability, automation Industry, Failure Rates , Safety Instrumented System , Functional safety

Introduction:

Reliability of any system, item or a component depends on its design, manufacturing technique, environmental stresses, failure modes and operator skills and maintenance procedures. Besides, the life of equipment/item and particularly its frequency of failure is very much dependant on its operating environment and O&M culture of the company(Rao, 1998). Hence, it is very essential that we have a structured and comprehensive data on failure of such equipment items/components to efficiently estimate their reliability. Historically, we have been using failure data from popular databases such as OREDA, MechRel, PERD etc, which predominantly collects failure data from sites in EU and US. The environmental conditions and the maintenance culture in these regions is vastly different than in India. Besides, the failure modes and causes are also expected to differ in proportion due to different environmental and operating factors(Rao, 1998). It is known to reliability engineers that change in failure data directly impacts the Reliability, Availability and Maintainability of the item/components. It significantly changes the calculations related to equipment downtimes, spare parts availability and maintenance schedules. Hence, having enormous impact on the reliability of safety and production processes.

As an example, the offshore wind farm industry in UK found that the failure causes of similar components used in offshore oil/gas industry is very different when used in wind turbine applications. Hence to improve the reliability of the wind turbine system they generated a separate database known as SPARTA (System

Performance, Availability and Reliability Trend Analysis) for wind farm industry.

India has decades of experience in oil/gas industry and already possess enormous database. Since our operating, maintenance culture and environmental conditions are very different than in EU and US, this paper tries to invoke a sense of awareness and encourage Indian industry to collect failure data from their installations and compare with existing foreign databases. At the least it is expected that the outcome of this exercise will be recorded as an effort to scientifically validate and compare the effect of sub-continent conditions and maintenance culture on failure data of common components/items used in oil/gas industries in other parts of the world.

The below mentioned points depicts the way functional safety is practiced in the Indian Industry by the stakeholders.

In the country like India where Indian Instrumentation engineer's knowledge about

the Instrumentation subject, is second to none, since the inception of Automation in Industry, this situation is not encouraging.

Status of awareness on Functional safety (SIS)

Sr. No	Stack holders	Present Status	Remark
1	Awareness of IEC 61511 in User industry	Only about 15% Industry professionals are fully aware of what is SIL	Increase in awareness through various service providers and Companies like TUV SUD and association like ISA
2	Awareness of IEC 61511 in Vendors	Miles to go	Sometimes there is awareness but indifference is found in response
3	Engineering Consultants	Improvement	
4	System integrators & System houses	Leaves lot to be desired	Needs improvement

How Functional Safety is practiced

Sr. No	Stake holder	Typical ways of practice	Remark
1	User Industry	Installation of SIL 2 certified instruments automatically gives sufficient protection	Not Correct
2	Vendors	Several times does not differentiate between SIL certification and Hazardous area certification	Major reason is lack of awareness
3	Engineering Consultants	General understanding is that whatever given by Basic engineering package supplier is Gospel	Approach needs to be changed at First level of Engineers

4	System integrators/System houses	They consider whatever is demanded by Client or Consultant, just deliver	Need to bring in depth understanding of IEC 61511

Maintenance history Log and contents

No	Type of Industry	Record keeping	Remark
1	Small and medium level chemical plants with Automation (Chemical and intermediate manufacturers)	Mostly non existent	
2	Large Private Owned Industrial establishments with substantial degree of automation (Chemical/petrochemical/pharmaceutical units)	Sometimes there is a system but no serous record keeping and analysis of faults. (calibration records only are maintained)	Available if ISO 9001 QMS or any other Management system is implemented but the accuracy and correctness of the data is challenge
3	Large Public sector owned Industrial establishments with substantial degree of Automation (e.g. Refineries, Petrochemicals, Cross country pipelines)	Same as above	Same as above

Major Accidents in News in past 10 years

The process and power industry is a highly complex system with diverse equipment, control schemes and operating procedures. When process failures occur, some may be recovered from, while others escalate into minor or major accidents and losses. The summary of the accidents

No	**Industry**	**Number of major accidents in past 10 years**
1	Refinery & Oil & Gas	6 to 7
2	Petroleum oil depots	3
3	Pipe lines	4
4	Power plants and other industries	Not less than 10

- * the data is approximate and for understanding purpose

Estimated Losses (Fatalities, Environmental, Asset, Financial, Outage)

No	**Specifics**	**Estimated Loss (order of magnitude) ***

1	Fatality	>50 (reported)
2	Environment	Huge releases of smoke, Toxic releases, Oil spills is widely reported in some cases
3	Asset	Billions of Rupees (As reported)
4	Financial	Billions of Rupees (As reported)
5	Outage	In some cases, services resumed only after fortnight

- * the data is approximate and for understanding purpose

Factors responsible for Losses

There is a possibility of many factors being responsible for these accidents and resulting losses.

1) Poor maintenance practice,
2) Improper Design,
3) Insufficient SOPs
4) inadequate Safety culture

Even if this one factor can be attributed 15% responsibility of the total losses, there is a reason to take a serious look at the way we are dealing with Functional Safety. With these details and explained earlier we have carefully analyzed the Indian scenario with respect to implementation of Functional Safety Knowledge and tried bridging the gap . We noticed that we are dealing with Industrial establishments which are having very high degree of instrumentation and literally hundreds of thousands of Control loops and instruments scattered across their establishments in India. But when it comes to obtaining failure rate data of their instruments they are completely dependent on Vendors or some databases which are not Indian but of some remote North Sea location.

Functional safety requires that the failure rates should be as close as possible to the actual Environment of the Installation. We are not at all claiming that this is the only reason for the Industrial accidents but this practice of using the failure rates not related to our country could be "ONE OF" the factors.

Possible Solution:

The Participating Industries and the independent organization like TUV SUD and the ISA Delhi may collaborate together to collect failure rate data of Instrumentation based on sampling and eventually an Indian Failure rate database can be established. This database can be subsequently shared with rest of the Indian Industry. This will be an enormous activity but this will help instrumentation and all participative industries.

Benefits:

There are direct benefits for this project

- We have found that certain Sites (which were operating for more than 10 years) can't be SIL certified because the Management faces a dilemma as below
- If they decide to go for SIL certification, it would mean that their existing instrumentation items have to be replaced, which amounts to large financial implication and also long outage.
- If the Indian failure rate database after due process of Verification can establish that the existing instruments can be certified by the Establishment by resorting to Prior use concept then part of the above mentioned difficulty is avoided.

- In this process of Indian database project participation, the participating establishment would increase the awareness of their engineers about functional safety.
- The meticulous requirement of record keeping of failures would instill a safety culture at the establishment and this would go a long way in avoiding accidents!

One avoidance of major accident is as much as saving 10 time the cost of the entire plant!

Reliability :

What do we mean

The probability that an item will perform a required function without failure under stated conditions for a specified period of time

How do we get Failure Data?

- Two ways
  - a) Predict
  - b) Estimate
- Prediction
  - a) Calculated by reliability testing (vendor datasheets)
  - b) Very different from field data.
- Estimate
  - a) Usually recorded in maintenance logs as
    - Equipment, component, cause of failure, mode of failure, service time, when and how frequently it fails, etc.
  - b) Statistical inference (point estimates and confidence intervals)

What are we using right now?

- PFD - probability of failure on demand which is derived from failure rates available in prevalent industry database.
  - OREDA, PERD, CCPS etc.
    - Basically, failure data of components collected from various sites in North Sea, GoM, UK/EU and US.
  - Vendor failure data derived from their reliability testing results
- *However, challenge using these database*
  - *Failure rates change with different service, operating conditions, maintenance regimes, downtimes, environmental conditions etc.*
- But can't be sure of the impact on the reliability unless we generate database specific to our environment and compare with the existing failure rates
- However, we are not the first one
  - BP, Chevron etc.

How do we collect Failure Data?

- You are already doing it!
  - Maintenance logs
  - Repair logs
- However, it may not be structured, because
  - All types of failures may not be recorded.
  - Failure may not be classified into different modes viz. Critical, degraded, incipient, no effect/unknown, etc.
  - Repair times may not be recorded (or downtime due to prolonged repairs may not be recorded)

- Replaced component or item may not be recorded. Similarly, small repairs during routine checks may not be recorded.
- Hence a structured approach is required to gather comprehensive failure data

How do we collect Failure Data?

- Any Computerized Maintenance Management System (CMMS) provided by ERP (SAP, IBM, ORACLE, etc.) can be used for data collection
- However, the data collection has to be meaningful and should cover at least following details
  - Item/component description
  - Failure mode
  - Failure cause
  - Time since last repair/replacement
  - Repair time
  - Downtime due to failure
  - No of demands
  - Operating hours during a year
- Remember GIGO – Garbage in = Garbage out!
- **Alternatively, the data can be populated in a pre-set table.**

How do we use this failure data?

- The raw data from the plants/sites will be structured as follows:
  - Similar items/components
  - Similar failure causes
  - Similar failure modes
  - Calculate mean failure rates
- Usually the collected data will fall into two categories
  - Identical items operating under same operation and environmental conditions – homogenous sample
  - Identical items from different installations operating under different operation and environmental conditions – multi-samples or heterogenous samples
- Presently, the estimation will be limited to homogenous samples (same site/facility) as statistics involved in calculation of mean failure data for multi-samples is too complex
- To overcome any uncertainty in data collection/recording a statistical analysis will be performed with 90% confidence interval
- This will provide with lower and upper bound range of the failure data and a statistical mean of the failure data.

Conclusion

1. It is necessary to work together to put together a system which will facilitate an organized Indian instrumentation failure database.
2. ISA Delhi and TUV SUD are proposing to direct, lead and execute a structured project to deliver in a time bound manner the first level of the Indian instrumentation failure database if the Industry is ready to join their hands.
3. Hence, a pilot project should be carried out where the component failure data from an oil/gas installation in India is compared with prevalent industry database and the differences are thoroughly analysed. This would act as a scientific validation and would highlight the difference in the failure modes/causes and frequency of failures between databases, if any.

Akhislesh has been working for around 15 years in the field of Risk, Safety, Reliability, Environment and Loss Prevention. His experience covers a wide range of engineering works for Offshore and Onshore Oil & Gas projects related to all engineering phases (e.g. conceptual design, front-end engineering and detail design). Over the past 8 years he has been responsible for safety studies/workshops for number of projects with major international Operators. He had chaired numerous HAZOP, SIL (LOPA) , HAZID/ENVID, Alarm Objective Analysiss (AOA), Design and Constructability reviews for onshore facilities and offshore platforms. He had also performed and supervised numerous risk and safety studies for offshore projects including Quantitative Risk Assessments, Environment Hazard identification fire and Explosion Risk Assessments, Safety Integrity Level Classification and Verification, Dropped Object Risk Assessment, Escape, Evacuation and Rescues Analysis, Emergency systems survivability Analysis, Flare Radiation and Exhaust Plume study, Noise Study, Fault Tree Analysis, Reliability Study, generating Performance Standards for Safety Critical Elements, Industrial Safety and Working Environment (ergonomics).

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FLUE GAS DESULPHURIZATION (FGD) Process Optimization with Nafion Dryer Based Extractive type SO_2 Analyzer

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ABSTRACT

Air and water pollution in India continues to increase at an alarming rate. The thermal power plants are one of the major contributors of air pollution, predominantly they release SO_2, NOx, CO_2 and Particulate. To check the air pollution the Central Pollution Control Board in India released new emission norms for thermal power industry which are forcing industries to invest billions of dollars in pollution control technologies. For SO_2 reduction flue gas desulphurization is the most popular and widely accepted technology, this can reduce the SO2 content by over 90%. For efficient operation of FGD the accurate SO2 measurement is very important. The FGD process poses a challenging condition to analyzer as not many economical options are available for SO2 measurement at low PPM level. This paper discusses how the extractive type CEMS system using Nafion based sample conditioning system can accurately and reliably measure the SO2 under challenging conditions.

KEYWORDS

Flue Gas Desulphurization, FGD, Nafion, CEMS, SO_2

INTRODUCTION

The new Sulphur dioxide emission norms for thermal power plants in India requires installation of Flue Gas Desulphurization (FGD), to control SO_2 emission. The emission norms are based on the plant capacity and year of erection.India has over 190 GW of installed thermal capacity and out of this Central Electricity Authority (CEA) has planned FGD plant retrofit in over 160 GW capacity. The installation of new pollution control system poses big challenge for power industry as it requires significant amount of capital investment. FGD retrofit requires plant shutdown for 2-3 months which is an area of concern as government has to ensure uninterrupted power supply also. Considering the available resources and challenging timeline CEA has prepared 5 year implementation plan for FGD. NTPC being the leading thermal power producer in India has taken lead role in FGD implementation.

The FGD process optimization mainly depend on the analyzer installed in the upstream and downstream of FGD process. The upstream analyzer measures SO2 in the range of 300-600 ppm while the downstream analyzer measures SO2 in single or double digit ppm level. The FGD process results into addition of water, formation of acids and salts in the downstream flue gas. The changes to the flue gas chemical composition have led to the need for changes in CEMS design, particularly components which are in contact with corrosive gases to ensure long term CEMS reliability.

This paper will specify the various available FGD technologies, the challenges of CEMS design and the suitability of Nafion dryer technology for measurement of SO_2 with extractive analyzer at single or dual digit ppm level.

CEA YEAR WISE FGD PHASING PLAN

Year	Capacity In MW	No. of Unit
2018	500	1
2019	4940	8
2020	27230	55
2021	64027	172
2022	64704	178
Plan Not Available	150	1
Total	**1,61,552**	**415**

NTPC SO_2 CONTROL PLAN

Total Capacity	Identified Units	Implementation Plan
160 Units (66 GW)	66 Units (38.5 GW) New and < 5 year old and units near NCR	Under Implementation /Tendering
	74 Units (26 GW) 5-15 Year old (18 Units + > 15Year old 56 Units	Under Bidding
	20 Units (2.15GW)	To be Phased Out

SO_2 CONTROL TECHNOLOGIES

The popular SO_2 control technologies in power plant are mainly sea water based, wet Limestone based and Ammonia based FGD with wet limestone based is the most popular one.

The Chemical Reaction in Wet Limestone based FGD

$SO_2 + CaCO_3 + ½ H_2O \longrightarrow CaSO_3 ½H_2O + CO_2$ (1)

$CaSO_3 ½H_2O + ½O_2 + 1.5 H_2O \longrightarrow CaSO_4.2H_2O$ (Gypsum as byproduct) (2)

The Chemical Reaction in Sea Water Based FGD

$SO_2+H_2O+1/2O_2 \longrightarrow SO_4^{2-}+2H^+$ (1)

$HCO_3^- +H^+ \longrightarrow CO_2+H_2O$ (2)

The Chemical Reaction in Ammonia Based FGD

$SO_2 + H_2O + xNH_3 \longrightarrow (NH_4)_x H_{2-x}SO_3$ (1)

$(NH_4)x H_2\text{-}xSO3 + ½O_2 + (2-x)NH_3 \longrightarrow (NH_4)_2SO_4$ (2)

In all of the above SO2 control processes either the acids are formed or the salts are formed which are detrimental to the instrument installed in the upstream of FGD process and care should be taken to avoid corrosion and clogging.

The majority of the India plants are likely to adopt the worldwide proven wet limestone based FGD technology. The addition of water in the slurry injection stage of wet FGD system promotes formation of acid gases, specifically sulfuric acid. The Wet FGD systems produce significant amount of acid gases due to the saturated flue gas conditions. The changes to the flue gas chemistry of FGD downstream gas requires changes in the CEMS system, particularly components in contact with the highly corrosive flue gas, to ensure long term system availability and reduced maintenance issues.

For running the FGD process efficiently the SO2 analyzer is used upstream and downstream of the FGD and their accuracy is very critical as the addition of reagents depends on SO2 readings. The SO2 measurement in the downstream of FGD is particularly challenging due to lower SO2 content, acid mist, high moisture and salts. Condensing coolers can remove all SO2 in the downstream sample gas by dissolving the SO2 in the condensation. Nafion based sample conditioning system takes care of all of these challenges and in many cases allows the existing analyzers to accurately measure low SO2 levels.

NAFION BASED SAMPLE CONDITIONING SYSTEM DESIGN

The system contains two temperature-controlled zones mounted in an environmentally sealed housing.

First Zone: High Ambient Temperature Area

The sample passes through filtration process to remove particles as small as 0.1 micron. Acid mists, if present, are coalesced and then removed by an auto drain. The sample then passes through a Nafion™ dryer, which removes the moisture in the vapor phase. The initial portion of the dryer is heated above the sample dew point to prevent condensation and make drying more efficient. The high-temperature zone can be controlled at 80-95°C.

Second Zone: Ambient Temperature Area

In the second zone, the sample passes through the remainder of the dryer, further reducing the dew point to as low as 0°C or lower. This zone is none heated and subjects to ambient temperature.

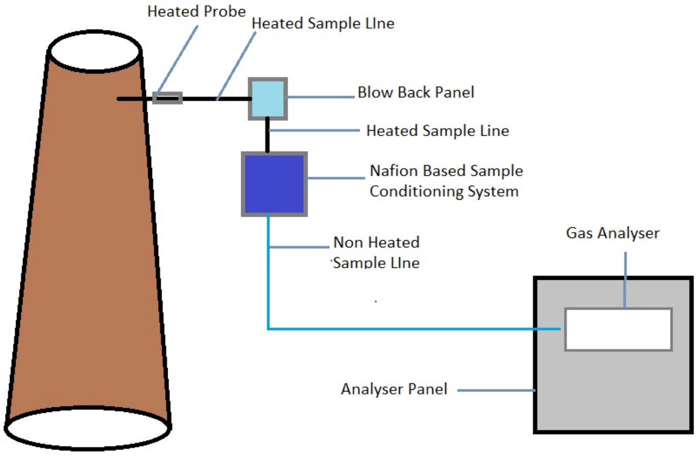
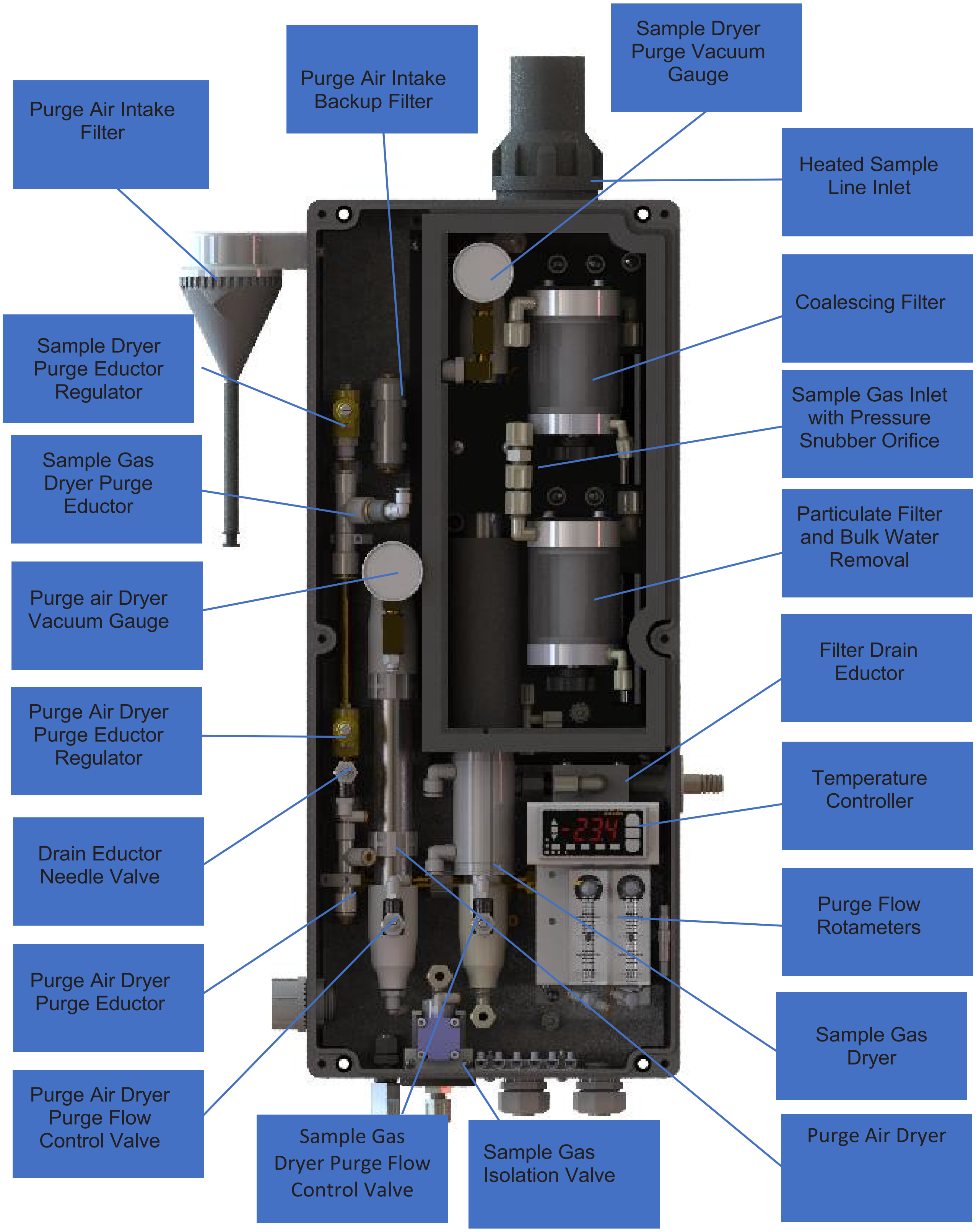


Figure 1: CEMS System Design with Nafion Based Conditioning System

NAFION BASED SAMPLE CONDITIONING SYSTEM



The Nafion based system design offers three main advantage for the FGD CEMS

1) **Excellent SO_2 Retention**

The moisture removal is done with Nafion membrane drying technology which removes the moisture in vapor phase thus not allowing highly water soluble SO_2 gas to get dissolved in liquid water. The Nafion based CEMS system allows accurate SO_2 measurement in single digit and also in triple digit ppm.

2) **Acid Mist and Ammonium Salt Removal**

The Nafion system design incorporates two stage filtration system which removes any acid mist and also particulates up to size 0.1 micron, thus saves the analyzer from corrosion due to the acid mist. A standalone ammonia scrubber upstream of the system will remove the ammonia thus avoiding the ammonia salt formation downstream and avoid sample line choking.

3) **In-Situ Mounting Eliminates Heated Line Requirement**

The Nafion system can be mounted near sampling point thus eliminating the need of high power consuming heated sample lines. Also the heated line tend to pose cold spot challenges which gets reduced with In-Situ mounting. With low levels of SO2, any condensation can dissolve most of the SO_2 in the sample gas making any cold spot in the heated sample line a major cause of inaccuracy.

CONCLUSION AND PERSPECTIVE

The Nafion based sample conditioning system will offer a reliable, accurate and economical sample conditioning solution for Flue Gas Desulphurization CEMS. The Nafion based system are proven worldwide and offer many advantages over conventionally designed CEMS system. With the introduction of FGD in Indian thermal power plant, accurate and reliable CEMS system are very important as billions of dollars will be invested in pollution control technologies and reliable CEMS data will be the key enabler for cleaner environment in India

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