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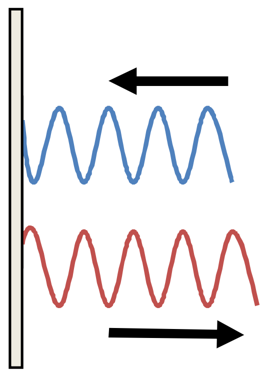
Theory of Operation

- Carbon absorbs microwave radiation.
- The other elements in coal fly ash do not.
- Many extractive instruments use this same principle.
- Unfortunately the amount of carbon present in the boiler back pass is relatively small.
- If a microwave signal is transmitted from one side of the back pass, and received on the other, the change in signal due to the presence of carbon is too small to measure.

Theory of Operation

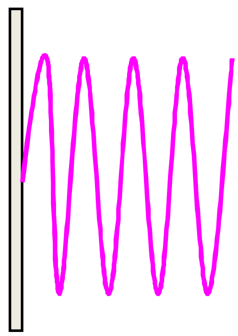
To increase the sensitivity to carbon, the signal can be reflected back and forth many times.

Theory of Operation



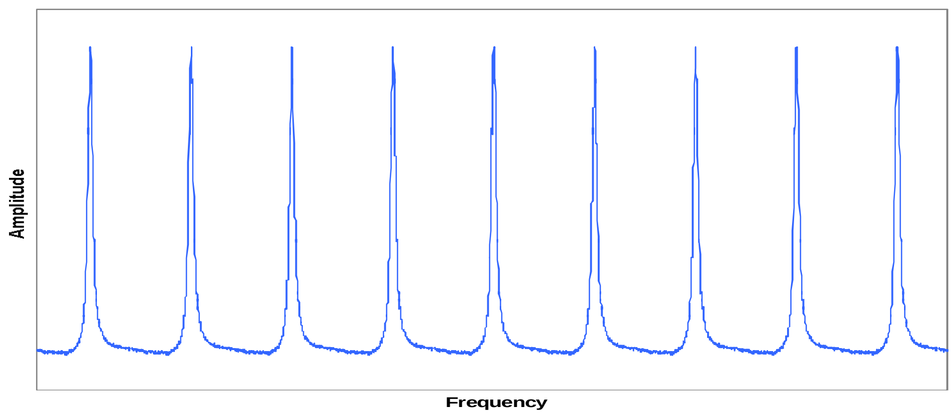
Typically, the reflected signal is out of phase with the transmitted signal. This causes the signals to decay quickly keeping the energy level low.

Theory of Operation



If the distance between the reflectors is an exact multiple of the wavelength of the transmitted signal, the reflection is in phase with the transmitted signal. This condition is called resonance.

Theory of Operation

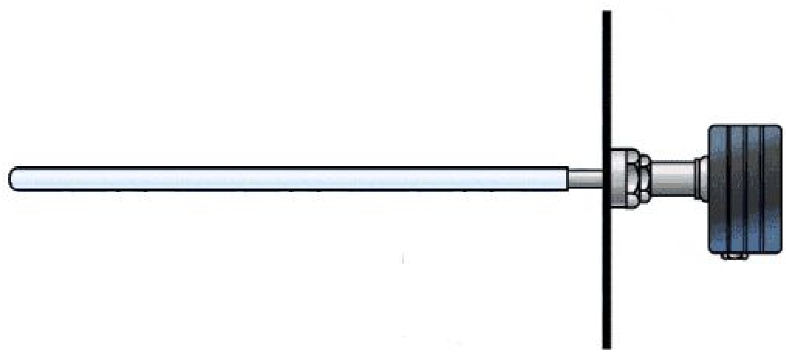


The frequency of the transmitted signal is varied across a 100MHz range. Whenever a resonance is encountered, a peak occurs. The amplitude of the peaks decrease in proportion to the amount of carbon in the backpass.

Theory of Operation

- From the signal peak amplitude we calculate carbon in grams per cubic meter.
- The most common way of measuring carbon is as a percent of fly ash.
- We need to know how much fly ash is present.
- An electro dynamic dust probe is used to measure the fly ash.

Theory of Operation



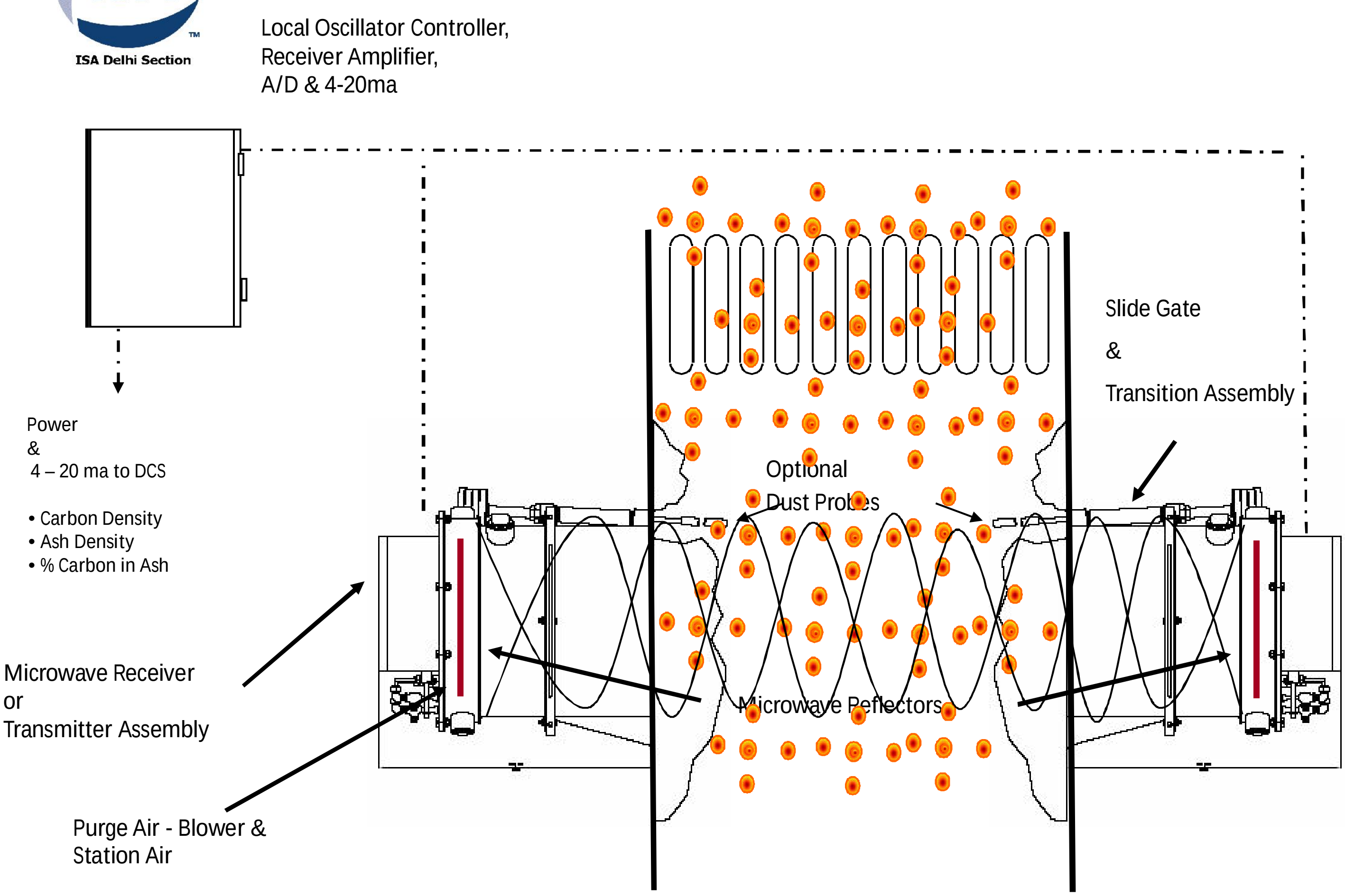
Flyash particles passing near the electrodynamic probe induce a small voltage in the probe. The frequency of this signal is analyzed to determine the flyash loading.

Theory of Operation

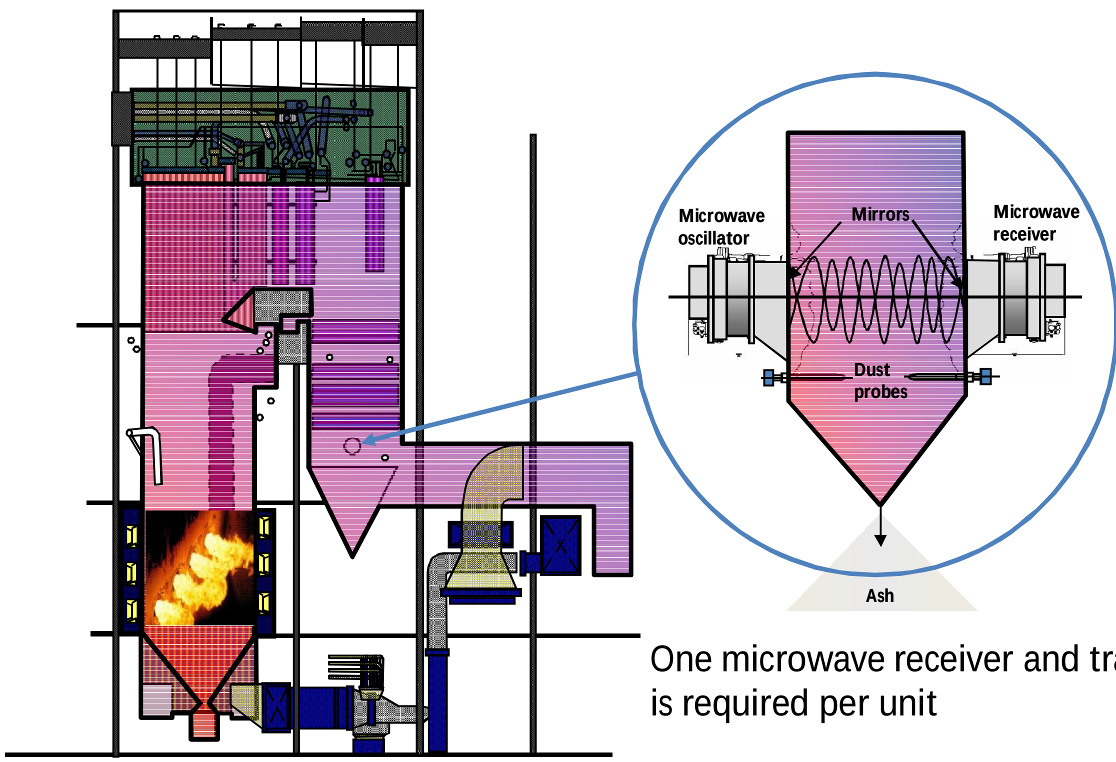
$$CIA(\%) = \frac{Carbon(g/m^3)}{Ash(g/m^3)} \times 100$$

Now that we have both carbon and ash loading it is a simple matter to calculate CIA as a percent

Carbon In Ash Load Instrument - Configuration

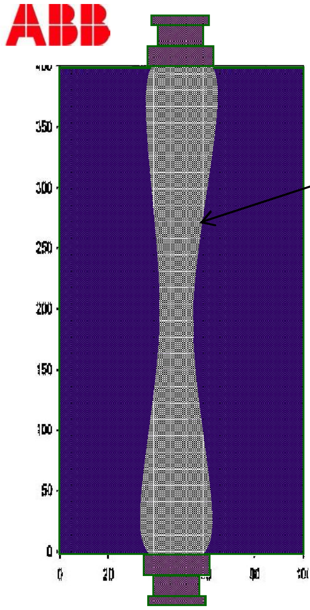


Real Time Carbon in Ash measurement

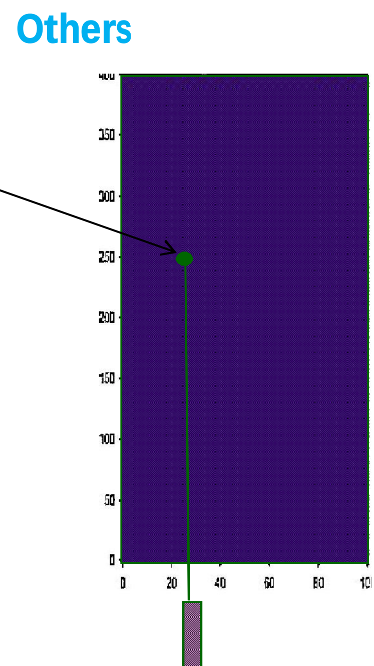


One microwave receiver and transmitter is required per unit

Carbon In Ash Instrument
Superior Sampling Method



Sampling Area



ABB's CIA analyzes conical volume
Can be used for closed loop control!
Volume sampled: 3-10%

Based on single or multi point sampling
Not suitable for closed loop control!
Volume sampled: ~ 0.000005%

Non extractive Vs Extractive Carbon In Ash Instrument

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Non Extractive

- **Non-Extractive**: Measures carbon passing through ~20 In. diameter cylinder
- **Real-time**: 1 minute (or faster) average values
- **Low Maintenance**: Simple design, can be maintained with furnace cold or in service, automatic mirror alignment
- **Integrated Solutions**: Advanced combustion control optimization solutions based on CIA data (in development !)
- **Accuracy**: 1% Absolute across duct width
- **System Cost**: Instrument cost, Installation, Annual maintenance
- **Fuel Type** Independent

Conventional

- **Extractive**: Extracts sample of fly-ash through a single point source
- **Slow Response**: 5 - 15+ minutes between samples
- **High Maintenance**: Consists of many moving parts - including vacuum pumps, weight scales, carbon detection method, and sample-volume purge system
- **Accuracy**: Typical 1% @ point of sample (across duct *f* (# of points)
- **System Cost**: Instrument cost, Installation (multiple sample points), Monthly (?) maintenance
- **Fuel Type** Dependent

Carbon In Ash Instrument
Hadong 7&8 PS, 2x500 MW, South Korea

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Project name: Hadong 7&8 CIA

Location: Hadong

Customer: KEPCO

Completion: February 2011

Customer need

- Minimize fuel usage and production costs
- Install a Unburned Carbon Measuring Instrument

ABB's automation response

- CIA Load Instrument

Delivered benefits

- Availability of ABB instrument
- Accuracy
- Real Time Measurement

Why ABB awarded project

- ABB Instrument has advantageous features respect to competitors

Carbon In Ash Measurement
2x 660 MW M/S La Spezia, FFPP Italy

Project: La Spezia
Customer: ENEL POWER ITALY
Completion: 2010

Customer need

- Minimize fuel usage and production costs
- Install a Unburned Carbon Measuring Instrument
- Remote access to Instrument

ABB's automation response

- CIA Load Instrument

Delivered benefits

- Availability of ABB instrument
- Accuracy
- Real Time Measurement

Why ABB awarded project

- ABB Instrument has advantageous features respect to competitors

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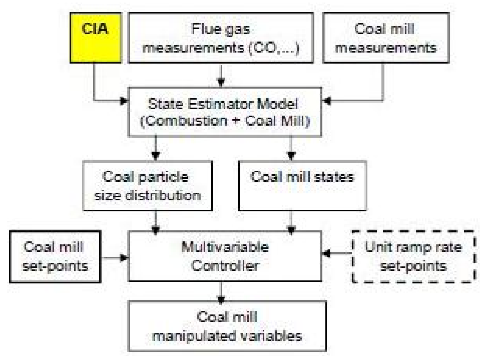
CIA in Advanced Ctrl and Optimization (1)

- **Coal mill monitoring & control**
  - Coal mill performance has the highest impact on combustion efficiency (coal particle size + air/fuel mixing)
  - State estimation of coal particle size distribution and mill states based on CIA + model (combustion + coal mill model)
  - Differentiate between improper combustion conditions and improper coal particle size
  - → Predictive maintenance through early detection of operational faults
- **Unit ramp rate optimization**
  - Implement faster coal mill response (increase grinding rate) to increase boiler ramp rate
  - → Faster load-following capability



Thank You!

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for a better world™

ABB

Mail: anup.kr.shukla@in.abb.com
Cell : +919810845978

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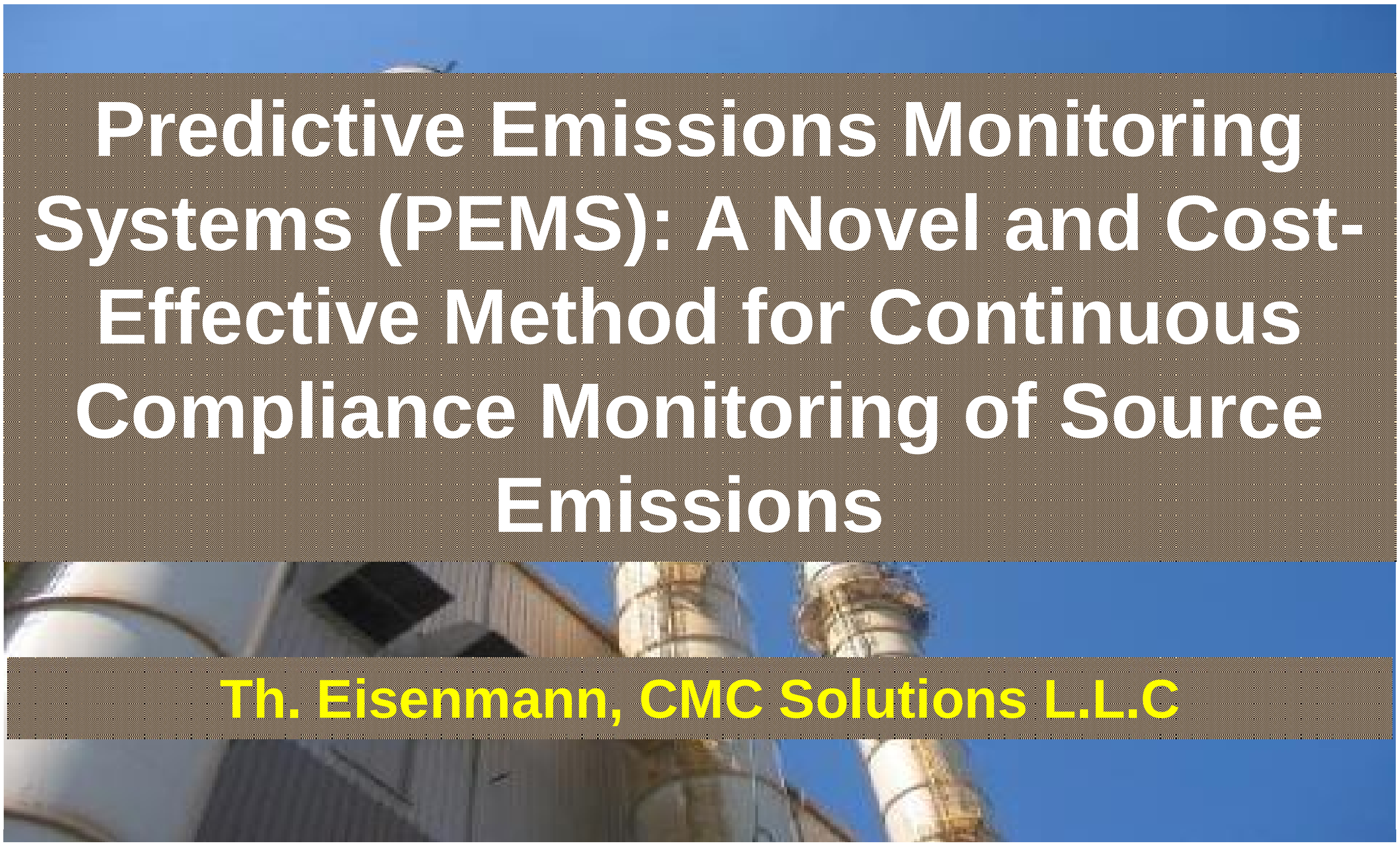

Predictive Emissions Monitoring Systems (PEMS): A Novel and Cost-Effective Method for Continuous Compliance Monitoring of Source Emissions

Th. Eisenmann, CMC Solutions L.L.C

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PEMS Presentation Outline

- Definition of PEMS
- Why choose PEMS instead of CEMS
- Relevant US EPA regulations 40 CFR Part 60 / 40 CFR Part 75 / EU regulations
- CEMS – PEMS schematics & configuration
- Selection criteria
- Different PEMS design Empirical - Parametric
- How to develop a model and what parameters are used
- QA / QC, Relative Accuracy Audit (RAA), Relative Accuracy Test Audit (RATA)
- Cost
- Summary PEMS – CEMS common features / differences
- Regional activities
- Benefits

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Definition of PEMS

A PEMS is a software based data acquisition system that is interfaced with the process control system and inputs from the combustion or pollution control process.

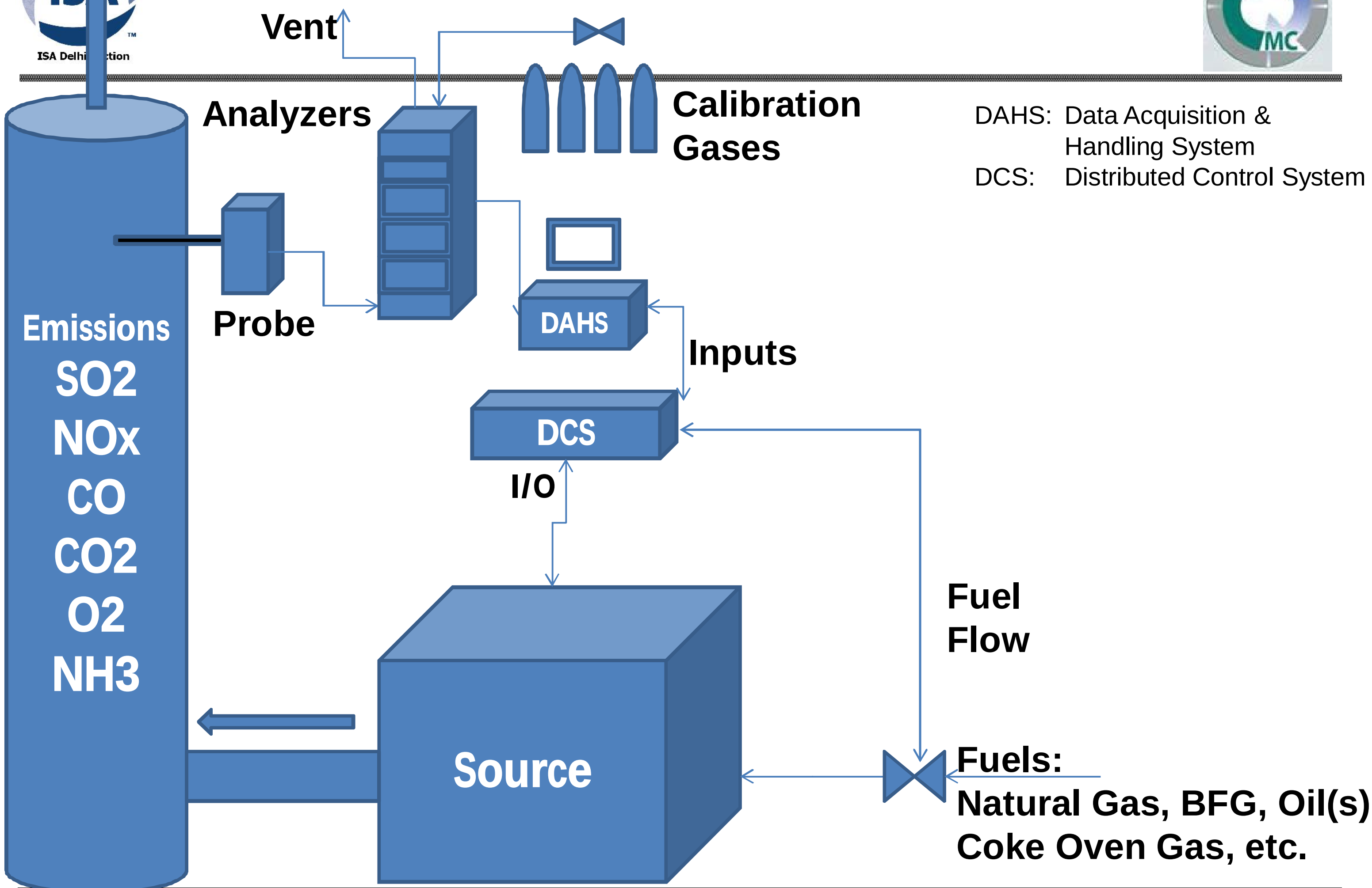
It utilizes these inputs to determine the emission rates of the various pollutants that are regulated.

A PEMS has no gas analyzers like a CEMS - Continuous Emissions Monitoring System.

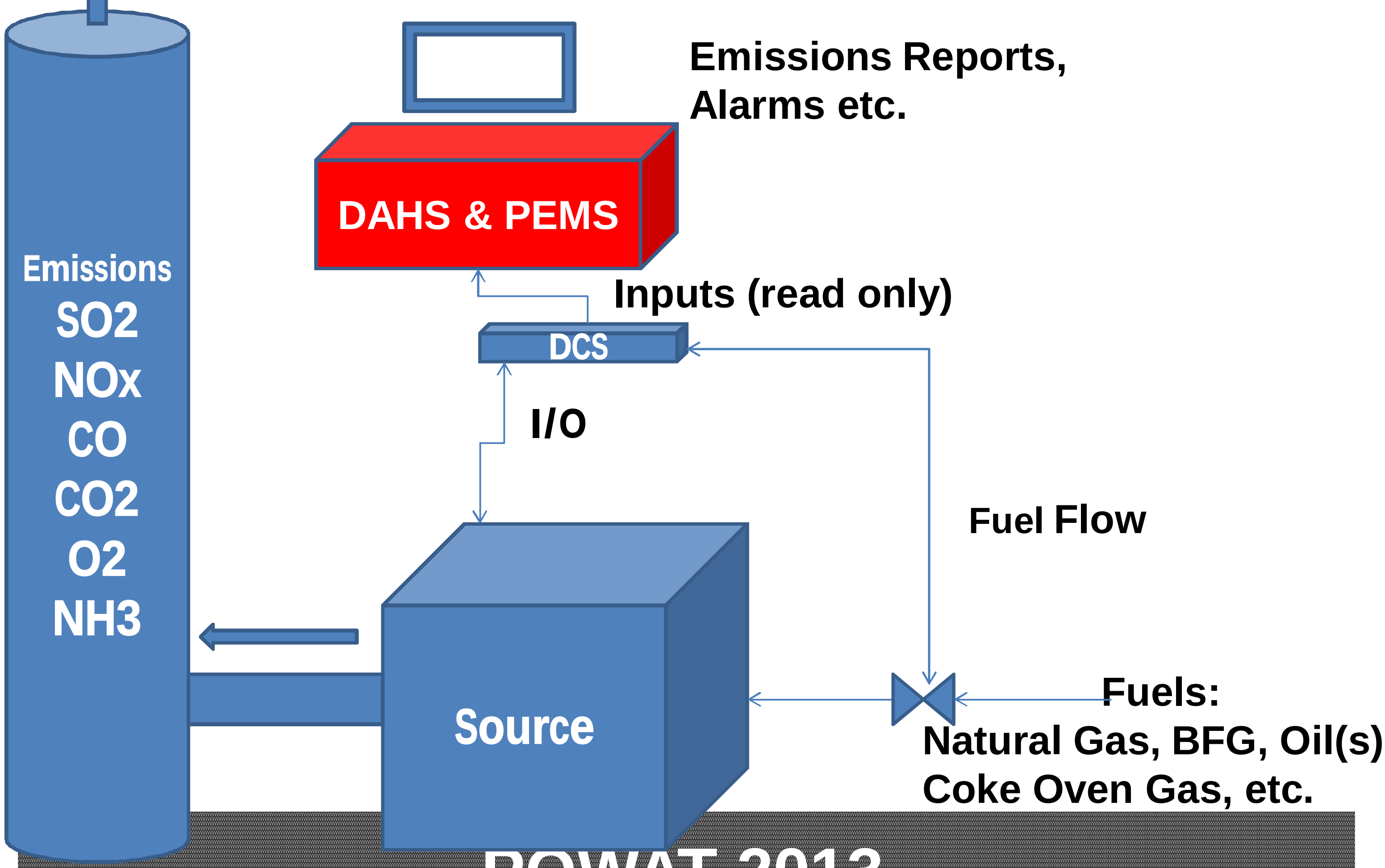
Why consider PEMS?

- Proven and patented product
- Certified according to U.S. EPA regulations
- Accuracy levels as good as that of a CEMS
- Minimal maintenance & operational costs
- It can replace an existing CEMS
- It consistently achieves very high data availability
- The model is developed and retrained onsite

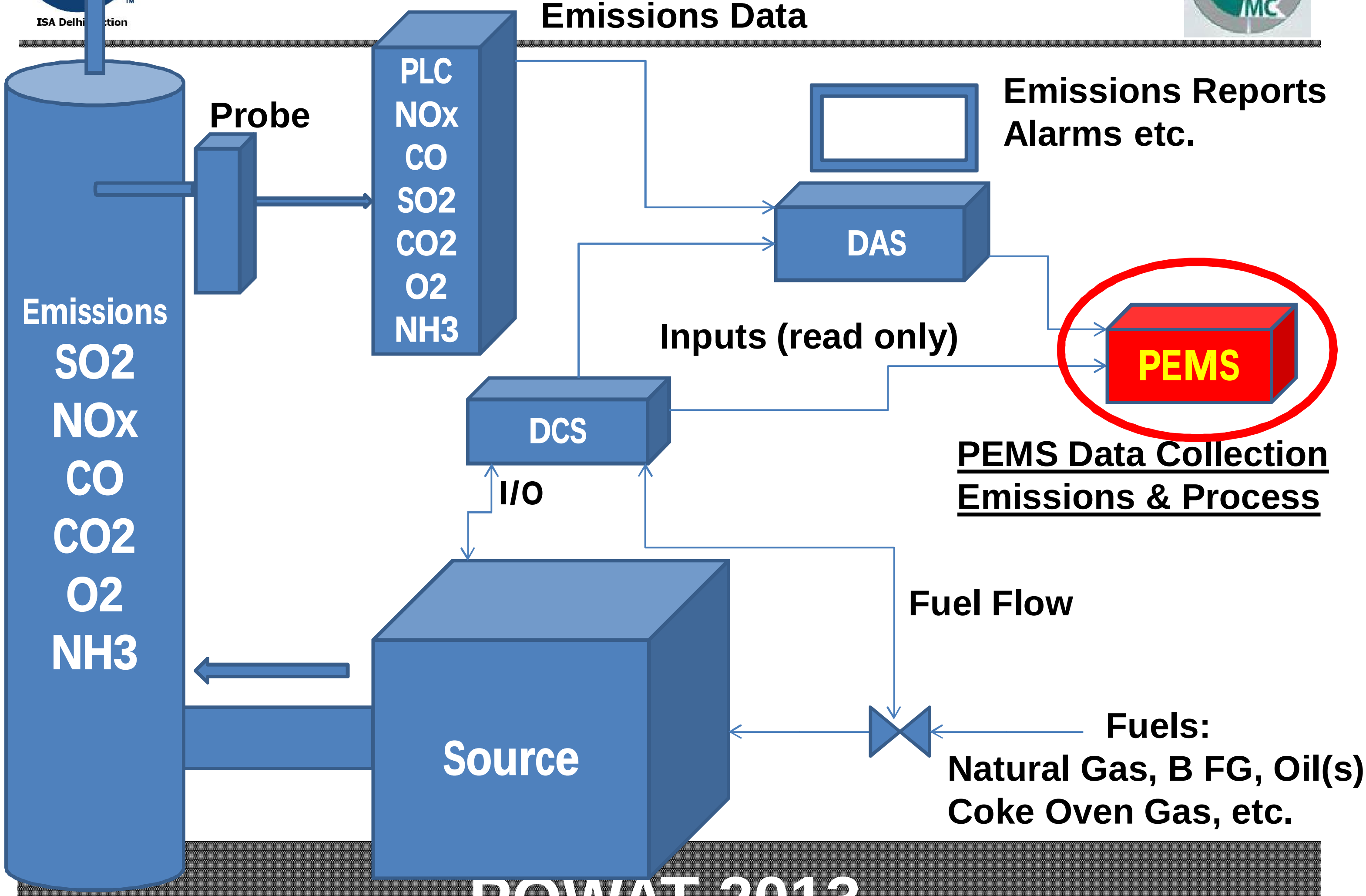
CEMS Standard



PEMS Installed & Certified



CEMS & PEMS


Emissions Data
PLC
NOx
CO
SO2
CO2
O2
NH3
Probe
Emissions Reports
Alarms etc.
DAS
Emissions
SO2
NOx
CO
CO2
O2
NH3
Inputs (read only)
PEMS
DCS
PEMS Data Collection
Emissions & Process
I/O
Fuel Flow
Source
Fuels:
Natural Gas, B FG, Oil(s)
Coke Oven Gas, etc.

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PEMS for Compliance with

40 CFR Part 60

NEW SOURCE PERFORMANCE STANDARD

(Performance Specification **PS-16 for PEMS**)

40 CFR Part 75

TITLE IV ACID RAIN (Subpart E requirements for alternative methods)

EN 14181: QAL2 / QAL 3 / AST

EN Norm (WG 37)

IED 2010/75/EU

EN 15267

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Part 60

- New Source Performance Standard - NSPS, promulgated first 1971;
- Subparts for each type of source with e.g. subpart D covering boilers, GG covering stationary gas turbines and J Petroleum Refineries;
- Applicable to Industrial Units >100 mmBTU (about 29 MW), in some case to smaller sources (e.g. Subpart Dc for small industrial boilers);
- Requires Continuous Monitoring of Primary Pollutants (NO_x, SO_2, CO, Opacity and VOC).

Part 75

- Originally published in January 1993;
- Continuous Emission Monitoring (CEM) requirements under EPA's Acid Rain Program (ARP), instituted 1990 under Title IV of the Clean Air Act;
- ARP regulates electricity generating units (EGUs) that burn fossil fuels and have > 25 MW;
- Part 75 requires continuous monitoring of SO_2 mass emissions, CO_2 mass emissions, NO_x emission rate and heat input;
- Part 75 requires emissions data to be reported for every hour that an unit is operating, including periods of start-up, shutdown, and malfunction (data substitution).

Regulatory Selection Criteria

Monitoring of Primary Pollutants (NO_x, SO_x, CO) and O_2, CO_2, VOC, HCl, NH_3, H_2S etc.

PEMS is an alternative to CEMS for all gas- or oil-fired boilers, chemical plants, gas-fired heaters, sewage sludge incinerators and simple or combined cycle turbines

Empirical Systems

- **Many process inputs with correlation to emissions**
- Performance can be the same as a CEMS
- Collect **Historical Training Dataset**
  - **Time synchronized process and emission data for 2 to 30 days** normal operating conditions through full load with varying ambient range
  - **Emission data for the model from existing CEMS or Reference Methods (RM)**
- Certification and Performance Testing: Annual or quarterly testing to validate the emission levels

Parametric Systems

- Up to 3 inputs with correlation to emissions
- Simple formulaic approach
- Accuracy is very limited
- Performance will not be the same as CEMS
- Normally over-reports emissions for the source
- Acceptable for peaking units (less than 10% operating time) and for **flares** where site testing is not feasible
- **Continuous Parametric Monitoring System - CPMS**

PEMS Model Development

- PEMS Engineering
  - List of Tags (inputs) and descriptions
  - Select (10 to 20+) inputs for emissions model
  - Collect process and emissions data
  - Build model configuration – define model levels
- Deploy and verify PEMS performance
- Certify system under Part 60 or
- Certify system under Part 75, 720 operating hours with a CEMS - submit reports to EPA for approval

Typical PEMS Input Parameters

Critical parameters:

- **Fuel flow rates, fuel composition (if it varies considerably), and unit load (MW or heat output)** or other critically important process parameters
- Pollution control parameters such as water or steam injection, ammonia injection rate, and scrubber DP

Secondary parameters:

- Temperature, pressure, and flow near the combustion zone, inlet and exhaust conditions; damper positions
- Fuel distribution, vane angle, compressor ratio, and draft

Tertiary parameters:

- Other exhaust or control settings or internal control parameters
- Ambient humidity, temperature, and pressure

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PEMS Periodic Quality Control

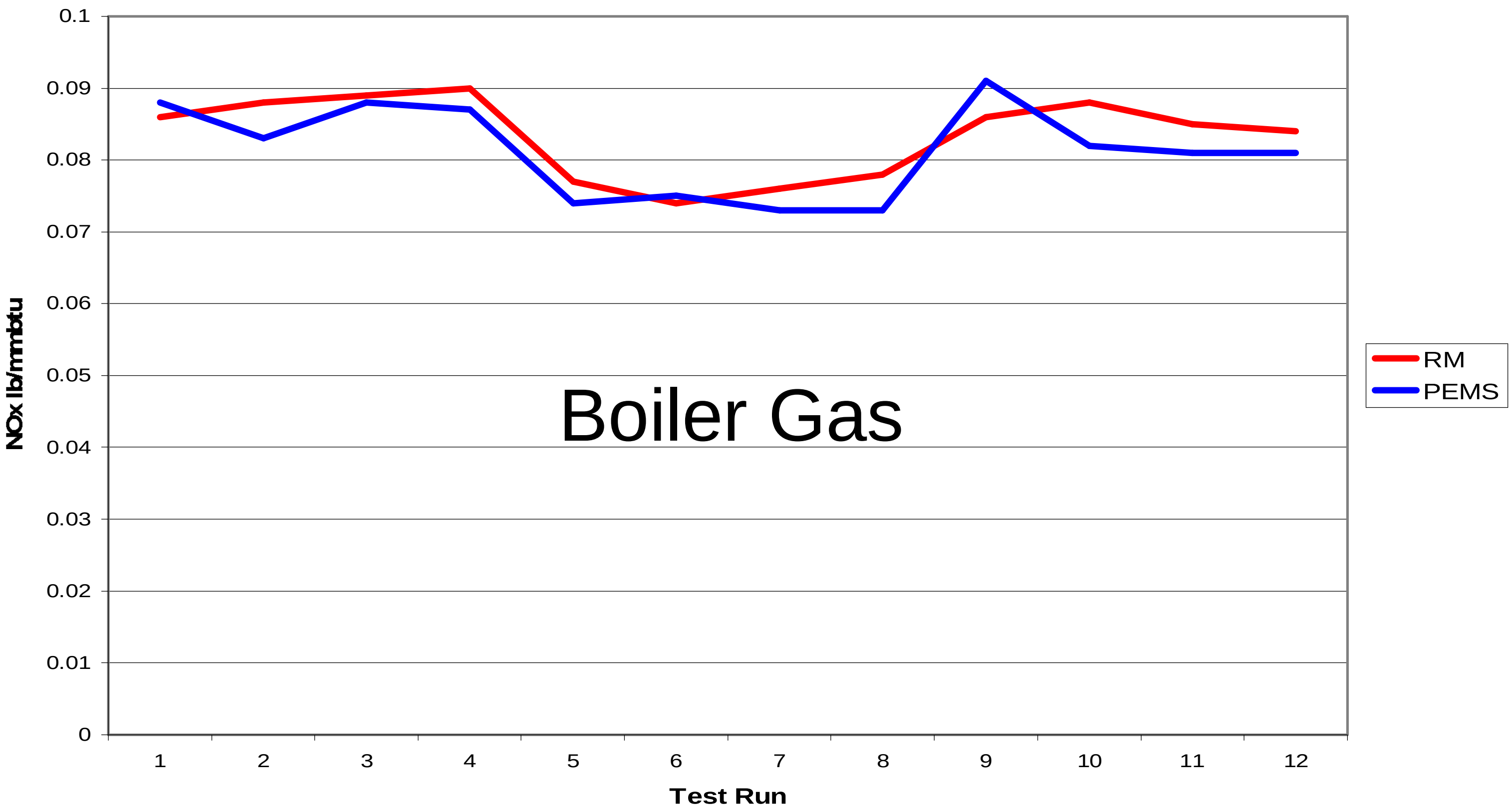
PEMS is an Analyzer!

Process Sensor Validation	Every Minute
Zero & Span	Daily
RAA (versus SRM)	Quarterly in the First Year
RATA	Annually

RATA (RAA)

- **"Relative Accuracy Test Audit"** Primary method of determining the correlation of CEMS / PEMS data to simultaneously collected reference method test data, using **no fewer than nine reference method test runs**, conducted as outlined in 40 CFR 60, Appendix A.
- **"RAA - Relative Accuracy Audit"** Alternative test procedure outlined in 40 CFR 60, Appendix F. **No fewer than three reference method test runs.**

PEMS Initial RATA Test



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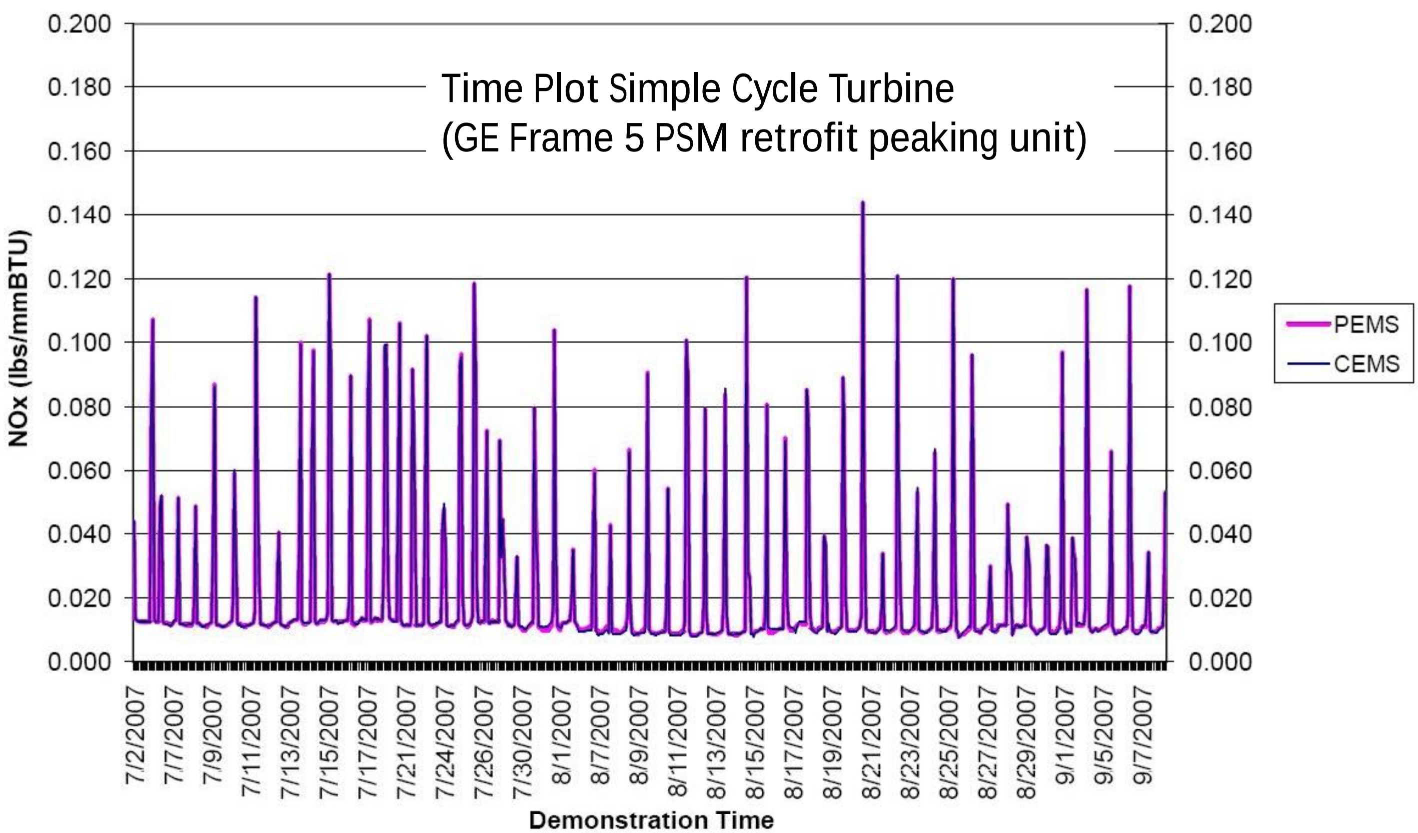
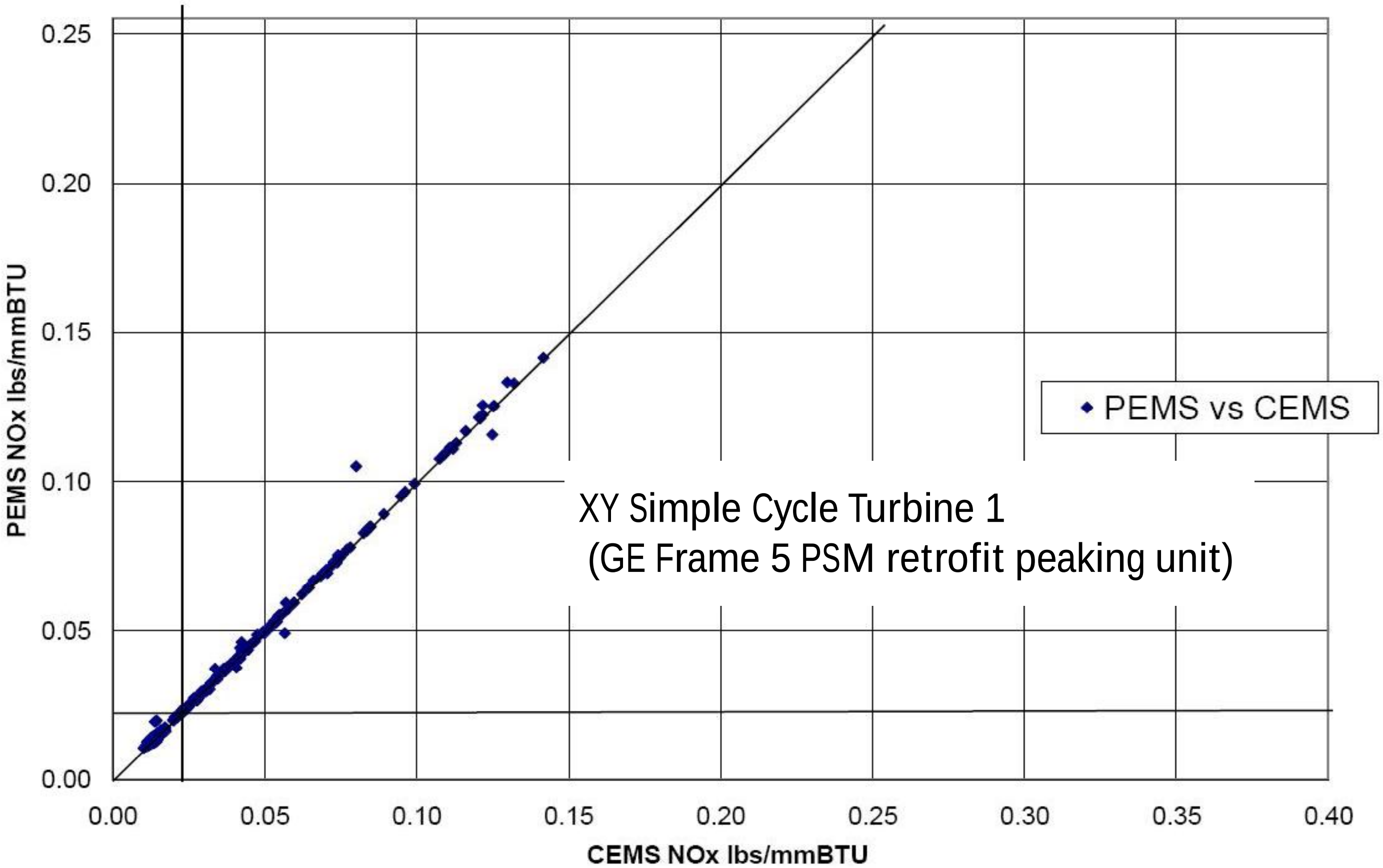
PEMS Subpart E Time Plot



PEMS Subpart E XY Plot



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PEMS Capital and O&M cost

CEMS vs. PEMS Quality Assurance
Cost about the same

PEMS vs. CEMS Initial Capital Cost
About 50 % to 60 % of CEMS

PEMS vs. CEMS Operational Cost
About 10 % to 15 % of CEMS

Common Features

CEMS / PEMS	
Continuous	Both methods can be used for continuous emissions monitoring
Plant Types	For all oil- and gas-fired sources
Accuracy / Precision	Accuracy and precision are comparable provided that the same quality assurance is applied
Quality assurance of data	Securing data quality with procedures of EN14181 / EN 15267 (EU) as well as RATA / RAA (USA)
Data Acquisition	For data representation and reporting of monitoring results, use of data acquisition and handling systems

Differences

	CEMS	PEMS
Hardware	• Gas Analyzers • Accessories like probes, heated lines, racks, shelters etc. needed	• Standard server hardware with means for data back-up and securing data integrity
Application	CEMS more universally applicable: • Plants fired with solid fuels • Components like dust and Hg	• Not suitable for solid fuels with large variability of composition • Coal-fired plants: Determination of SO_2 restricted, especially if sulfur content varies significantly
Cost	• Capital cost : Approximately 50 % of a comparable CEMS. In case of model transferability or for ex-proof areas, cost difference may even be much higher • Operations and maintenance: Approximately 10-20 % of CEMS cost • Quality assurance: No cost difference	
Uptime / Drift	• PEMS: Less drift (only by drift of process sensors) • PEMS: Larger uptime (typical 99.5 %+)	

PEMS Regional Situation

USA: PEMS applied for Part 60 and Part 75 plants: Power sector, chemical, petrochemical, steel plants, glass manufacturing etc.

Asia: Countries US EPA look for PEMS implementation, e.g. Malaysia, Philippines, Singapore, Indonesia etc. China and India need investigation of current potential.

Middle East: Activities in Bahrain, Qatar, UAE, Saudi-Arabia. Many plants do not consider the use of CEMS and want to exclusively apply PEMS.

Europe: Some countries use PEMS in lieu of CEMS (e.g. Netherlands, Norway or Ireland). Large EU countries Germany, France, UK, Italy and Spain are starting now.

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Key element of making PEMS suitable for continuous monitoring is to actively involve DoE's and to solicit their willingness to accept and approve PEMS!

PEMS Benefits

- Significantly lower capital expenditures
- A fraction the operational and maintenance costs of a CEMS
- Maintenance and repair costs virtually eliminated
- If a particular parameter is missing, the model utilizes other available parameters for prediction – Hybrid aspect of the model
- Valid for normal operating conditions and during transitional states such as startup and shutdown.
- Accuracy equal to or better than a CEMS
- Resilient to input failures
- Model can be setup by staff onsite or third party consultants
- PEMS can be used to determine the source of excess emissions; diagnostic tool to lower emissions

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Thank you so much !Questions?

Thomas Eisenmann

Vice President International Marketing

CMC Solutions

teisenmann@cmcsolutions.org

Hedwig-Dransfeld-Allee

80637 Munich / Germany

Phone +49 152 0153 7104

Please see us at DURAG - CMC stall 16

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NTPC
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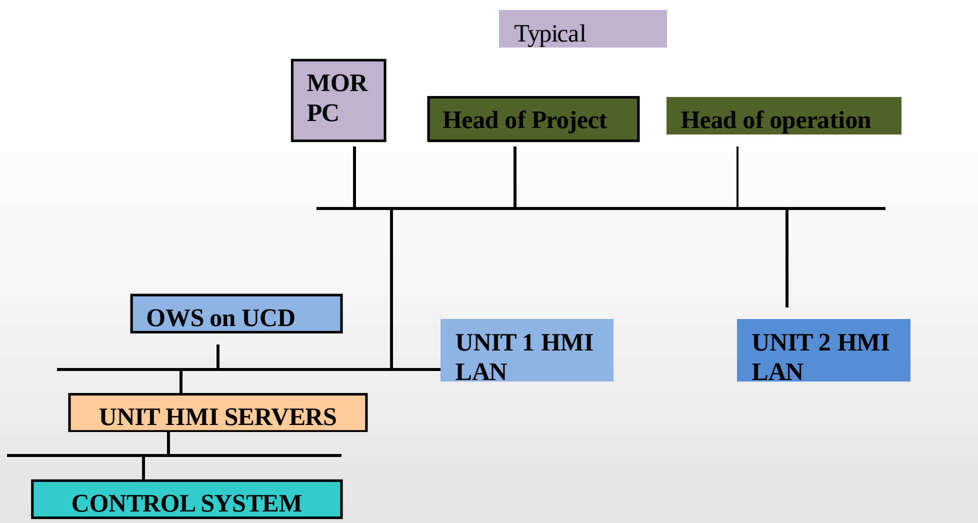
Defence in depth: A multi layered approach to cyber security of IACS

R. Sarangapani,
AGM(PE-C&I) ,
NTPC Ltd.

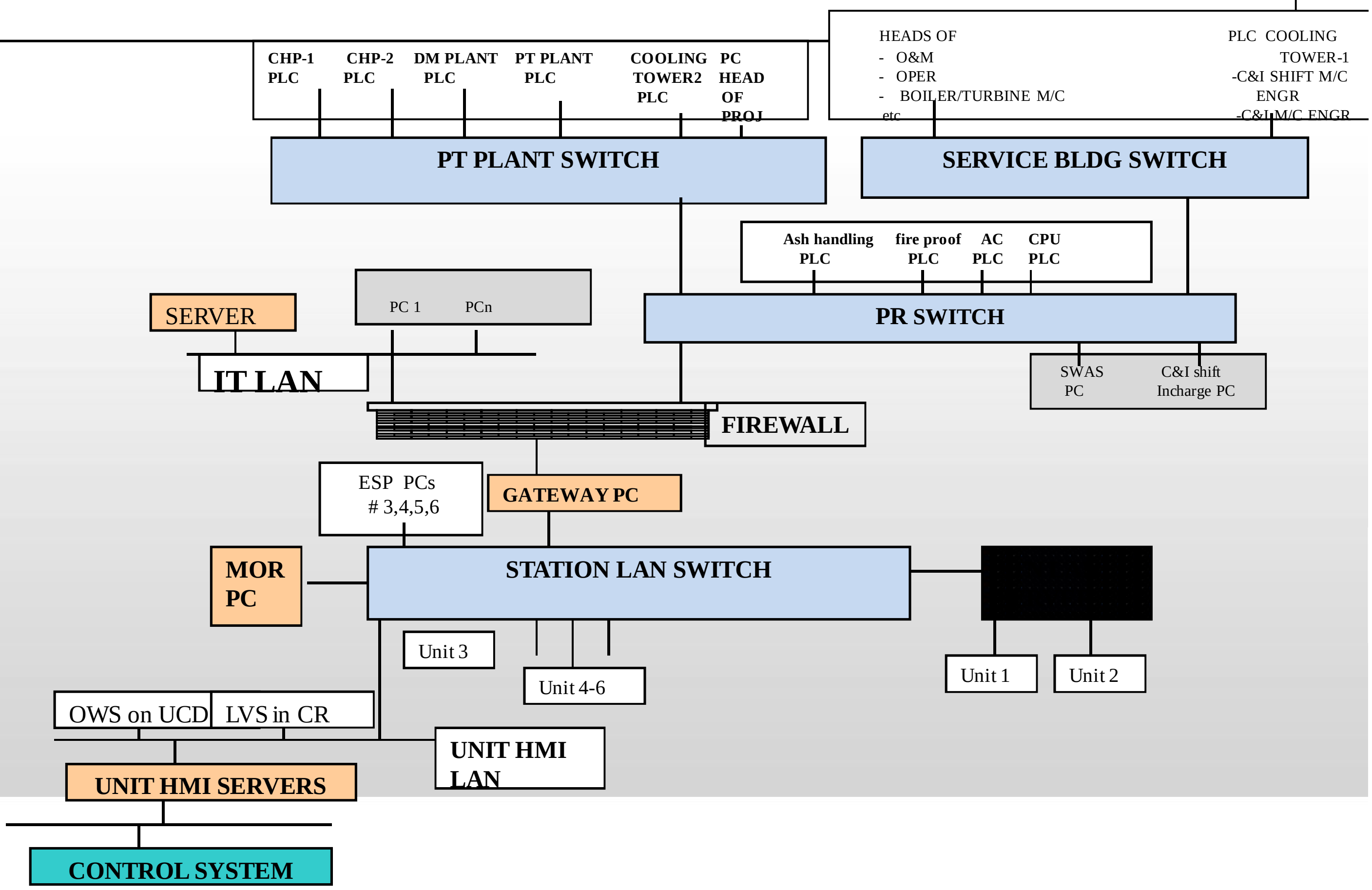
Presentation Agenda

- Networking in Distributed Control Systems & significant changes.
- Security threats
- Components of a DCS Security program
- Distinction between IT security and Process Control security
- Standards
- Areas addressed by standards
- Issues facing our industry
- Vendor Certification

Networking in DCS- The scenario before….



The scenario thereafter….



Significant Changes

- Windows Operating system entered DCS
- Use of Commercial off the shelf (COTS) hardware/ software in DCS
- Open architecture (Use of commercial network protocols)
- Continuous connection with enterprise network for real time data of DCS

But these are some of the associated by-products..

- Virus
- Worms
- Trojan Horse
- Hacking
- Denial of Service (DOS) Attacks

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Some major security incidents in Process Control domain…

- Sewage plant in Australia hacked releasing millions of liters of sewage
- Davis-Besse nuclear power plant safety monitoring system disabled
- Browns Ferry nuclear plant shutdown for two days because of excessive control bus network traffic
- Stuxnet hit Siemens control system PCS 7

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Some major security incidents in Process Control domain…

- US auto plants shut down by an Internet worm named Zotob
- Brazil’s electrical grid attacked via the Internet
- And many more….

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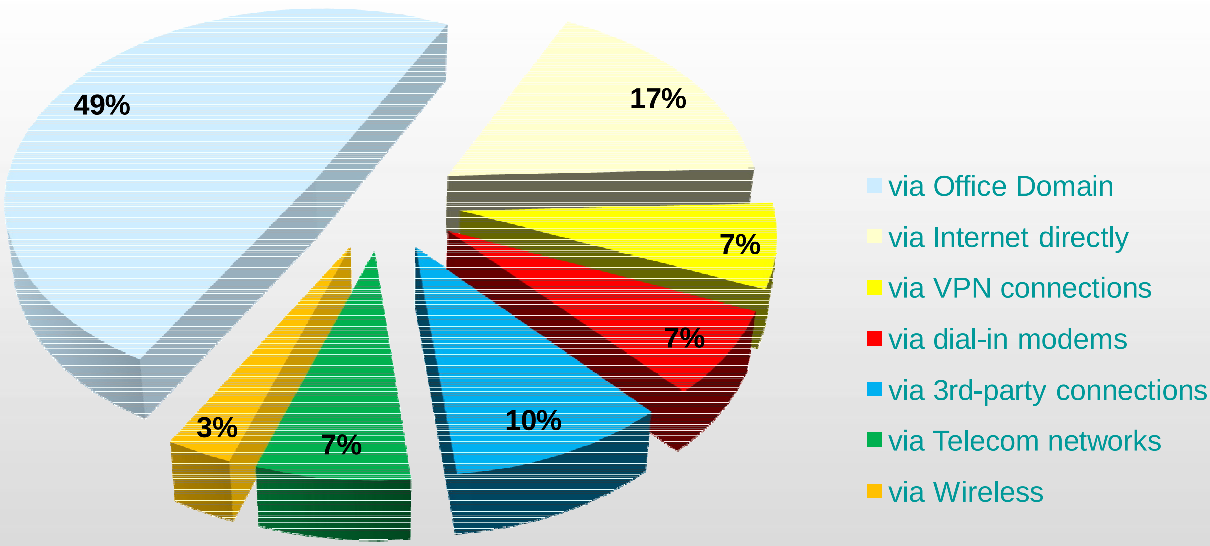
Sources of vulnerability



Sources of infections

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Can this happen in your plant…

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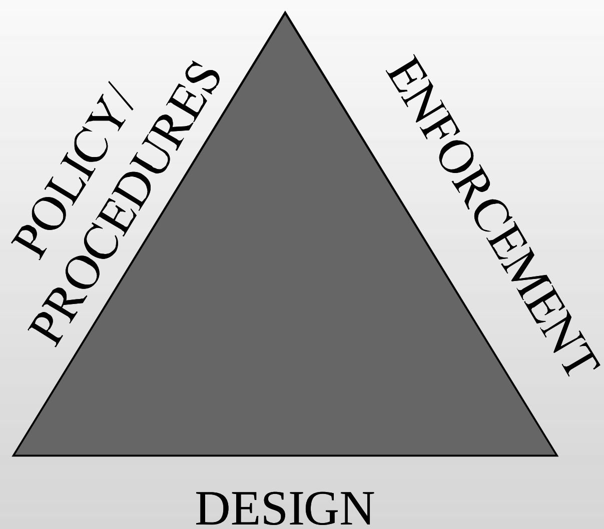
Three pillars of DCS security program



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Components of a DCS security program

- A. ‘Defence in depth’ System architecture
- B. Policies & procedures
- C. Enforcement of A & B (Security Audit)

  -Vulnerability Assessment

  -Penetration testing
- D. Crisis management program
- E. Awareness, Knowledge & Skills

  (for the asset owner)
- F. 24 X 7 Assistance Desk (for large multiple installations

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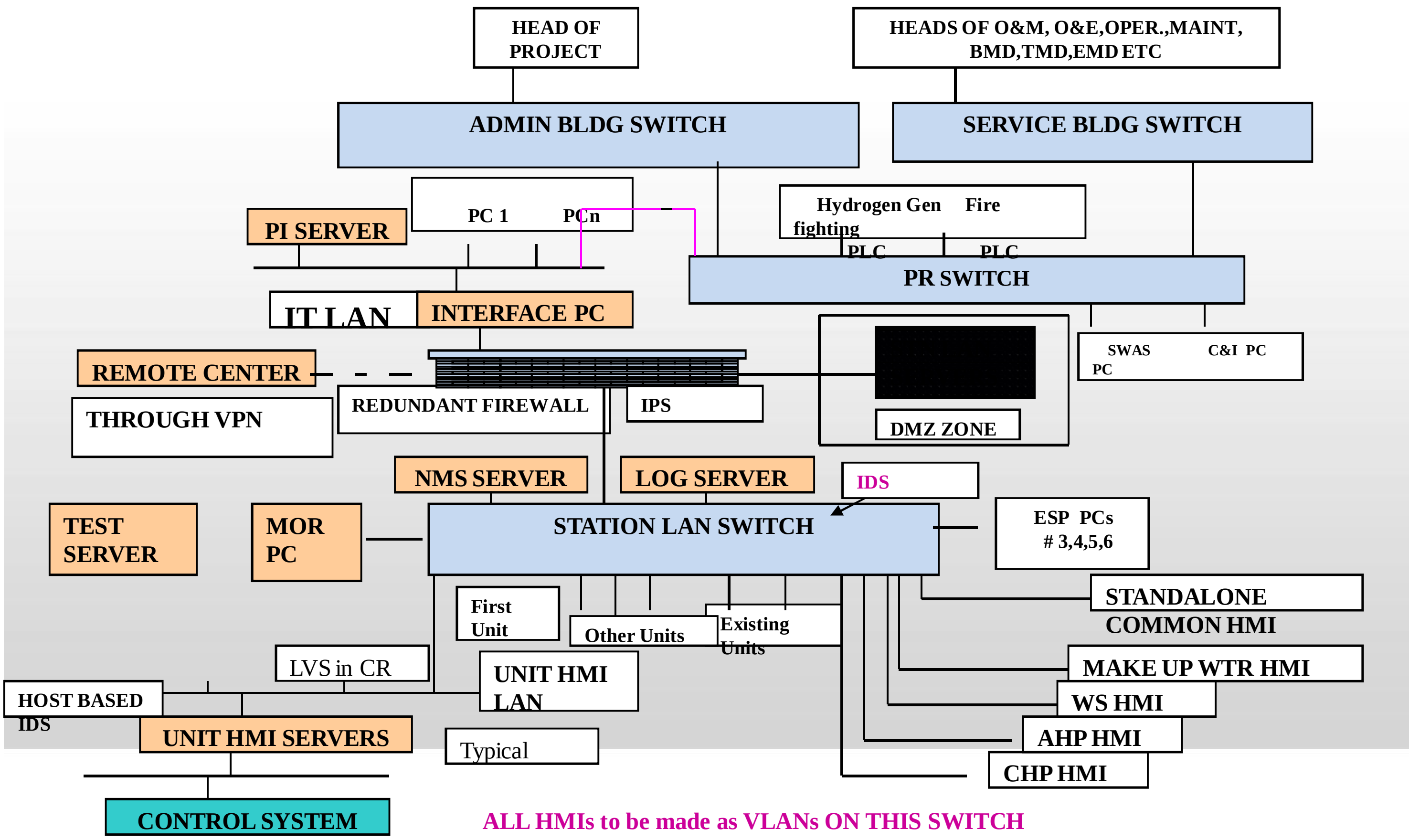
Typical Secured System architecture



Security Policies and Procedures

- Foundation of a security program
- Guide for Managers, Security Team & users to understand their specific role within the security framework
- Articulation of overall security objectives providing a management framework

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Security Policies and Procedures

- Information Security Team Policy
- Firewall Policy
- Information Identification & Classification policy
- Security Policy Review Policy
- System Planning & Acceptance Policy
- Capacity Management Policy
- Media Handling policy
- Information Security Awareness Policy
- Third Party Access Policy

Security Policies and Procedures Contd..

- Change Control Policy
- Anti Virus Policy
- System Access Policy
- Monitoring Policy
- System Planning & Acceptance Policy
- Incident Handling policy
- Information Backup & Restoration Policy
- Network Access policy
- User access management Policy

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Vulnerability Assessment

- Methodology

- Information gathering & analysis
- Vulnerability scanning using special tools on two Unit servers, Station LAN server, One OWS per unit, Gateway PC
- Physical Verification-Servers/OWS
- Analysis of the findings & recommendations

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Penetration testing or Ethical hacking

- Methodology
  - Test conducted from IT LAN for penetrating into C&I network using specialized software
  - Firewall rules tested
  - Analysis of the findings & recommendations

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Distinction between IT security & Process Control security

IT Security	Process Control Security
System Response Importance ↓	System response Importance ↑
Impact ↓	Impact (Can impact critical infrastructure; safety of equipment & personnel) ↑
Skill set ↑	Skill set ↓

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Security Standards

- Security standards …
- ISA
- ISO 27002
- NERC CIP
- NIST
- VDE (VDI 2182)
- IEC (IEC 62443)
- Target groups for the security standards
- -Asset Owners, System Integrators, Component providers or manufacturers

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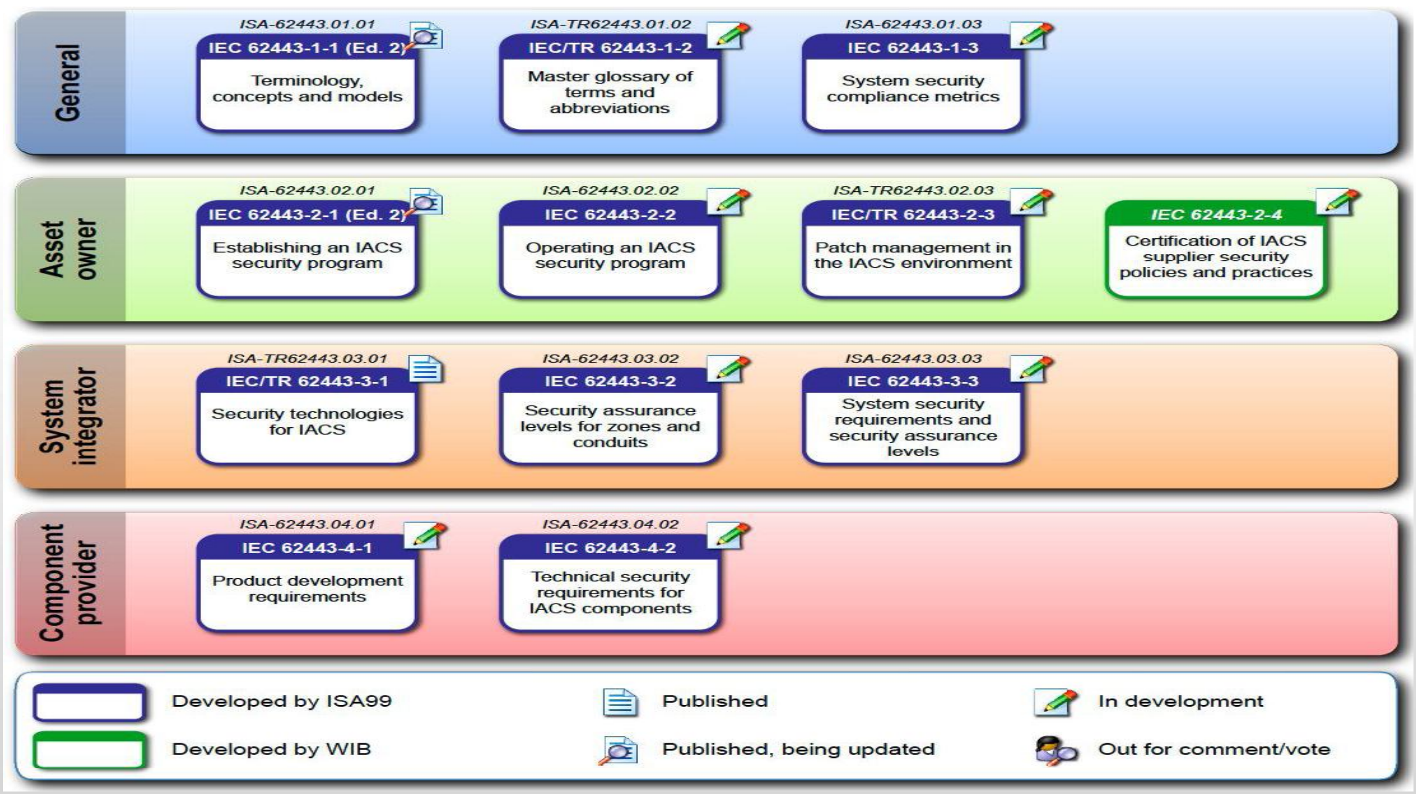
ISA/IEC standards on security



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Security assurance levels

SAL	Level Definition
1	Casual or co-incidental violation
2	Intentional violation using simple means
3	Intentional violation using sophisticated means
4	Intentional violation using sophisticated means & extended resources

Some areas being addressed by standards

- SIS (Safety Instrumented system) as a separate entity
- Wireless Connectivity
- Patch management
- Account management
- Remote access
- Data encryption (Cryptography)

Vendor Certification

- A mechanism to enforce security in your system without knowing the details
- Best practices on one site gets embedded as system capabilities in the DCS/PLC
- Developments in security technology gets into the process control domain **faster** !!

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Issues facing our industry

- Auditors not specialized in process control domain
- Lack of a comprehensive & uniform enforceable standard
- No distinction between IT security & process control security
- Interface to regulatory bodies by IT

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End user concerns & Expectations from vendors

- New technology evolvement or new product development should take into account security vulnerabilities at the conceptual stage itself
- Assurance or certification for secure system should come from vendors
- Security of embedded devices should also be included in the above assurance
- High priority to critical infrastructure

Quote

“Security is a journey, not a destination. Peace of mind is the reward.”

Source: 2007 Advantage Business Media

THANK YOU