Isotope separation methods for real-time stack monitoring of Tritium, C-14, and other radioactive effluents

Bob Goldstein
Overhoff Group

Radioactive Effluent Technical Specifications
and Radiological Environmental Monitoring Programs Workshop
San Jose, CA | June 28-30, 2010

Abstract

Use of physical separation techniques and multiple detectors are explored. Three specific flow diagrams demonstrate the strengths and weaknesses of resultant Multi-Nuclide Stack Monitor designs. Separate and simultaneous measurement and reporting is achieved for Tritium gas (T2), Tritium dioxide (T2O and HTO), Organic C-14, Inorganic C-14, Alpha Particulates, Beta Particulates, Iodine, Xenon and Argon, Krypton.

Stack Monitor Upgrade or Replacement is a timely topic for existing Nuclear Power Stations since, according to the NRC, additional requirements for Tritium and Carbon-14 stack monitoring are likely in relatively near future. Also existing stack monitor systems are 40 years old at many plants and should be replaced or upgraded due to excessive wear and to take advantage of current technology.

It is hoped these multi-nuclide Stack Monitors will be of interest as well for the new Nuclear Power Stations now going through the licensing process.

Tritium

- Deuterium (liquid D_2O)is used in heavy water reactors as shielding.
- Add another neutron, and deuterium becomes tritium.
- Tritium is usually emitted as gas (T_2) or mixed with water (T_2O)
- Tritium can occur in any molecule which includes H if the molecule is bombarded with neutrons.

Regulations

- See http://www.nrc.gov/reactors/operating/ops-experience/tritium/safety-requirements.html
- Upcoming for heavy-water reactors (according to NRC)
- NRC, NEI, EPRI

Premise

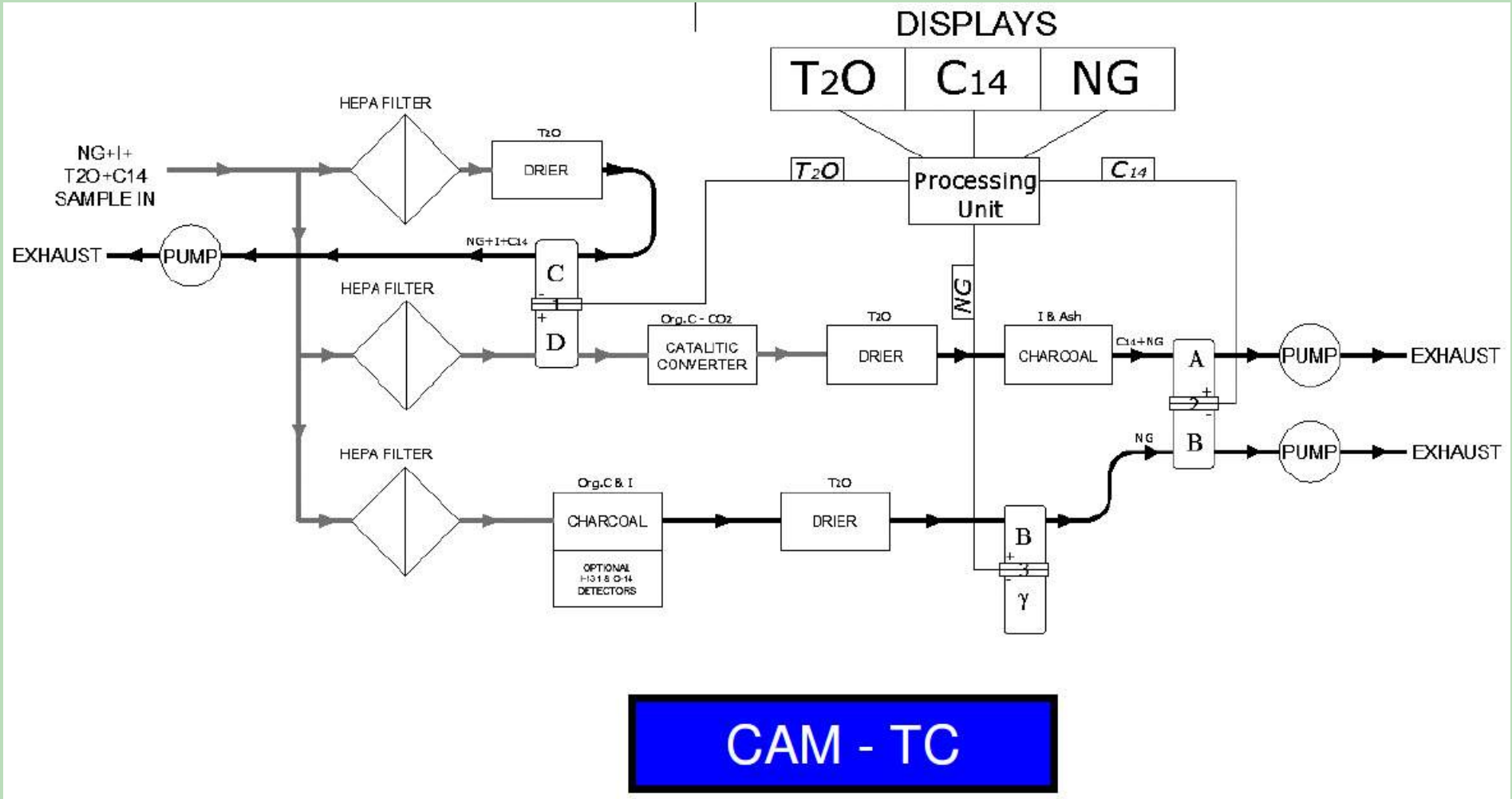
It's an engineering challenge to tease out the different components in order to be able to measure and report them separately.

We must separate out: particulates, noble gasses, iodine (and other active chemicals- iodine is the most common), organic carbon, “inorganic” carbon (CO_2), Tritium

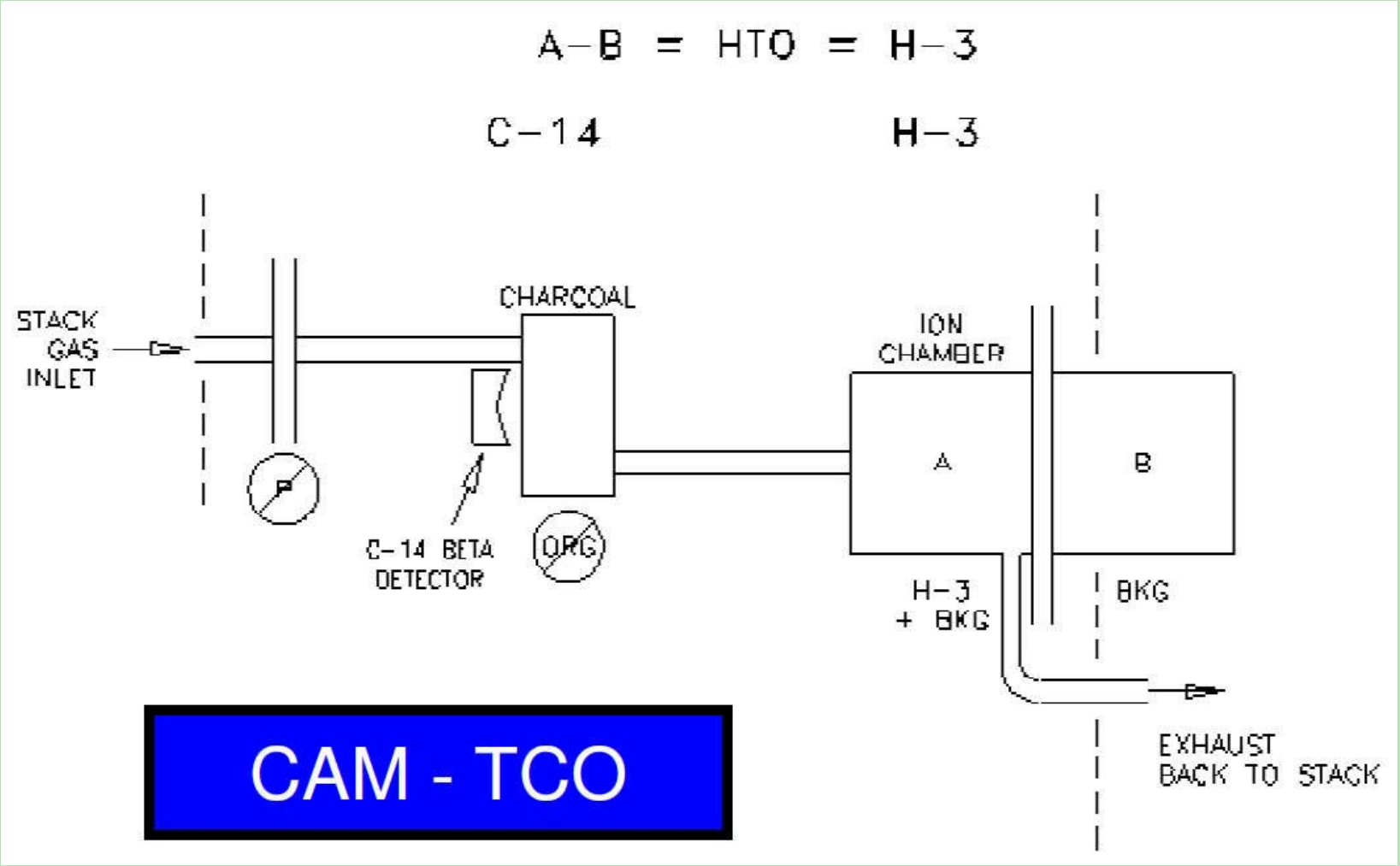
Tools

particulate filter, charcoal filter, nafion membrane, a dryer (to catch T_2O water vapor), catalytic converter (for organic carbon), subtracting one signal from another

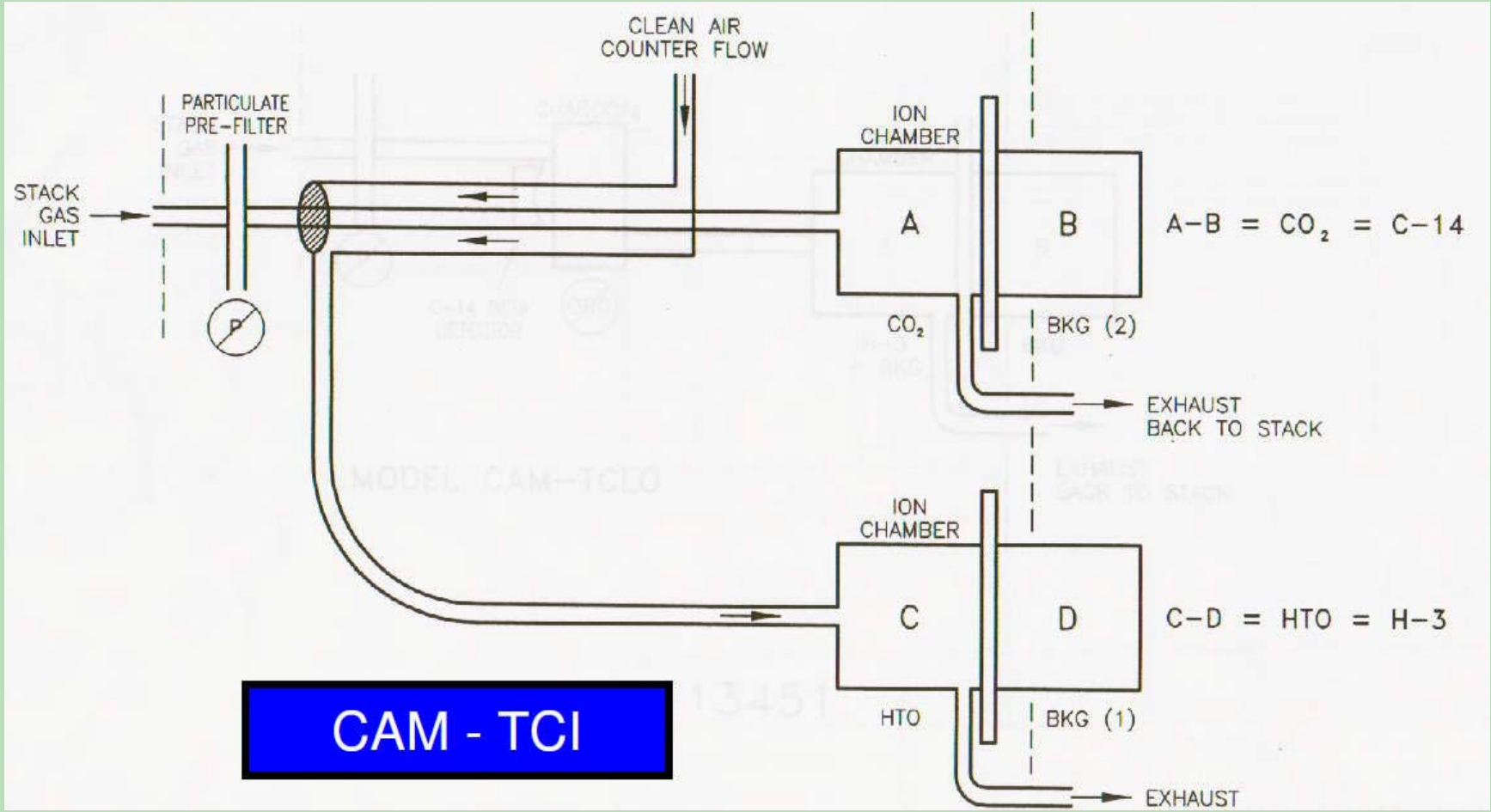
Power Plant Stack Monitor



Power Plant Stack Monitor (continued)



Power Plant Stack Monitor (continued)



Detection ranges

(as applicable to the CAM-TC)

Measurement Ranges of Optional Detectors	From	4 Decade Model	6 Decade Model
Tritium	10^{-7}	10^{-3}	10^{-1} uCi/cc
Inorganic C-14	10^{-8}	10^{-4}	10^{-2} uCi/cc
Organic C-14	10^{-9}	10^{-5}	10^{-3} uCi/cc
Alpha particulate	5×10^{-8}	10^{-4}	uCi/cc

Airborne Activity	Model	CAM TCO (1)	CAM TCI (1)	CAM TC	CAM 33	CAM 33-4	CAM 33-6	321/421 NPPM (1)
	Chemical Form							
Tritium H3	T_2, HTO T_2O	YES	YES	YES			YES	YES
Carbon C-14: Inorganic Organic	CO_2 Various	— YES	YES —	YES OP			OP YES	
Particulate	Alpha							
Particulate	Beta				YES	YES	YES	
Iodine				OP	YES	YES	YES	
Noble Gas: Gross/All Argon Xeon Radon		RX	RX	YES OP OP RX	YES	YES	YES OP OP RX-OP	CURIE-MeV OP OP RX

Issues / desirable features

(feel free to add to the list)

- USB and Ethernet ports
- Alarm
- Data logging
- Hard copy printer?
- Dynamic background radiation compensation
- Can operate in presence of other radioactive gasses
  (see chart in CAD-CAM spec sheet)
- Cleans gas stream of particulates and ions
- Rugged
- Can be controlled remotely

Questions?