Radiochemical & Decommissioning Solutions

A new bomb-combustion system for ^{3}H extraction

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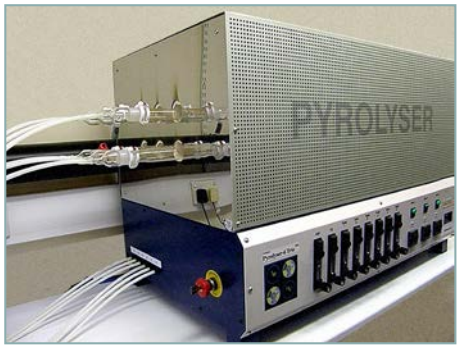
Outline

- ^{3}H extraction
- Analytical requirements
- Bomb combustion
- The HBO_2 system
- User case studies

Options for ^{3}H extraction

- Techniques for ^{3}H sample preparation typically include combustion furnaces and sample oxidisers
  - ↪ Versatile (sample type, throughput)
  - ↪ Well suited to inorganic matrices



- Organic matrices can be problematic
  - ↪ Incomplete combustion
  - ↪ Limited sample mass / LOD

Appropriate analytical techniques limited

Analytical requirements

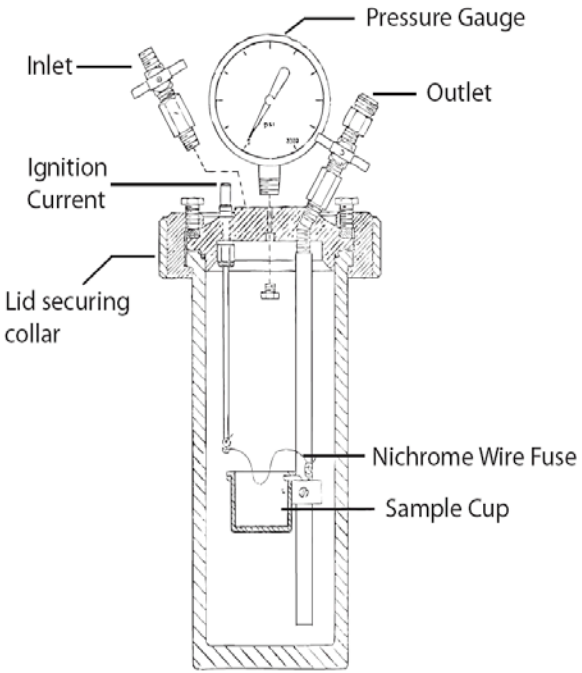
Instances where extraction of ^{3}H from organic-rich samples is beneficial:

- Environmental monitoring
  - ↪ **Often organic rich + low LOD requirements**
- Nuclear decommissioning
  - ↪ **Orphan wastes e.g. oils, rubbers, plastics**
- Fusion reactor operational support
  - ↪ **Heterogeneous soft wastes**

Bomb Combustion

- Enable ^{3}H extraction via complete oxidation in an excess oxygen environment.
- Few commercial systems available for ^{3}H extraction, typically a Parr 1121 used

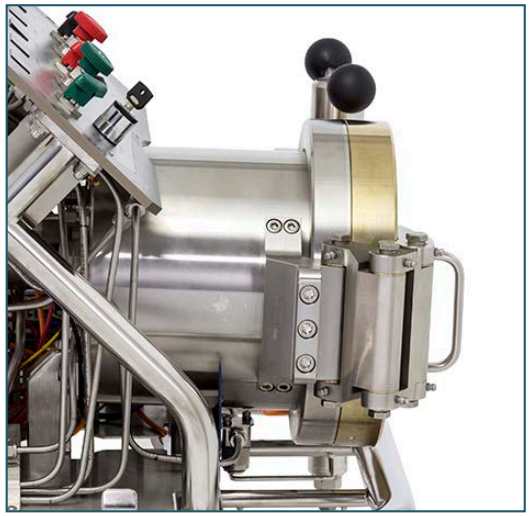
  e.g. Moghissi et al., (1974)



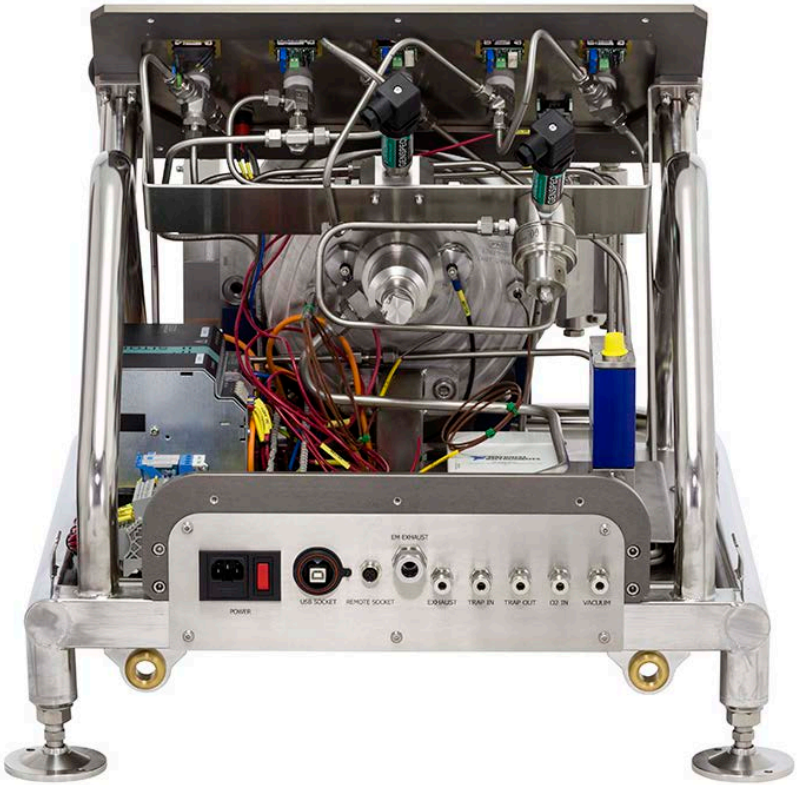
- Limited sample size (< 10 g)
- Manual operation
- Incomplete oxidation (quenching)

The Raddec Hyperbaric Oxidiser (HBO_2)

- Designed specifically for ^3H extraction
- High capacity combustion vessel
- Operates at pressures ≤ 100 bar
- Optimised for organic-rich matrices
- Large samples can be combusted (typically up to 30 g)



System components (I)



Combustion Procedure

Sample pelletised or cut to size

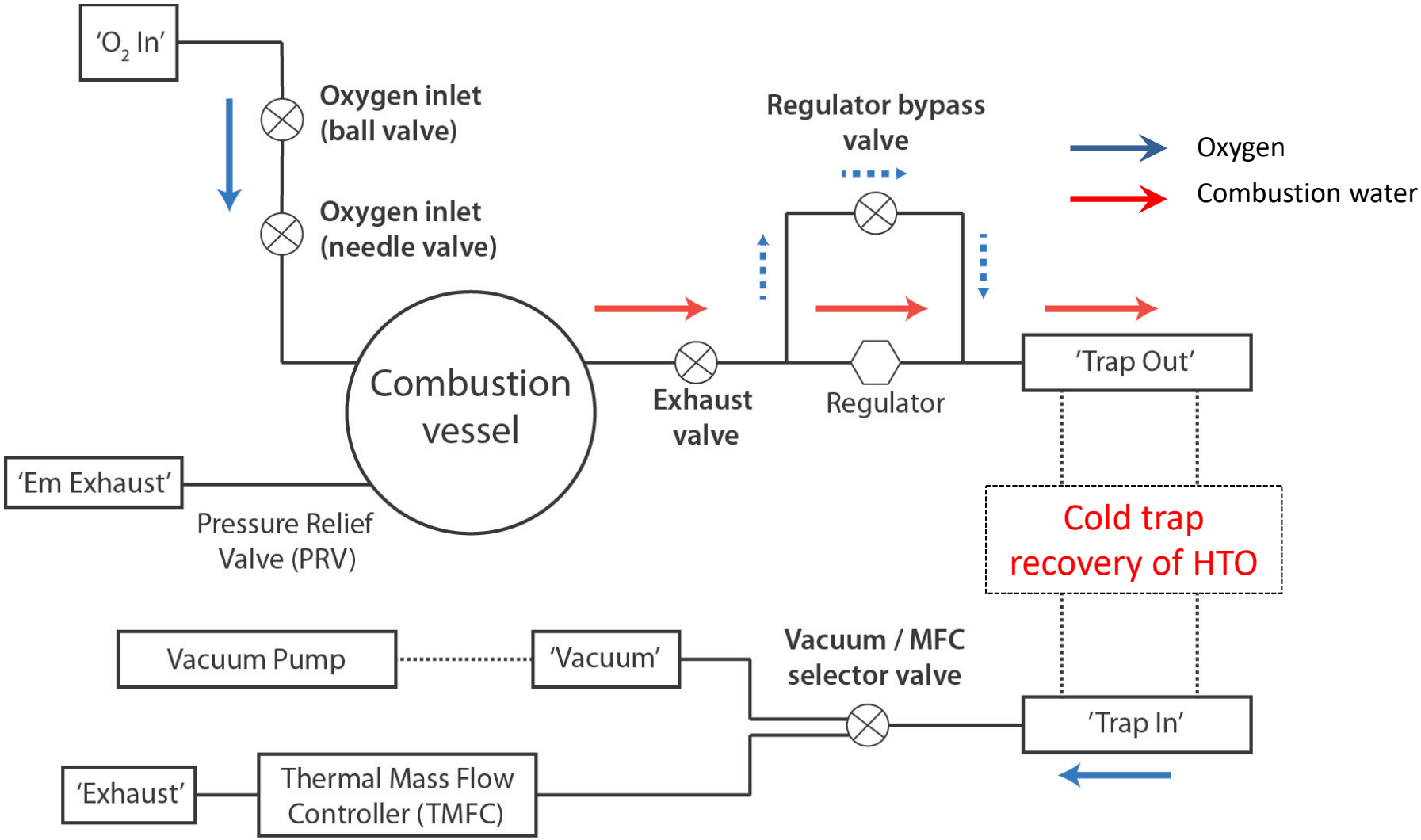
Sample loaded into disposable silica crucible

Combustion water recovered under vacuum

Measurement by LSC

Sample combusted

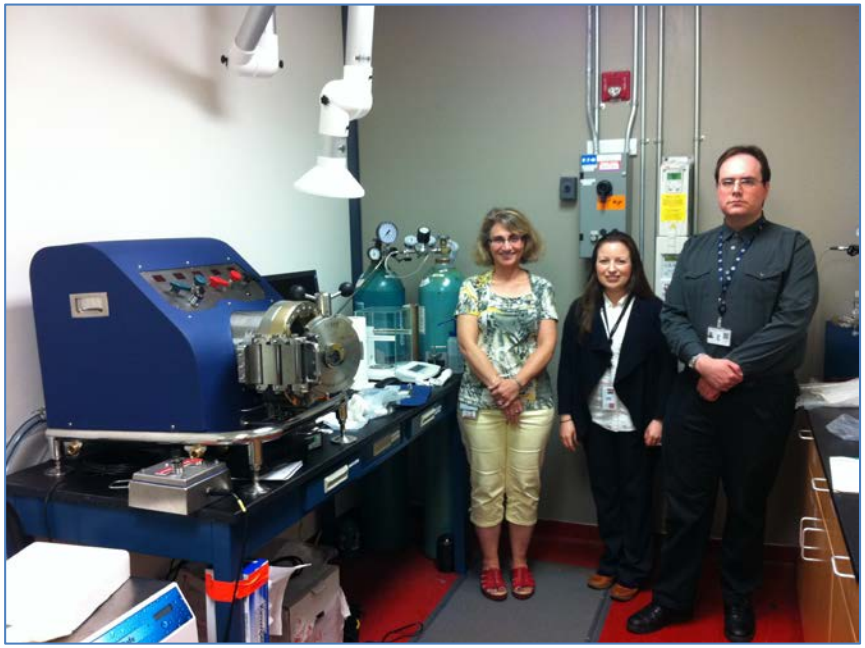
System components (II)



Case Study 1

Environmental ^{3}H Measurement

Canadian Nuclear Safety Commission (CNSC), Ottawa



All data & images courtesy of Nadereh St-Amant, CNSC, Ottawa.

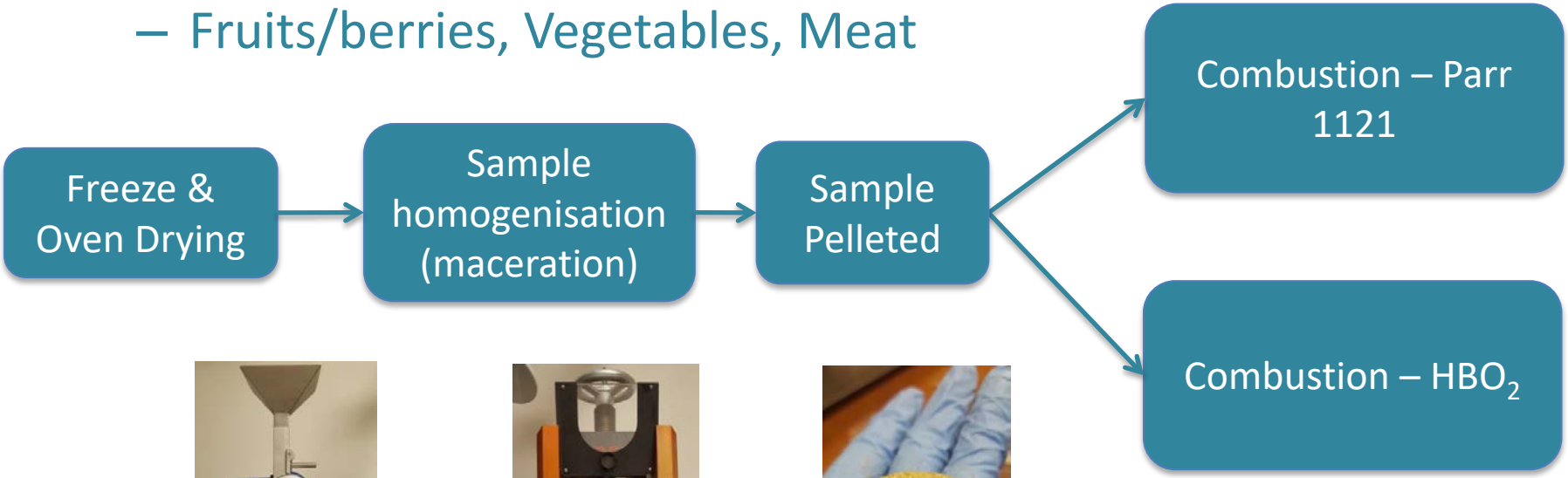
Background

- Discharges from Canada's nuclear industry regulated by CNSC
- Principal releases from D_2O moderated CANDU reactors e.g. Bruce, Darlington etc.
- Also ^3H processing, removal and research facilities e.g. Chalk River, SRB Technologies etc.

Independent discharge and environmental monitoring – compliance and reassurance

^{3}H analysis

- HTO in water, HT/HTO in air and OBT in foodstuffs
  - Fruits/berries, Vegetables, Meat



System comparison (I)

Parr 1211

- Max sample size 10 g
- Combustion process not visible and often incomplete
- Manual (incomplete) combustion water recovery
- Cloudy / coloured combustion water
- Requires purification prior to counting by LSC

HBO_2

- Max sample size 30+ g
- Combustion progress is visible
- Integrated vacuum collection of combustion water
- Direct measurement of combustion water is possible

System comparison (II)

Parr 1211

tSIE % difference typically 12-24%

HBO_2

tSIE % difference typically 0-1%

tSIE % difference values measured for wheat samples, relative to distilled water quench values.

OBT Environmental data

- 1.5 to 60 Bq/kg fresh weight

System	HBO_2						Parr 1121	
Foodstuff	Fruits and Berries	Vegetables	Potatoes	Beef	Chicken	Pork	Milk	Fish
Typical LOD (10 g sample)	2 Bq/kg (0.5 - 1 for 20-30 g sample)						3 Bq/kg	
Tritium Processing Facility	11.8 - 17.5	1.5	1.5	N/A	N/A	N/A	1.5	N/A
NPP1	1.5 - 2	1.5 - 2	2	2 - 56.5	1.5	2 - 21	2	1.8 - 2
NPP2	1.5	1.5	1.6 - 2.1	N/A	1.5 - 10.5	N/A	1.5	N/A
NPP3	1.5 - 2.8	1.5 - 1.6	N/A	N/A	N/A	N/A	1.5	1.5 - 15.9

All results are Bq/kg fresh weight

Case Study 2

Heterogeneous Soft Waste

Culham Centre for Fusion Energy (CCFE), Oxfordshire, UK

All data & images courtesy of Natasha Cooper, CCFE, Didcot.

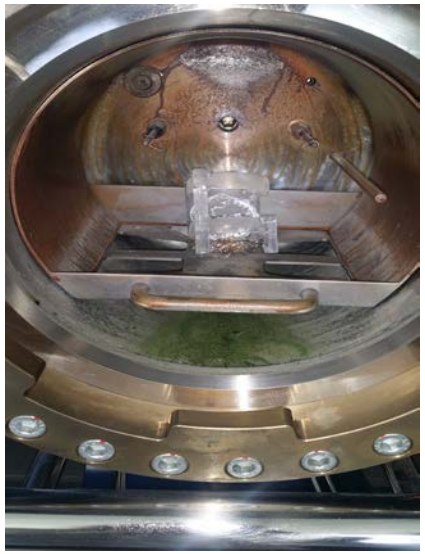
Background

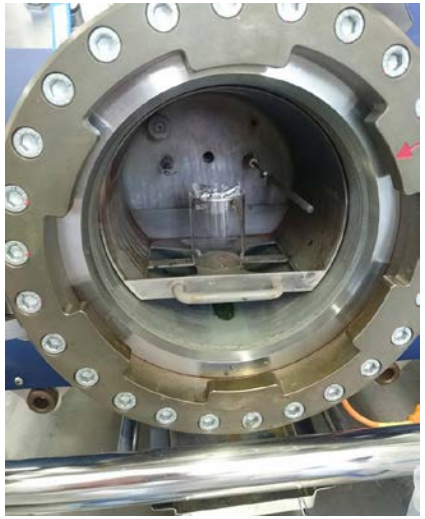
- Operation of the Joint European Torus (JET) – generation of various tritiated waste streams
- Diverse mix of materials:

  PVC, cardboard, housekeeping (mix of gloves, tissues, paper, plastic, cotton)
- Heterogeneous activity & organic rich
- Significant ^{3}H activity - Bq to kBq / gram
- HBO_2 operated in a controlled environment

Sample preparation experience

- Cellulose powder used to assist binding of housekeeping materials
- Samples pelleted in non-PVC cling-film
- Reduces incomplete combustion
- Vessel combustion chamber can be readily cleaned and re-polished





HBO_2 – Pyrolyser validation

Sample	HBO_2	Pyrolyser	HBO_2 memory (%)
Cardboard	11284	11202 ± 2240	0.62
Cardboard	5885	7526 ± 1505	0.51
"Housekeeping"	614	3072 ± 614	0.33
"Housekeeping"	76	2674± 535	1.32
PVC	2973	2648 ± 530	N/A

- Good agreement for Cardboard and PVC samples
- Minimal observed memory
- Discrepancy between "Housekeeping" data are associated with the highly heterogeneous nature of the samples

Conclusions

- The HBO_2 enables rapid and efficient recovery of ^3H from organic rich samples up to 30 g
- The system is applicable to a wide range of sample types including biota and soft-waste
- Also applicable to orphan wastes such as oils and sludge's
- Offers improved LODs compared to thermal oxidisers (Pyrolysis/sample oxidisers).

Acknowledgments

- Thank you to both CNSC Ottawa and CCFE for sharing their data and experiences with the HBO_2 and allowing us to present some of these in this talk.

OBT Wheat Intercomparison