Energy Recovery from Waste by

Ecofein™ Combustion Systems

Technology Presentation

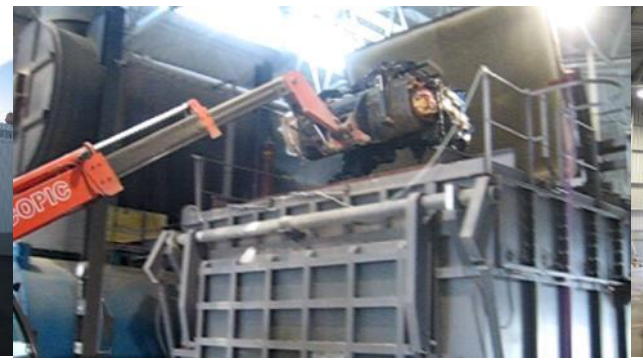
FRIÐFINNUR EINARSSON

Mechanical Engineer M.Sc. - Process Inventor

Ecofein™ Combustion Systems

www.asbg.co.uk




Introduction – Gasification and Excess Air Combustion

Gasification is the thermo-chemical reaction in which combustible material is converted into syngas which is a mixture of; hydrogen, carbon monoxide, methane, water vapour, carbon dioxide, nitrogen, tar and various trace elements and solid residue. As standalone process gasification cannot complete the combustion neither of the gaseous nor solid products because the process does not enter excess air combustion. The resulting products are therefore combustible syngas and char both of which contain various levels of impurities and pollutants, and need further treatment to become either useful products and/or readily disposable.

Combined Gasification and Combustion Process is a process where combustible material is processed in a primary process, where it is first gasified under starved air conditions and following combusted at excess air conditions in the same chamber, to produce carbon free ash and process gas of various composition both combustible and non-combustible which is mixed and combusted in a down stream final combustion chamber.

Ecofein™ Combustion System utilises Einarsson's patented invention the Sequential Batch Gasification and Combustion Process Design; where controlled flow, mixture and entry points of recirculated flue-gas and air is fed under the waste batches in multiple primary chambers. This reduces the oxygen concentration and therefore the flame front temperature, resulting in reduced nitrogen oxides and increased heat value of the syngas produced. Combustion air for the down stream final combustion process is preheated in external cooling jackets on the primary chambers, before it is used as additional combustion air in the final combustion chamber, increasing system efficiency and longevity of the primary chambers.

Ecofein™ System - Process Inventor

Fridfinnur Einarsson, Mechanical Engineer M.Sc.

Thirty years' experience with complex mechanical engineering projects, incineration, gasification, energy recovery and emission control technologies as; Managing Director, Plant Manager, Systems Designer, Equipment Manufacturer, Project Director, Technology Director, Commissioning Director and Technology Developer. Inventor of patent protected Advanced Sequential Fixed Hearth Batch Gasification and Combustion Processes: *"Advanced Sequential Batch Gasification Process" (WO2013179313 A1) filed May 2012 (https://register.epo.org/application?number=EP13740373)*

- *The **Ecofein™ Combustion System** has a unique front end sequential combustion operation followed by final combustion producing continuous superhot flue-gas output which is excellent for heat recovery in many forms including continuous electricity production.*
- *The Intellectual Property rights are managed globally by Ecofein ehf. - ASBG Environmental Ltd., **Ecofein™** is a registered trade mark.*

Ecofein™ System, Technology Overview

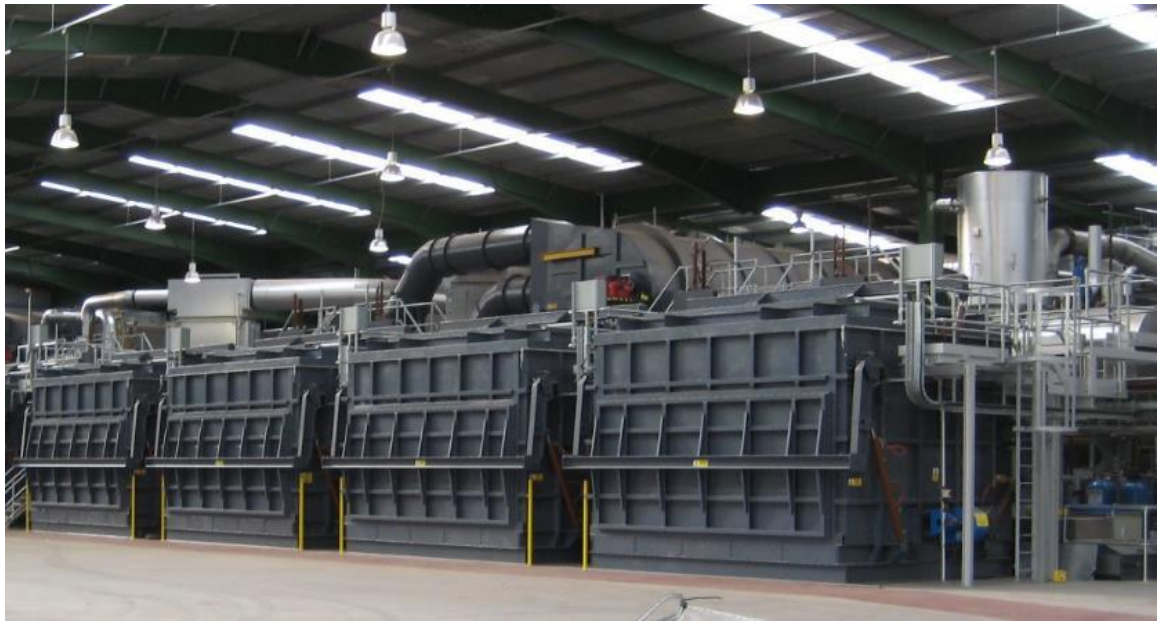
The ***Ecofein™ Process*** Design is the latest technology evolution of Fixed Hearth Batch Combustion Processes, both for sequential and non-sequential systems. The waste batch is combusted with precisely controlled flow and mixture of recirculated flue-gas and air, blown under the waste batch. The flow and mixture are controlled individually in the multiple nozzle areas in the primary chambers bottom (hearth).

Air is circulated through external cooling jackets on the primary chambers were, it cools the gasification chamber casing and refractory lining. This air which is warmed up in the jackets is following used as combustion air in the final combustion chamber to complete the combustion of the mixture of syngas, flue-gas and hot-air from the multiple primary chambers.

All fans and burners are automatically controlled with feedback signals from various parts of the process.

The process is run sequentially in multiple primary chambers connected via duct work to a common final combustion chamber. Standard system layout of a sequential system consists of four primary chambers and one final combustion chamber.

How does an Ecofein™ ASBG Process Line look like?



Four primary chambers process train designed by and built under Einarsson's command

Typically four, but up to six, primary chambers which are sequence operated and connected to a common final combustion chamber. Where the syngas, flue-gas and hot-air from all the primary chambers are mixed and combusted with additional controlled flow of air at superhot and precisely controlled temperature.

The heat is recovered in a boiler system & steam produced in a turbine genset.

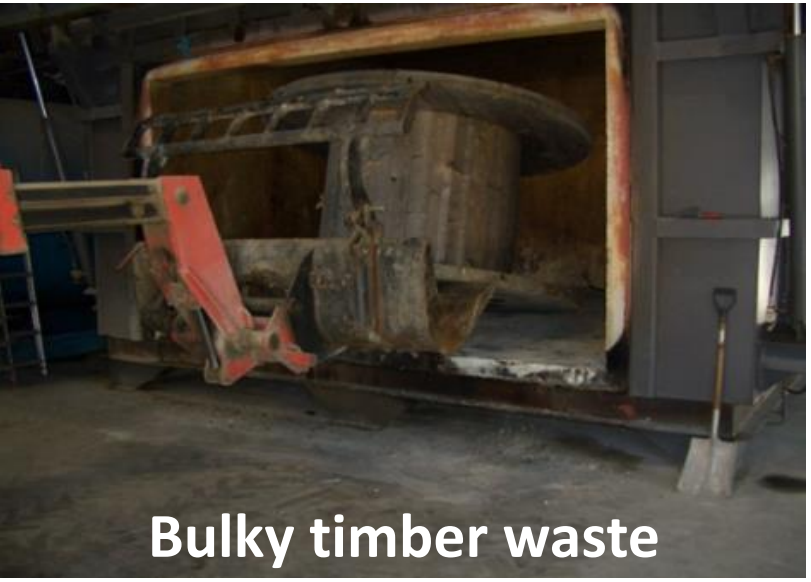
Flue-gas is treated in a dry scrubber system; with powder injection, a reaction vessel and baghouse system.

ECOFEIN™ Advanced Combustion Systems							
ECOFEIN™ system Type	# of gasification chambers	Capacity each chamber t/d @ 250 kg/m^3	Total process train capacity t/d	Volume of each gasification chamber m^3	Active output duration h/d	Thermal power output MW_t* per train	Electric power output MW_e* per train
ECOFEIN™ - [ABGM] Mobile Advanced Batch Gasification and Combustion System (not 24/7 operation)							
ABGM-1G1-2 Mobile	1	2	2	8.8	6.0	1.4	N/A
ECOFEIN™ - [ABG] Advanced Batch Gasification and Combustion Systems (not 24/7 operation)							
ABG-1G2-2	1	2	2	8.8	6	1.4	N/A
ABG-2G2-4	2	2	4	8.8	12	1.4	N/A
ABG-1G5-5	1	5	5	22.0	6	3.5	N/A
ABG-2G5-10	2	5	10	22.0	12	3.5	N/A
ABG-3G5-15	3	5	15	22.0	18	3.5	N/A
ABG-1G10-10	1	10	10	44.0	6	6.9	N/A
ABG-2G10-20	2	10	20	44.0	12	6.9	0.7
ABG-3G10-30	3	10	30	44.0	18	6.9	0.7
ABG-1G15-15	1	15	15	66.0	6	10.4	1.0
ABG-2G15-30	2	15	30	66.0	12	10.4	1.0
ABG-3G15-45	3	15	45	66.0	18	10.4	1.0
ABG-1G20-20	1	20	20	88.0	6	13.9	1.4
ABG-2G20-40	2	20	40	88.0	12	13.9	1.4
ABG-3G20-60	3	20	60	88.0	18	13.9	1.4
ECOFEIN™ - [ASBC] Advanced Sequential Batch Gasification and Combustion Systems (24/7 operation)							
ASBG-4G10-40	4	10	40	44.0	24	6.9	1.4
ASBG-4G15-60	4	15	60	66.0	24	10.4	2.1
ASBG-4G20-80	4	20	80	88.0	24	13.9	2.8
ASBC-6G20-120	6	20	120	88.0	24	20.8	4.2

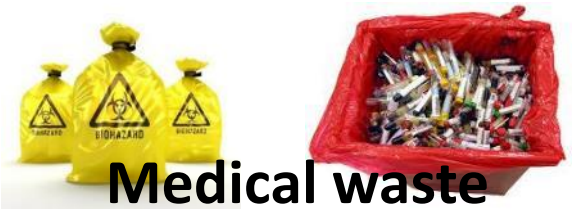
- * Thermal and electrical power output and duration of systems active power output is waste heat value and composition dependent
  (15 MJ/kg assumed in table)
- Other variations in system orientation available, for example trains with 6 primary chambers
- All standard size process trains have one common final combustion chamber, adequately sized to provide ample residence time for the final combustion
- Higher capacity can be reached with multiple process lines
- Standard size primary chambers: 2, 5, 10, 15, 20

Plastic wastes

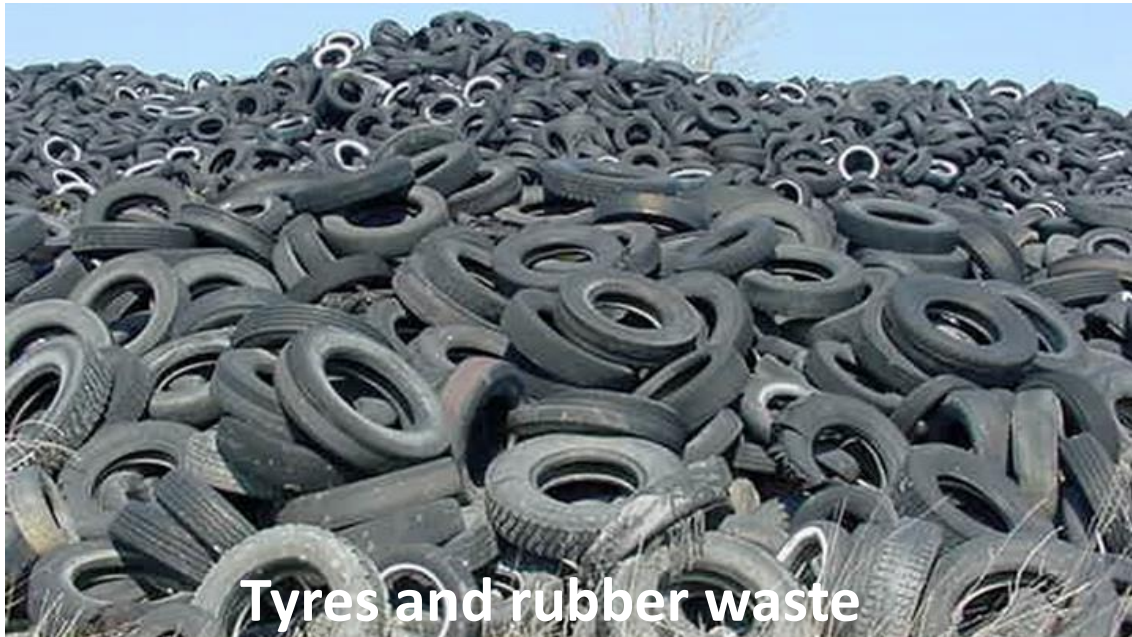
MSW, timber and slaughterhouse waste



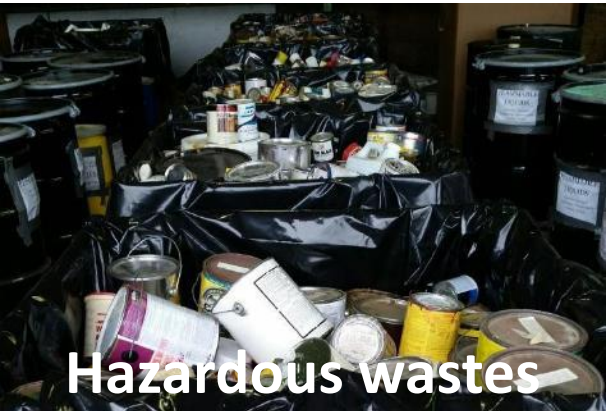
Bulky timber waste



Medical waste



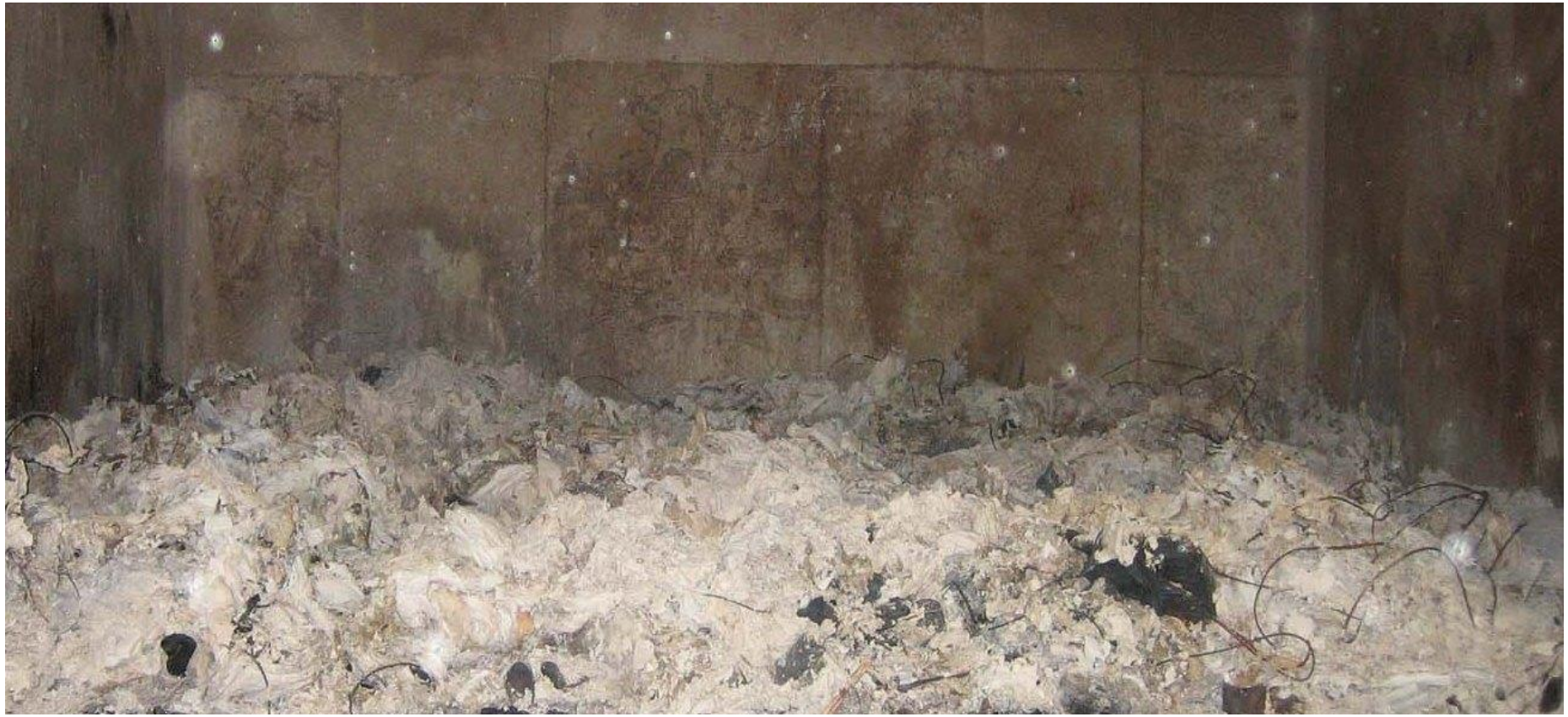
Tyres and rubber waste



Hazardous wastes

Animal carcasses

Bottom Ash



Ash from processing mixed MSW, I&C waste, the chamber was fully loaded with waste

Photo from earlier project built under an EPC contract by Einarsson's company and managed by Einarsson

Previous Fixed Hearth Batch Gasification Projects using Einarsson's Designs

- **Ronald Reagan Ballistic Missile Defence Test Site, Kwajalein Atoll, Parallel/Sequential Batch Combustion System (30 t/d)**
  - Equipment design by F. Einarsson, engineering specifications and production management in cooperation with Stephen Cochrane. Manufacturing complete 2018.
- **Old Crow, Yukon, Canada, Batch Combustion System (1 t/d)**
  - Process and equipment design, commissioned in 2012
- **US Air Force, Wake Island Atoll, Batch Combustion System (2 t/d)**
  - Process and equipment design, commissioned in 2010
- **Ascot Environmental, Dumfries, UK, Sequential Batch Combustion System (120 t/d)**
  - Process and equipment design, combustion equipment and emission control system construction, installation and commissioning, emission control equipment construction, installation and commissioning. Commissioning complete in 2009
- **Cayman Islands Department of Environmental Health, Batch Combustion System (4 t/d)**
  - Process design, commissioned in 2008
- **Sorpsamlag, Húsavík, Iceland, Parallel/Sequential Batch Combustion System (20 t/d)**
  - Process design, project EPC contractor (combustion, energy recovery and emission control), commissioned in 2006

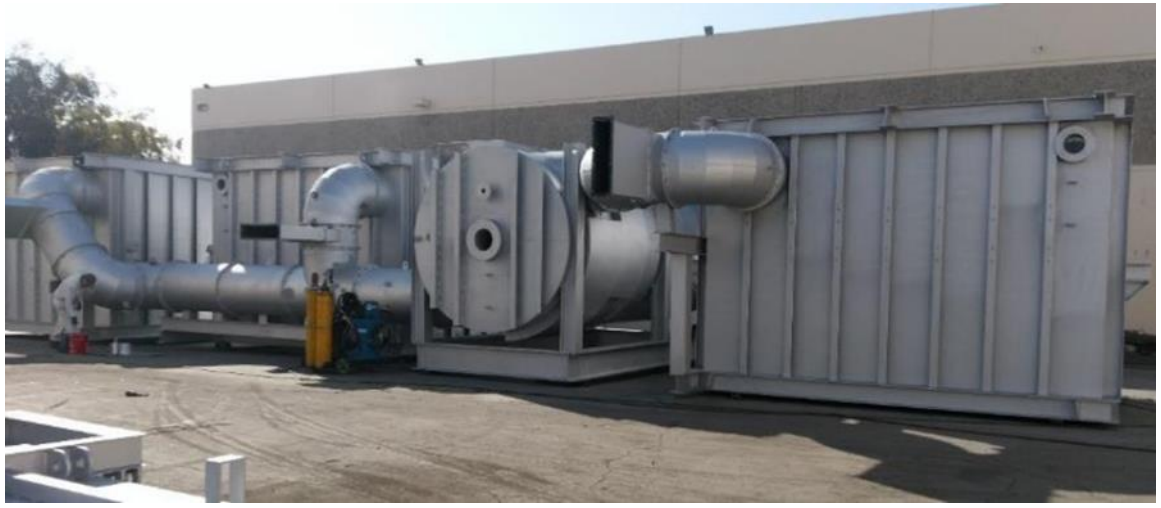
Ronald Reagan Ballistic Missile Defence Test Site, Kwajalein Atoll, Parallel/Sequential Batch Combustion System (30 t/d)

The batch combustion system for the US Army on Kwajalein Atoll was delivered to the client in Kwajalein by end of 2018. Installation and commissioning by the local engineering crew due to the sensitivity of the military station.

F Einarsson designed the equipment, engineered the system and managed the project with his long time associate Stephen Cochrane; using US subcontractors for the manufacturing process.

The equipment was supplied to replace a previous version of fixed hearth batch gasification system which was designed and built by Enerwaste Corp. Existing foundations and infrastructure were reused.

The new system has important upgrades in line with Einarsson's more recent systems designs. These upgrades will ensure improved performance with respect to emissions and environmental effect as well as much more reliable system operation and longevity of equipment components.



Combustion system major components during fit test at subcontractor’s manufacturing site

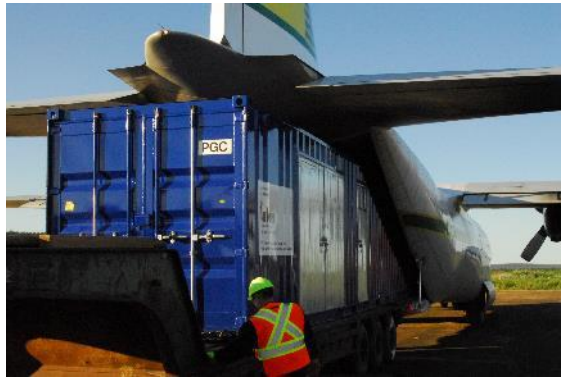
Old Crow, Yukon, Canada, Mobile Batch Combustion System

The mobile batch gasification system in Old Crow, Yukon, Canada was commissioned in 2012. Processing capacity is 1 t/d.

Einarsson got involved with the project in 2011 for heading the design of the gasification equipment part of the project.

Design challenges were among other that since there are no roads to Old Crow the only possible freight method was by plane.

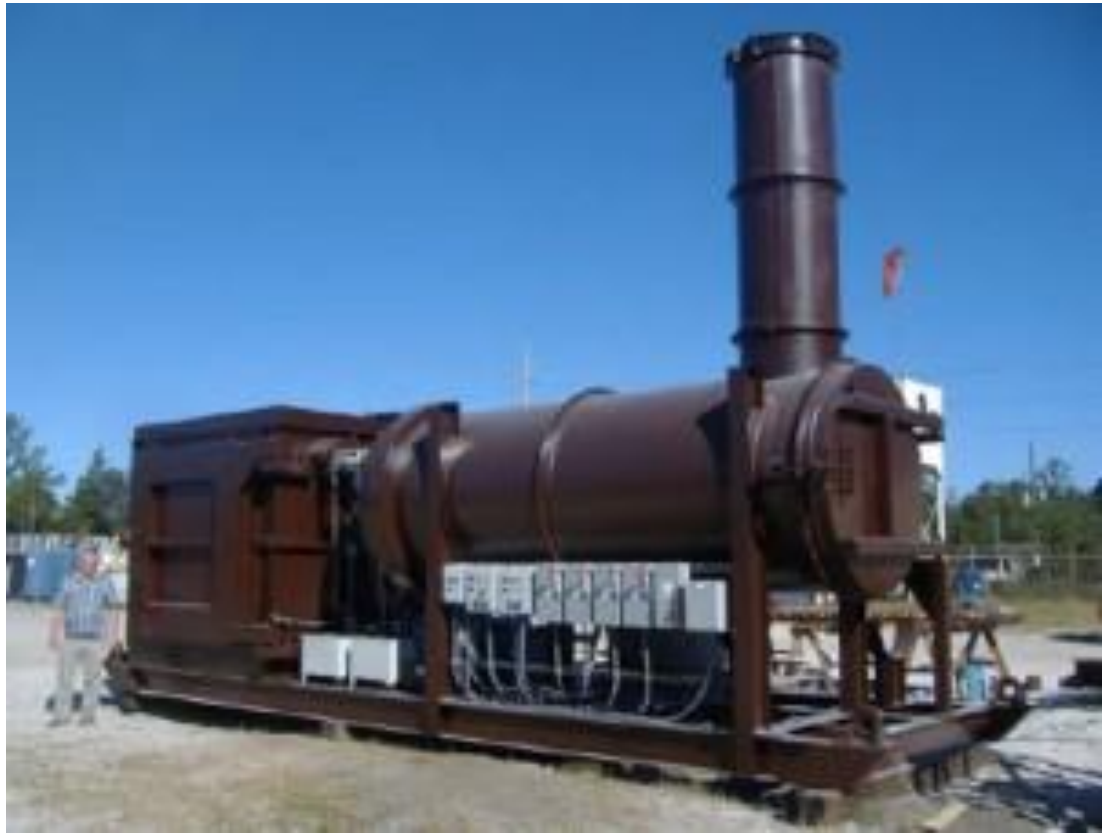
The equipment had to be balanced within the container with respect to the freight plane maximum payload and balance which was successfully completed.



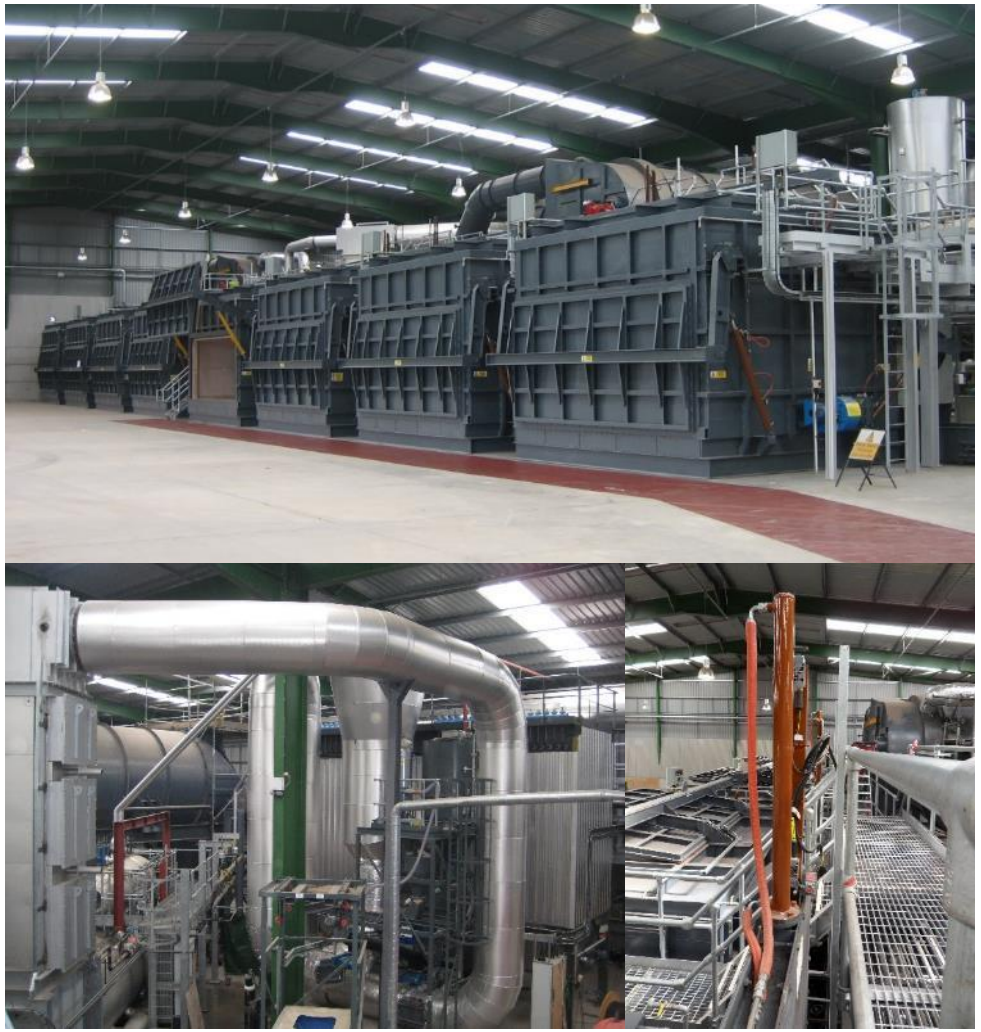
US Air Force, Wake Island Atoll, Batch Combustion System (2 t/d)

Batch combustion system for the US Air Force in Wake Island Atoll commissioned in 2010. Process capacity of 2 t/d.

Einarsson got involved with the project in 2009 for heading the design of the combustion process and equipment.



Dumfries, Scotland, Sequential Batch Combustion System

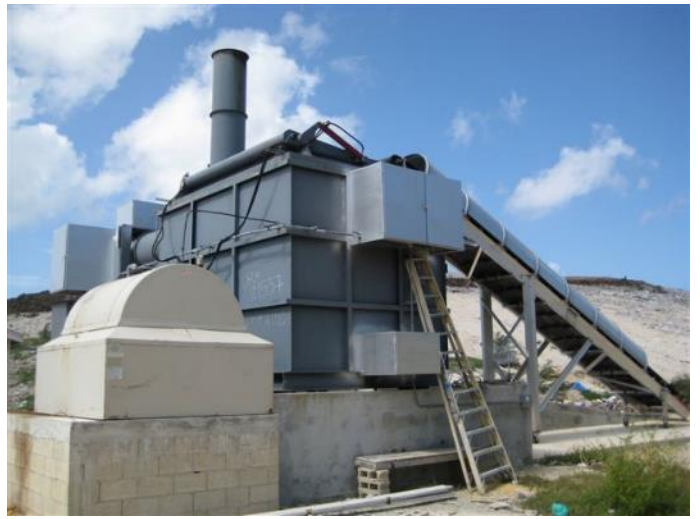


Sequential batch combustion system, commissioned in 2009. Process capacity of 120 t/d total, 60 t/d each process train. Fully sequential operated for 24/7 waste processing and electricity production.

Recovered energy utilised to produce electricity for the national grid (6 MW export). Emission control by dry scrubber system; reaction vessels and baghouses using sodium bicarbonate and active carbon.

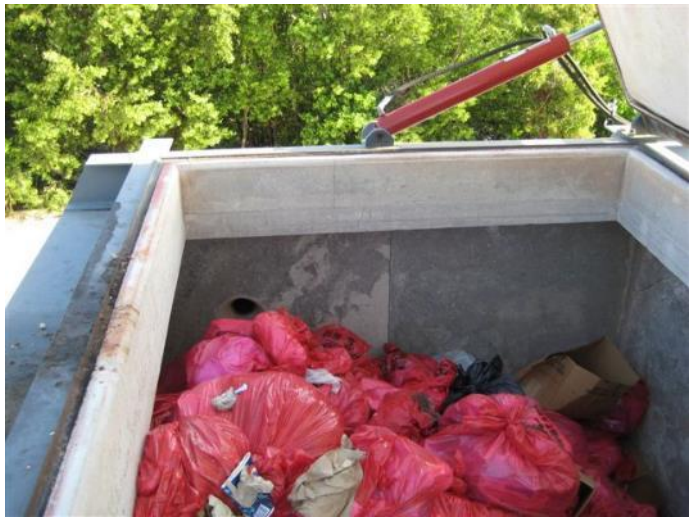
The combustion system was designed under Einarsson's directions and from his conceptual designs and the manufacturing, installation and commissioning was managed by Einarsson and Stephen Cochrane.

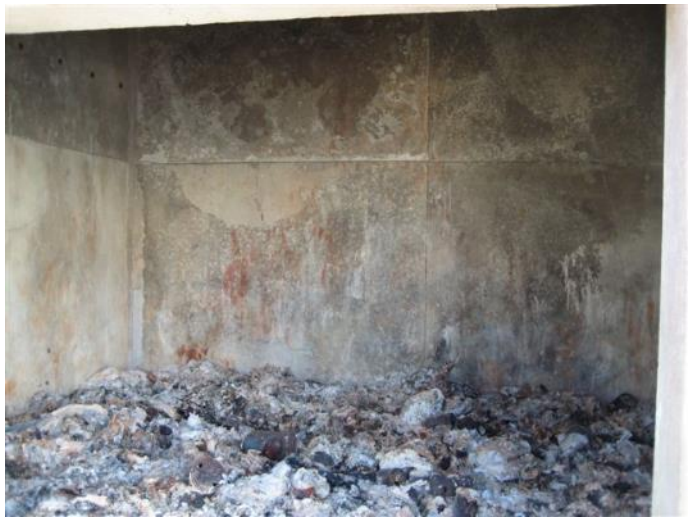
Grand Cayman
Department of Environmental Health,
Batch Combustion System (4 t/d)

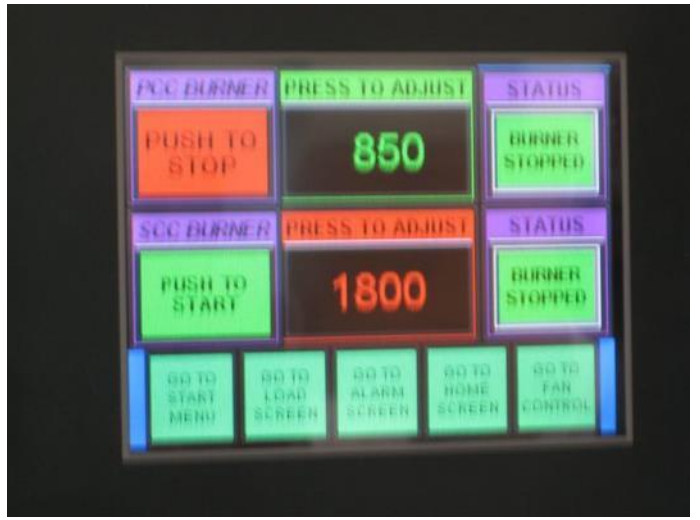


Batch combustion system for medical waste.

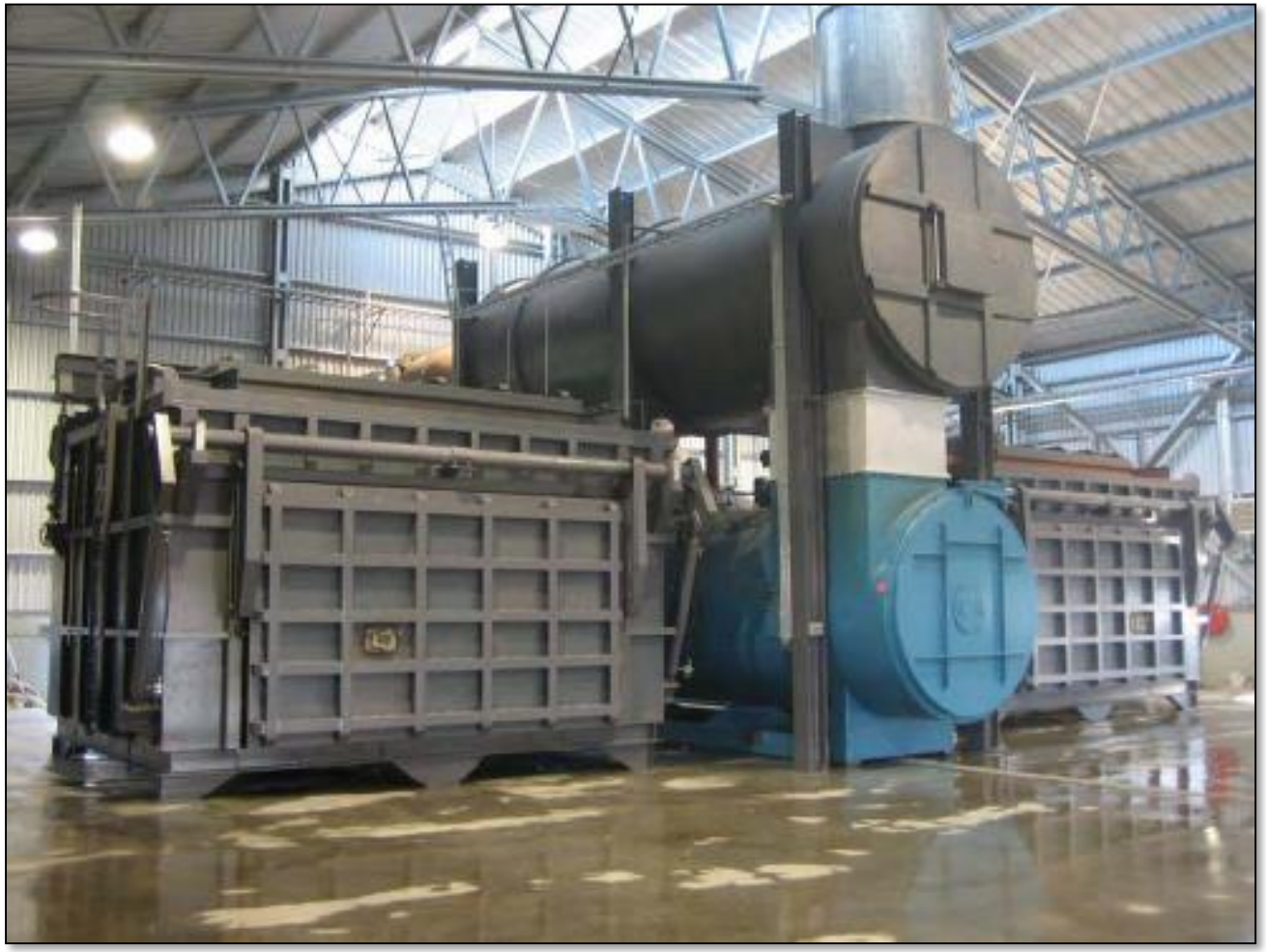
The equipment design was done by Enerwaste, but the process design and control functions were modified in line with Einarsson's process and control designs ahead of commissioning which was done under his direction in 2008.







Húsavík, Iceland, Sequential/Parallel Batch Combustion System



Parallel/sequential batch combustion system commissioned in 2006.

Process capacity 20 t/d total, 10 t/d in each of the two gasification chambers. Energy recovery by single pass fire tube boiler, recovered energy used in district heating system. Dry scrubber emission control system.

The original equipment design was by Enerwaste, while the project construction, installation and commissioning was managed by Einarsson.

During commissioning the process control and system functions were upgraded by FE.

Ecofein™ Combustion Systems

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