



NEWSLETTER 1

The nature and effects of the processes and events used to assess the safety of a geological disposal facility must be considered for timescales of hundreds of thousands of years. One of the main issues is the ability to assess these events and processes with sufficient confidence over these long timescales. Confidence depends on the quality and presentation of the research executed. This newsletter is one of a series of newsletters which are intended to inform stakeholders with a general interest in the CAST project.

CAST (Carbon-14 Source Term) is a research project that aims to develop understanding of the potential release of carbon-14 from radioactive waste materials under conditions relevant to waste packaging and disposal to underground geological disposal facilities. The project focusses on the release of carbon-14 as dissolved and gaseous species from irradiated metals (steels, Zircalloys), irradiated graphite and spent ion-exchange resins.

The CAST consortium brings together 33 organisations from 14 countries in the EU, Switzerland, Ukraine and Japan. The involvement of waste management organisations ensures that the project is aligned to European geological disposal programmes and that end results are of use in the safety assessments.



The progress of CAST is visualised in a digital growing tree and continuously updated on the website of CAST www.projectcast.eu

Carbon-14

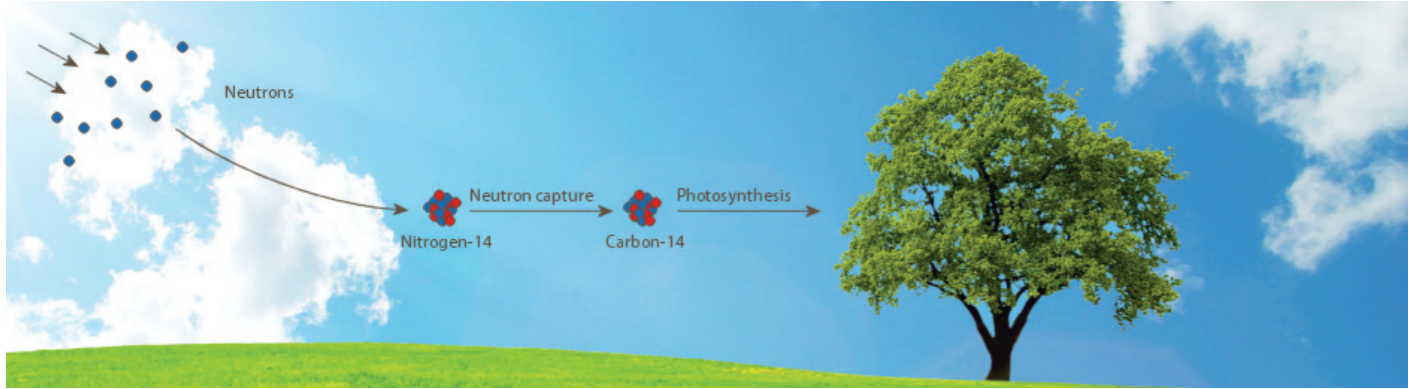
Carbon-14 is a natural radioactive substance (radionuclide) that is continuously generated in our atmosphere and on the Earth's surface, from nuclear reactors. Carbon-14 is radioactive, but does not present an external radiation hazard as the radiation cannot penetrate the skin. When the radiation dose mainly comes from this radionuclide, e.g. irradiated graphite, remote handling or shielding is not necessary.

The photo to the left shows the inspection of graphite from a nuclear research reactor in Romania that is undergoing decommissioning. The person working in the photo is well-protected against the effects of the ionising radiation of carbon-14. He wears gloves to protect the skin of his hands and a mask to prevent inhalation of potential radioactive dust, since carbon-14 is easily incorporated into living things.

This is why carbon-14 is used to determine the age of objects with biological origin, such as bone, cloth, wood and plant fibers. The incorporation of carbon-14 stops when the organism dies and its content decreases by radioactive decay over time. By counting the carbon-14 concentration, age can be determined up to about 50,000 years old. The chemical forms determine how easily carbon-14 can be assimilated. This is why it is important to understand how carbon-14 is released from radioactive waste. The types of radioactive waste investigated in the CAST project are introduced in this newsletter.

Natural carbon-14

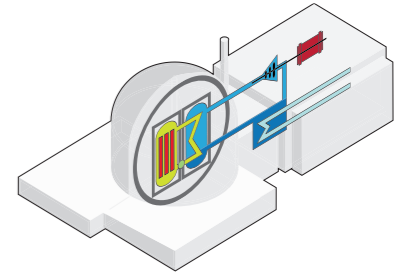
A description of natural carbon-14 is given here to familiarise the reader with carbon-14, and to set the context for the CAST project. Then, the origin of carbon-14 in radioactive wastes considered in the CAST project is presented. In the second newsletter, the radiological characterisation of the wastes will be explained.



Natural carbon-14 originates from cosmic rays. When cosmic rays enter our atmosphere, they undergo various transformations, including production of neutrons. The air that we breathe is made up of about 80% nitrogen, and carbon-14 is generated when nitrogen captures a neutron. A visualisation of this process is given on the website of CAST (www.projectcast.eu) when you hover your cursor over the picture below.

Steels

Steel is frequently used in water moderated reactors, and the largest structural material is the reactor vessel. The carbon steel wall thickness can be several decimetres thick. The inside of this vessel consists of several millimetres of stainless steel to prevent corrosion of the vessel. Other structural materials include components to assemble fuel elements and ducts to transport heated water. Irradiated steel becomes (decommissioning) waste. Release of carbon-14 from this steel in cement-based disposal facilities is investigated in Work Package 2 in CAST.



Carbon-14 waste

Different waste types that generate carbon-14 are studied within CAST. What are these wastes, and where do they come from?

Artificial carbon-14, like natural carbon-14, is produced by neutron capture. The neutrons for generating artificial carbon-14 originate from fission of uranium and plutonium inside a nuclear reactor. Carbon, nitrogen or oxygen are present as components of the fuel, moderator, and structural materials or as impurities. Neutrons are mainly captured by carbon-13, nitrogen-14 and oxygen-17 and will produce carbon-14.

Different waste types in CAST are investigated in separate work packages. Some of the waste types investigated and corresponding work packages in CAST are highlighted on the diagram of a pressurised water reactor to the right.

Graphite waste

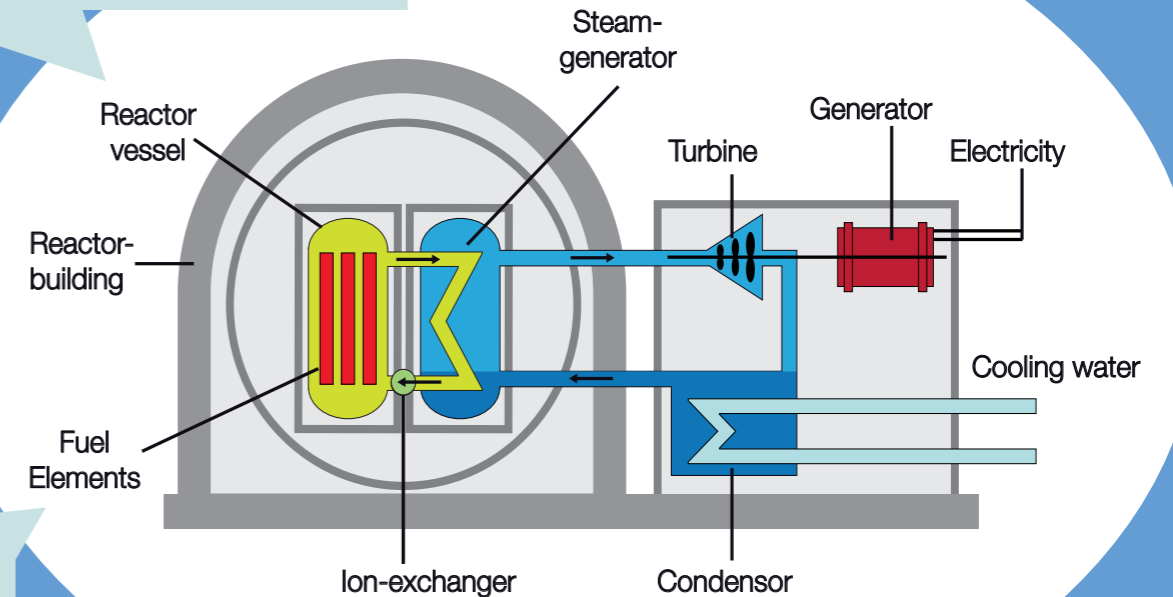
Some types of reactors use graphite moderators and reflectors, instead of water. This produces irradiated graphite, which may release carbon-14 under geological disposal conditions. Graphite waste is studied in Work Package 5 in CAST.



Zircaloy

The cladding of fuel elements is normally made of Zircaloy. The thickness of these claddings is usually less than 1 mm. Fuel elements are replaced several times during the lifetime of a reactor. Spent fuel can be reprocessed: carbon-14 is released from irradiated metal-oxide fuel during the fuel dissolution process. The claddings are not dissolved during reprocessing and become waste. Release of carbon-14 from irradiated Zircaloy under cementitious and argillaceous conditions is investigated in Work Package 3 in CAST.

The main source of carbon-14 appears to be neutron capture by nitrogen impurities present in steel and Zircaloy. The surface of both metals becomes oxidised under reactor conditions and this oxidation layer reduces further corrosion. In CAST the release of carbon-14 from irradiated metals including this oxidation layer is being studied, to simulate the waste form conditions for geological disposal as closely as possible.



Ion-Exchange Resins

Oxygen is a component of the moderator water. Neutron capture by oxygen and corrosion products are the two origins of carbon-14 in the primary circuit of the reactor. Carbon-14 is filtered from water with an ion exchanger. These exchangers are frequently replaced and become waste. Release of carbon-14 from ion exchange resins is investigated in Work Package 4 in CAST.

More information?

For more information on any of the technical publications from CAST, please visit the 'publications' section of the website at: <http://www.projectcast.eu/publications>.



Past events

General Assembly meetings are held to periodically update and review the project status and progress. The CAST Expert Advisory Group reviews the key deliverables from the project. This group consists of the end-users (national waste management organisations executing the safety assessment in Work Package 6 of CAST) and two independent experts. These experts are a corrosion specialist, Dr. Fraser King and a carbon-14 specialist, Dr. Irka Hadjas. Two meetings have been held so far.

The first meeting was in London in November 2013 and was hosted by Radioactive Waste Management Limited. The second meeting took place in Brussels in October 2014 and was hosted by ONDRAF/NIRAS. The minutes of the first and second General Assembly Meetings are published on www.projectcast.eu.



The research leading to these results has received funding from the European Union's Atomic Energy Community's (Euratom) Seventh Framework Programme FP7/2007-2013 under grant agreement no 604779, the CAST project.

Upcoming event

Organisations not participating in CAST but with an interest in waste containing carbon-14 are invited to attend the General Assembly meetings, as observers. The third meeting will be held on 14th – 15th October 2015 in Bucharest, Romania. It will be hosted by the institute for Nuclear Research Romania (INR) and the Romanian Institute of Physics and Nuclear Engineering (IFIN-HH). To attend the next General Assembly Meeting, please e-mail Ellie Scourse (eleanor.scourse@nda.gov.uk)



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