Primekss Concrete R&D center collaboration with Institute of Chemical Physics at UoL:

Tritiated water (HTO) and concrete interaction

09.10.2023

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Agenda

1 **PPRIMEKSS CONCRETE R&D CENTER**

2 **PRIMEKSS & CERN COLLABORATION: HISTORY & CURRENT/ FUTURE ACTIVITIES**

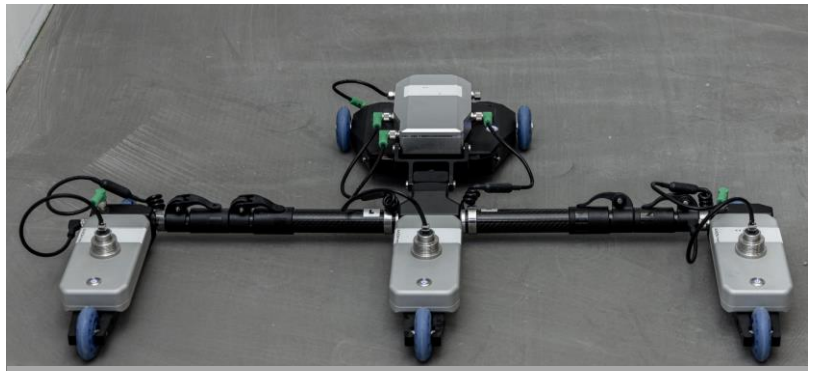
3 **TRITIATED WATER (HTO) AND CONCRETE INTERACTION: PRELIMINARY STUDY**

Primekss Concrete R&D Center

R&D Center opening May, 2023

Chemical laboratory

Mechanical testing



Floor testing and surveying

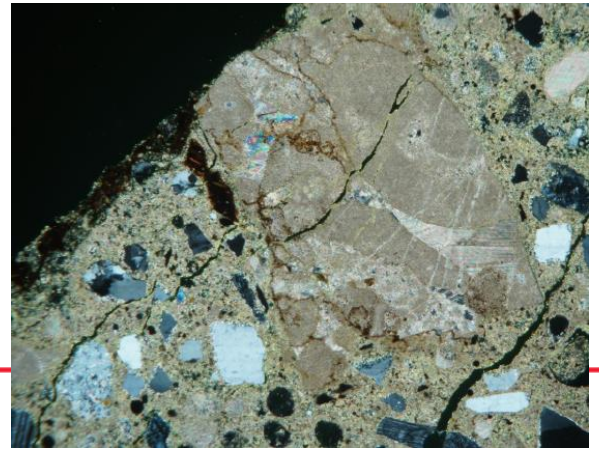
Shrinkage laboratory

PRIMX

Primekss & CERN collaboration: history & current activities

supplier

- **#1**: Technical assessment of the condition and causes of vertical deformations of the concrete floor slab at the CMS experiment (**detector at the large hadron collider**) = **COMPLETED**.



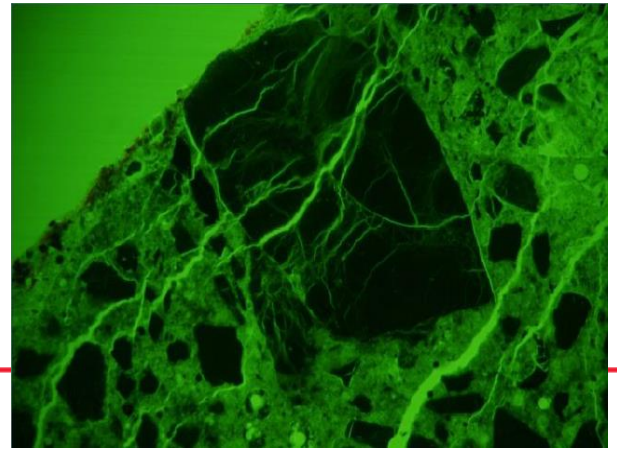
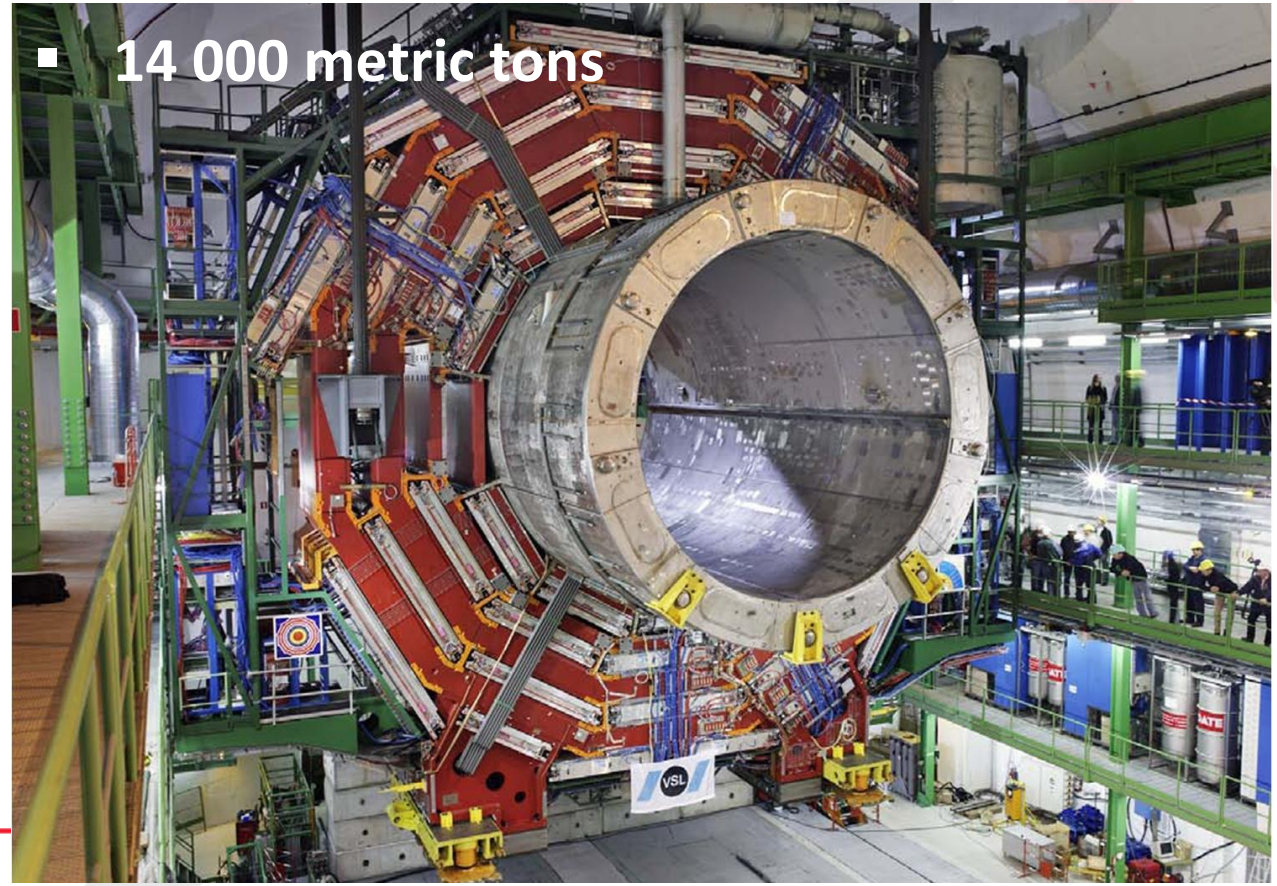


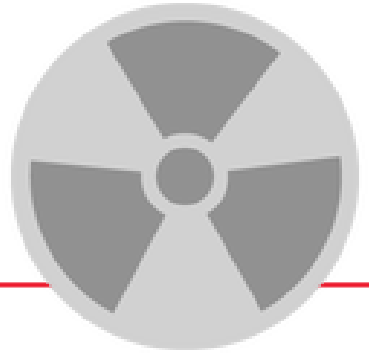
Fig: CERN



Primekss & CERN collaboration: history & current activities

- **#2**: Joint studies of the ***PrīmX*** **Specialist Concrete in view of Radiation Protection Aspects**.

- CERN is interested in Primekss unique high-performance Zero shrinkage jointless concrete technology – ***PrīmX*** because it allows to build efficient watertight and gas-proofing solutions. For **CERN** such technology is actual because it's important to prevent efficiently any leakage of radioactive waste from building structures where experiments are held. **Radioactive waste products** in this case can be both – in form of gas (particularly – Tritium gas) as well as in liquid form (Tritiated water - **HTO**).



PRĪMX

Primekss & CERN collaboration: history & current activities

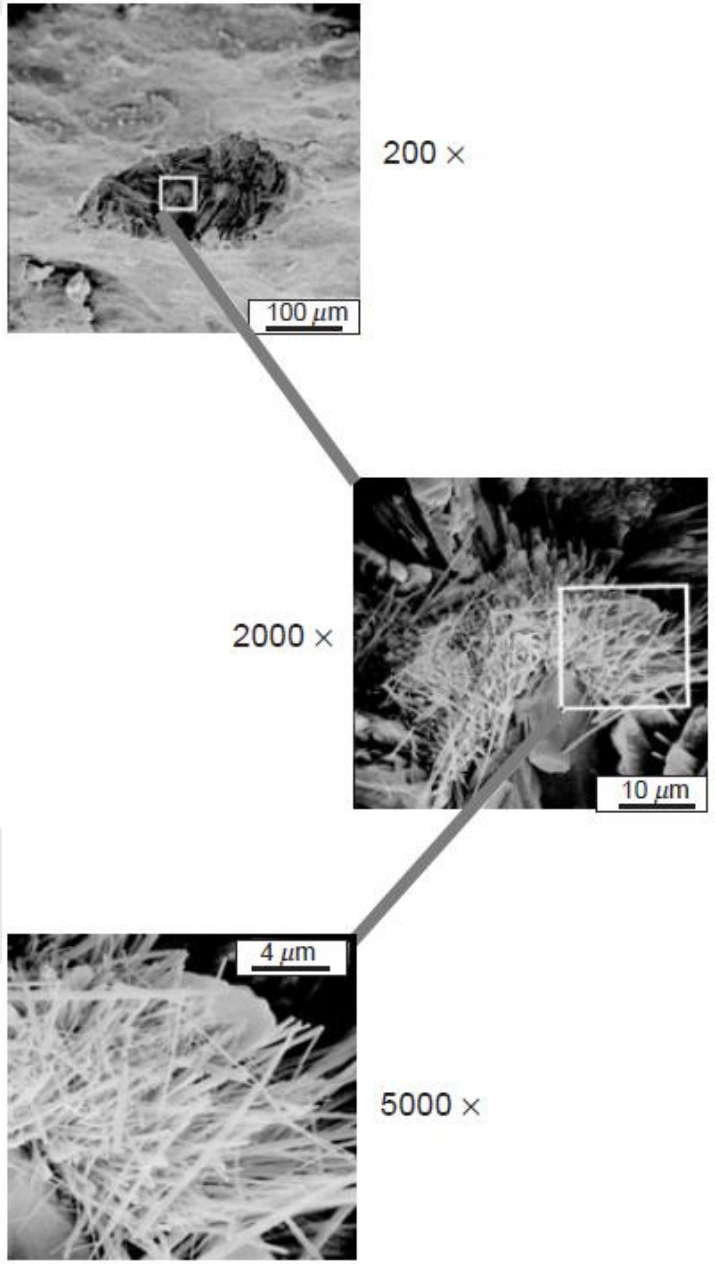
- **RADIONUCLIDE RETENTIONS MECHANISMS IN THE CONCRETE:**

- **Surface and bulk sorption** (mainly affected by the surface area of C-S-H gel and porosity of cementitious material);

- **Radioactive species take part in ion exchange with crystalline phases** of hydrated cement;

- **Isotope exchange reactions** (tritium participates in an isotope exchange reaction with structural water present in concrete).

- **Micro- and nano-filler addition to concrete composition firstly with the aim to achieve more dense concrete structure, secondly nano-filler surface defects can act as tritium attachment places.**

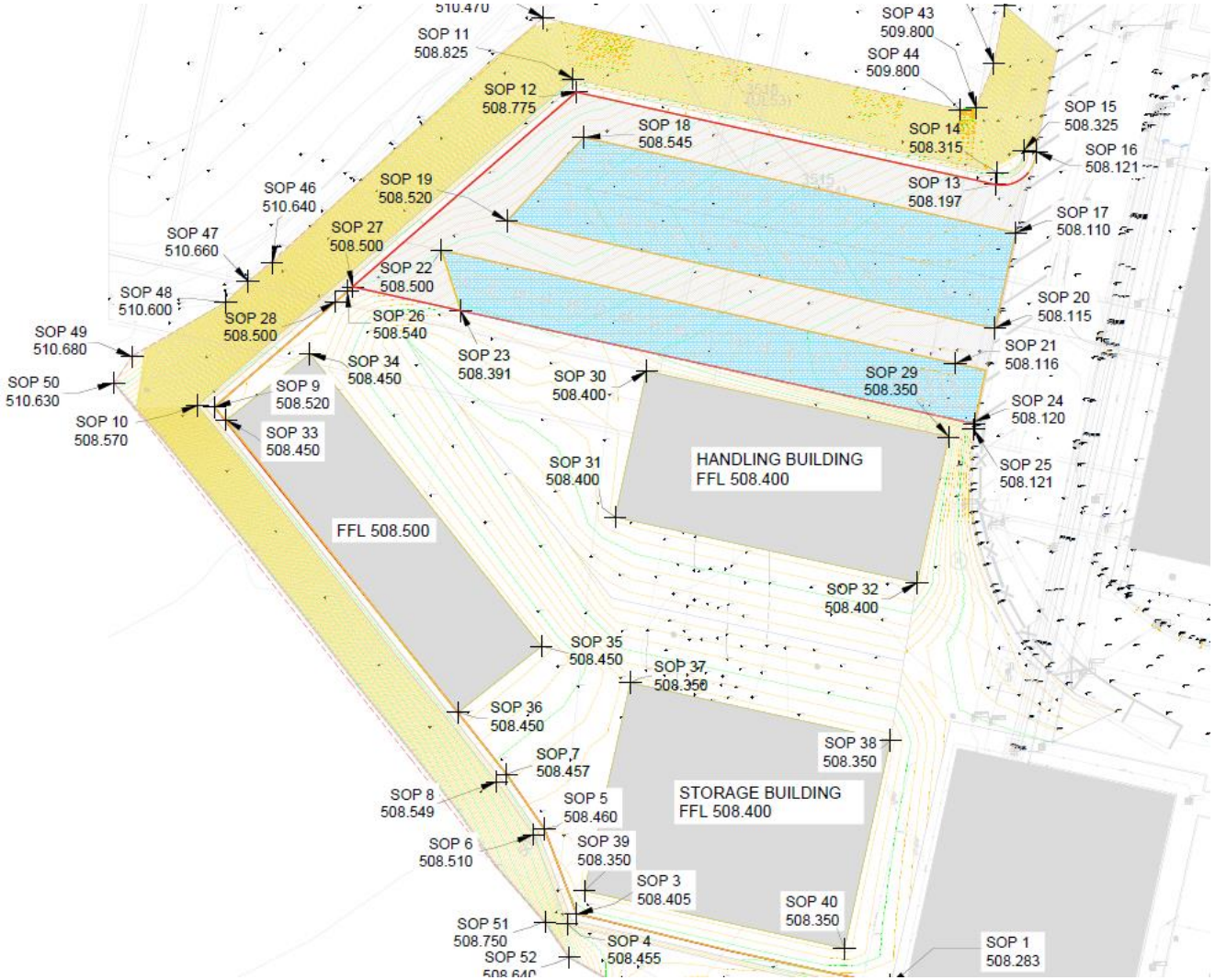


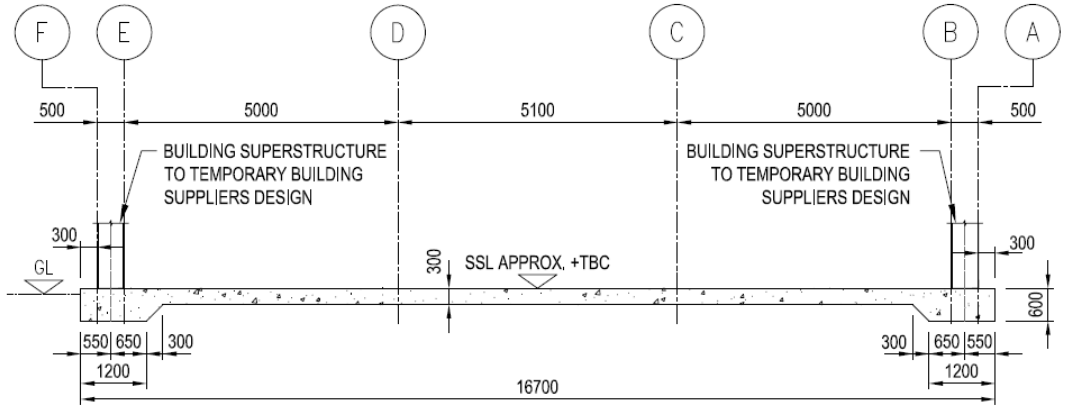
[**Fig.**: Mehta, P.K. & Monteiro P.J.M, 2006]

PRIMX

Primekss & CERN collaboration: history & current activities

#3: PrīmX Specialist concrete slabs at the CMS experiment





SECTION B-B

SCALE 1:100

CERN

Project	CERN WEST SLAB
Title	HANDLING BUILDING PROPOSED SUBSTRUCTURE GA & SECTIONS

University of Latvia - experience in tritium studies

Horizon 2020 & Horizon Europe, EUROFusion

2014 - up to now, Plasma facing components, tritium breeding blanket

ITER organization services contracts

2023- 2025 Tritium Behavior in Thermal insulation materials and assemblies for TBSs (Test Blanket Systems)

2020-2022 Tritium behavior in Thermal insulator Test blanket Systems

ERDF

2020-2023 Graphene-based electrochemical pumping system for radioactive hydrogen isotope separation"

European Fusion Development Agreement (EFDA) projects:

2013-2014 JW13-FT (Fusion Technology) -1.21 Investigation of fuel retention in various JET tiles.

2011-2013 JW11-FT-1.19 AMS and FCM measurements of tritium in laser cleaned tiles and tritium depth profiles in JET divertor tiles.

2010 -2012 JW10-FT-3.62 - Post mortem analysis of tritium accumulated in selected plasma facing components.

Fusion for Energy project

2010 -2012 F4E-2009-GRT-030(PNS-TBM)-A3 - EFDA Fusion Technology Tritium release under action of temperature, radiation and magnetic field from beryllium pebbles HIDOBE

Central Finance and Contracting Agency Republic of Latvia

china eu india japan korea russia usa

Tritiated water and concrete interaction: preliminary study

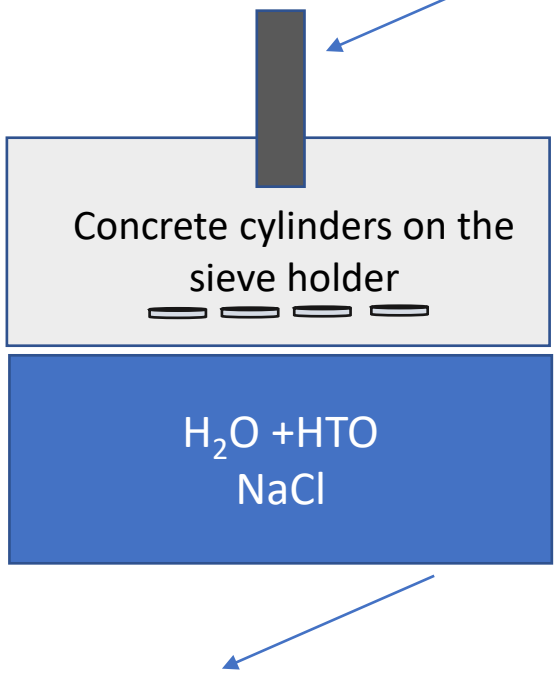
Material exposure to tritiated atmosphere
(HTO vapor or HT containing gas)

- **Absorbed tritium measurement**
  (concentration in the bulk of the material)
- **Tritium outgassing in ambient conditions or by purging with dry air**
- **Tritium thermal desorption**

Exposure to tritiated water (HTO)

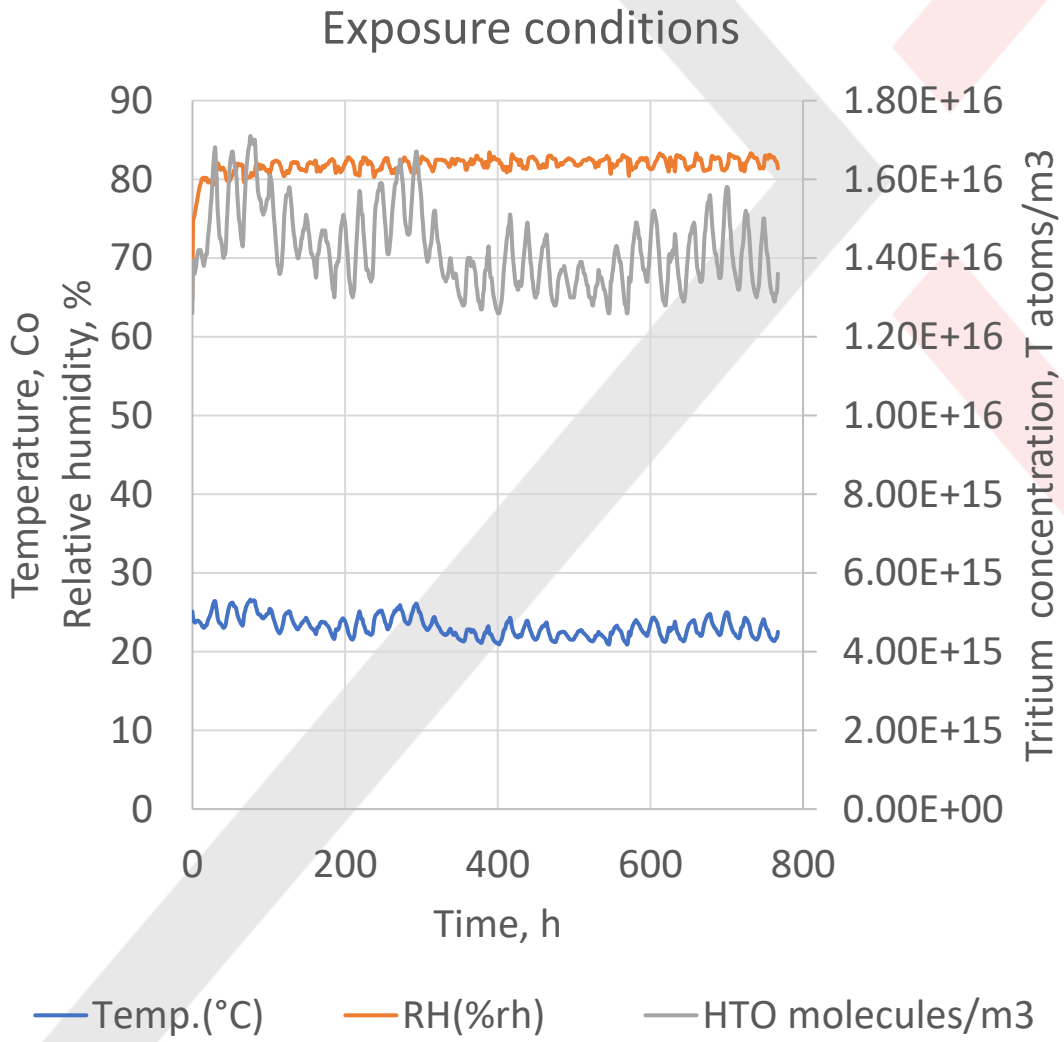
Exposure time **32 days**

PeakTech 5185 - Air Temperature
& Humidity USB-Datalogger



Average tritium concentration in air 30 MBq/m^3
or
1.7×10^{16} HTO molecules
or
0.07mPa (partial pressure)

TriTec tritiated water, 1.78 MBq/mL



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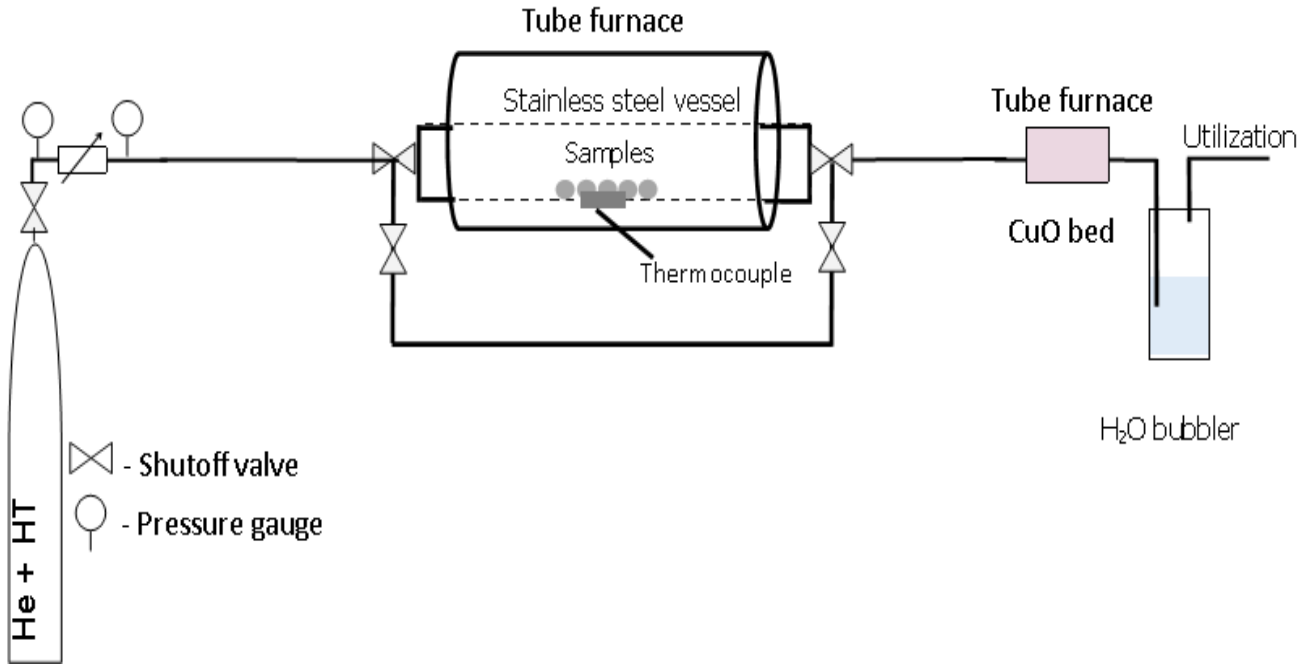
Exposure to tritiated gas (HT)

Exposure time **30 days**



Stainless steel vessel after filling with gas from the cylinder (TriTec) hermetically closed by Swagelok valves

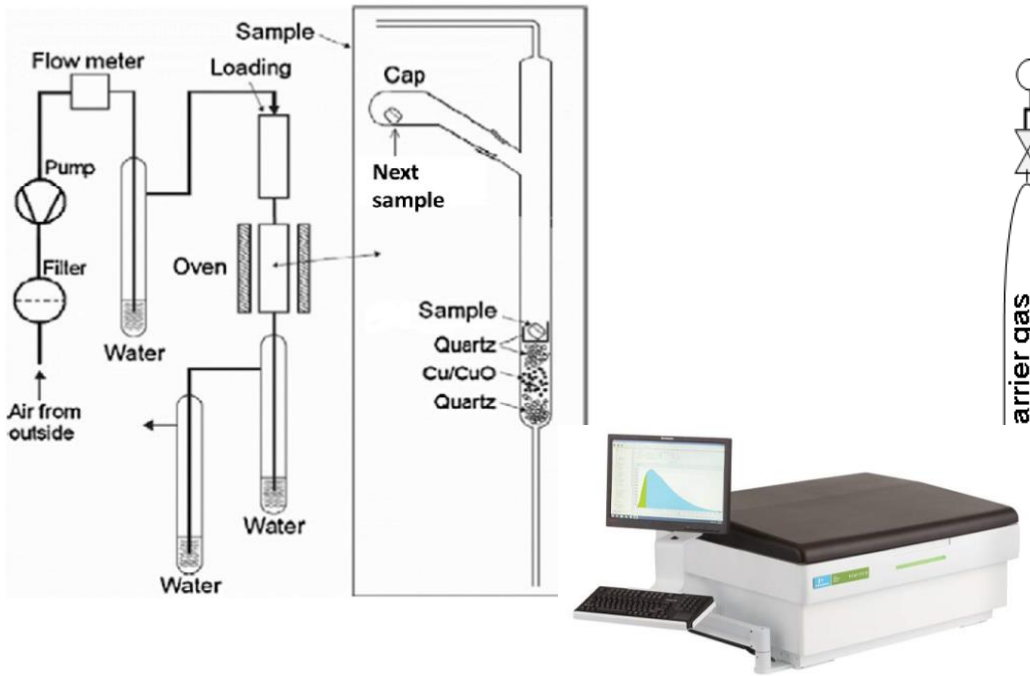
He + 0.1%H_2 + HT

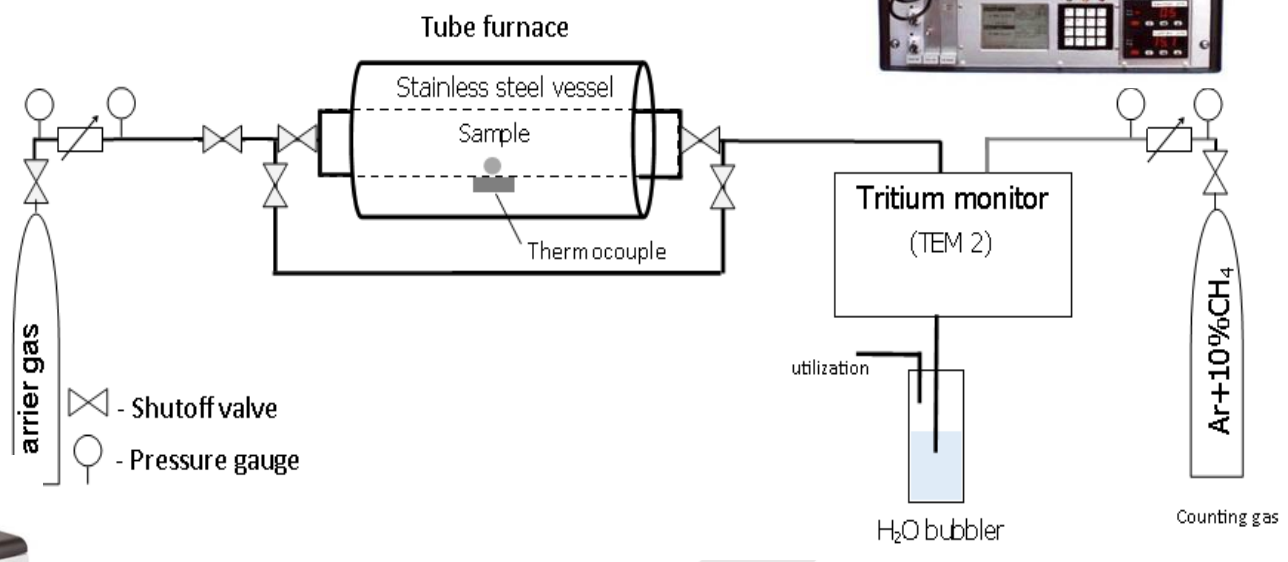
HT concentration 5.9 GBq/m^3

or

13.5mPa (partial pressure)

Measurement after exposure



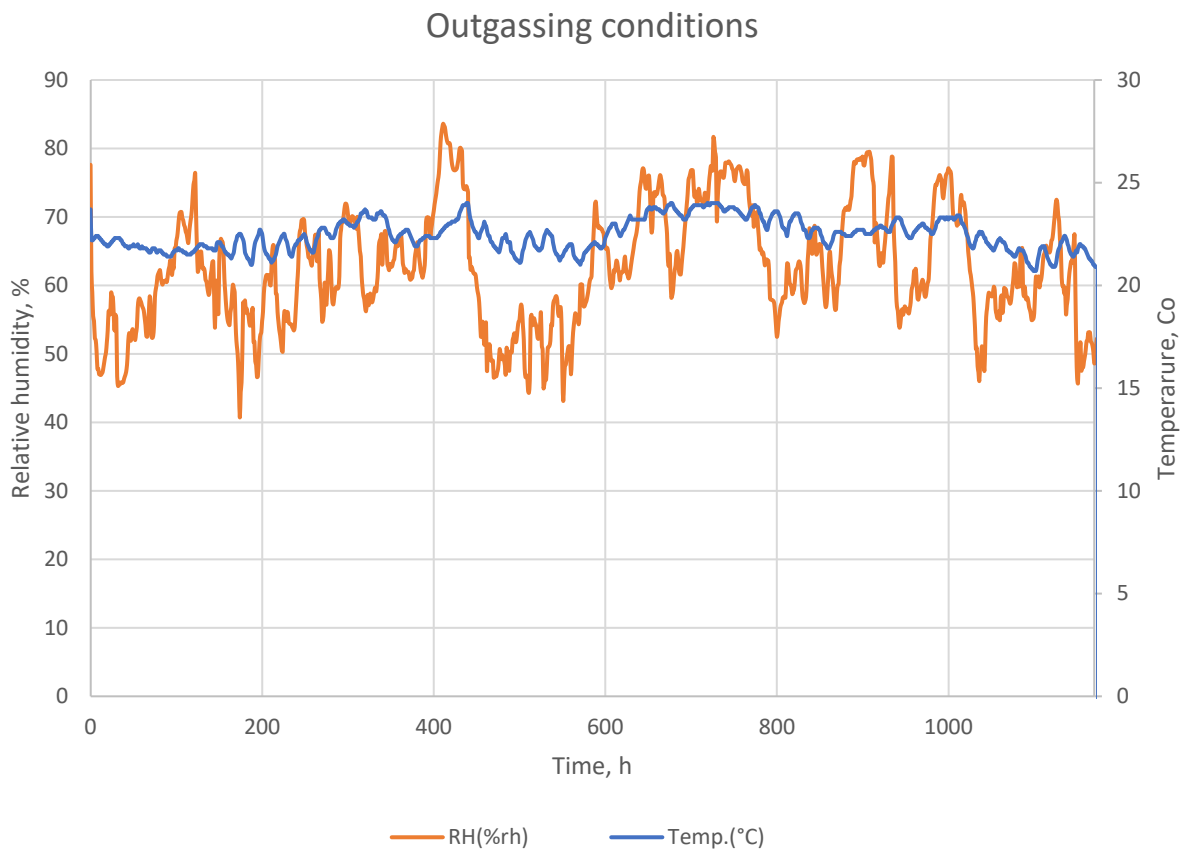


Vance set-up in which tritium is measured by liquid scintillation method (Perkin Elmer, liquid scinttillation spectrometer TRiCarb) .
The sample is heated in the moisturized air flow up to 1073K for 4 to 6 h, released tritium is oxidized by the CuO at elevated temperature and collected in the water bubbler

Tritium desorption either in room temperature of elevated temperate. Tritium measured in the released gas by means of proportional counter TEM 2100 (gas flow detectors DDH32)

Thermal desorption with heating rate 20C/min up to 600C.

Tritium outgassing in ambient conditions



Samples taken for measurement by Vance set-up.
Main assumption - initial tritium concentration in all samples similar

PRIMX

Results - absorbed tritium concentration

HTO

100 kBq/g or 2×10^{11} Bq/m^3

A(concrete)/A(air) = 10 000

HT

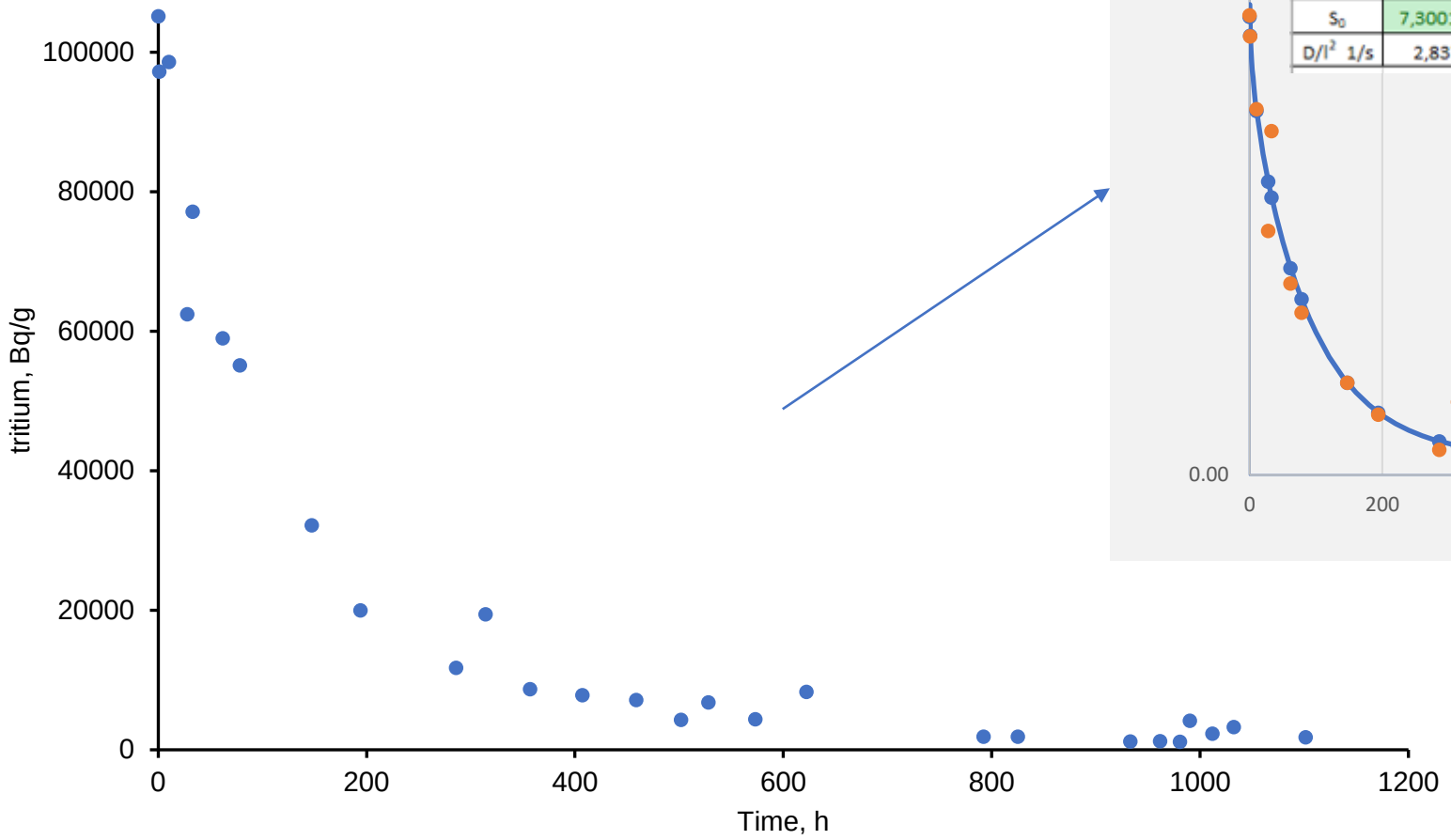
15 kBq/g or 0.3×10^{11} Bq/m^3

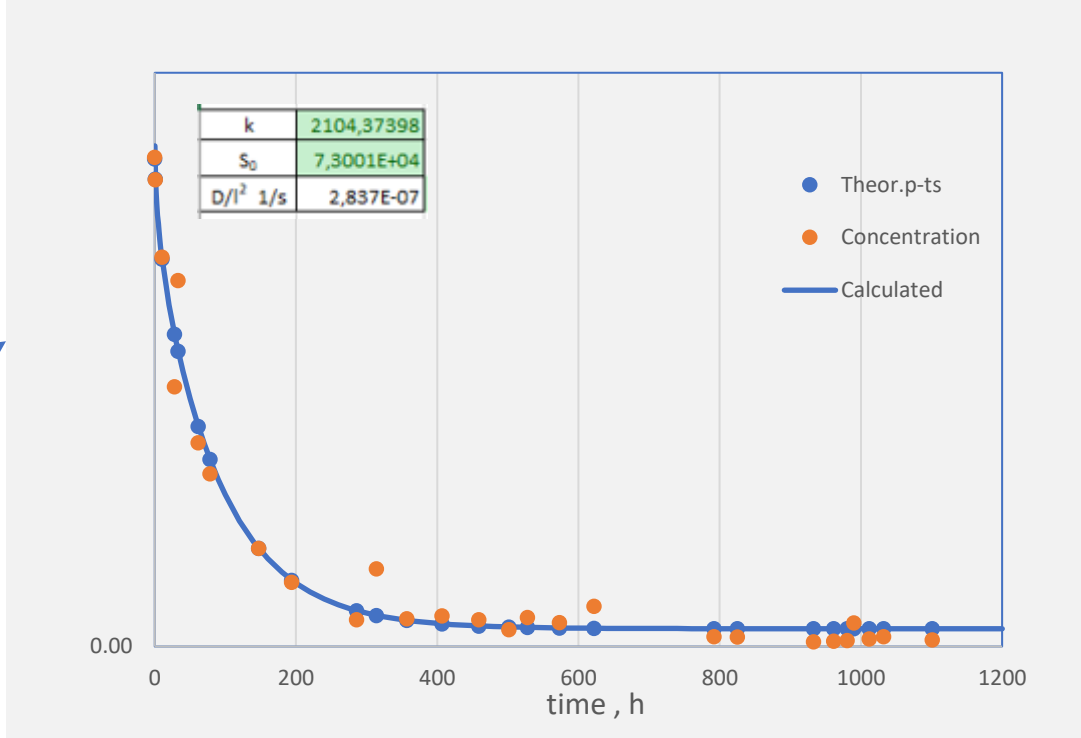
A(concrete)/A(air) ~ 5*

** In case of HT considerably higher concentration of tritium was used*

Results - tritium outgassing (HTO)

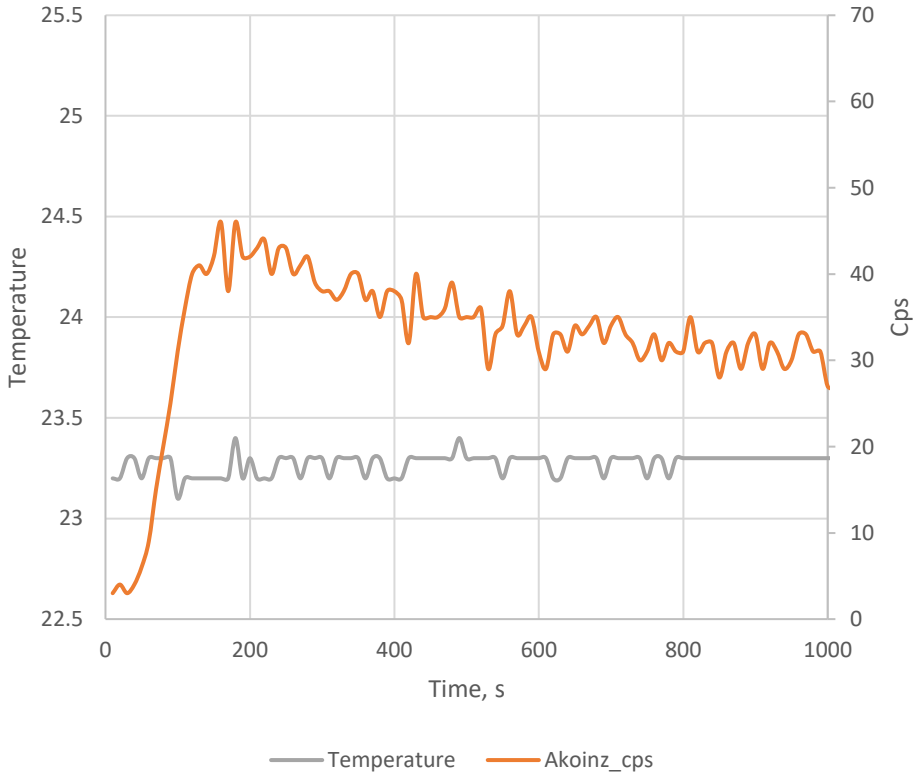
(HTO; 18.06.-20.07.2023)

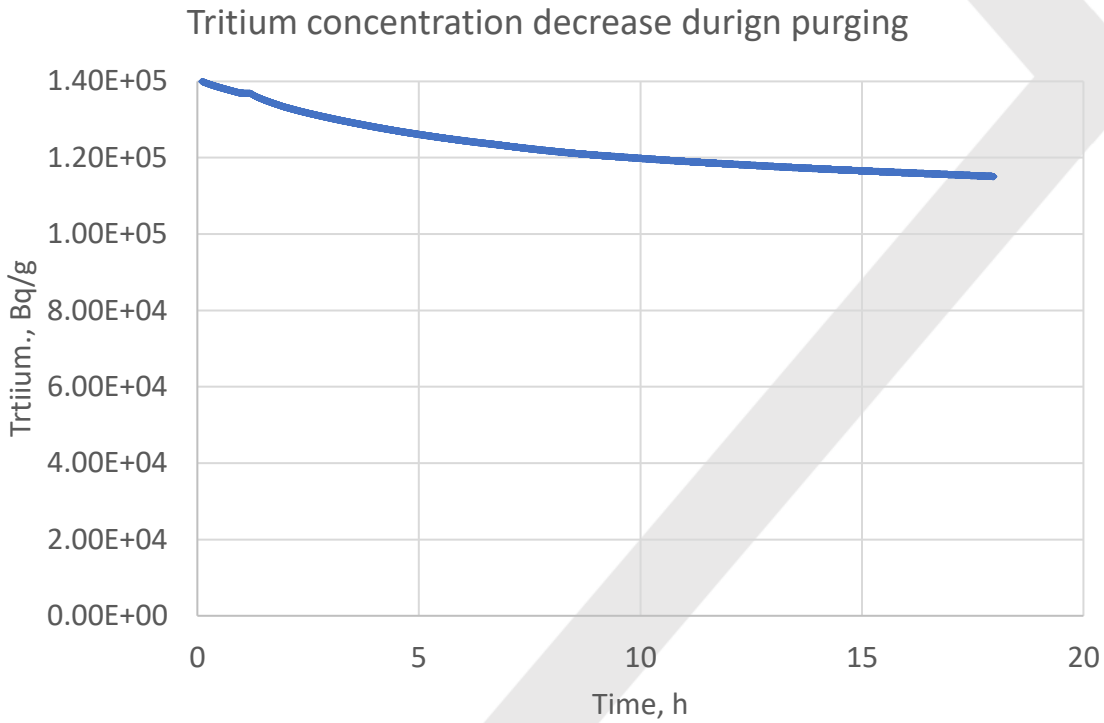




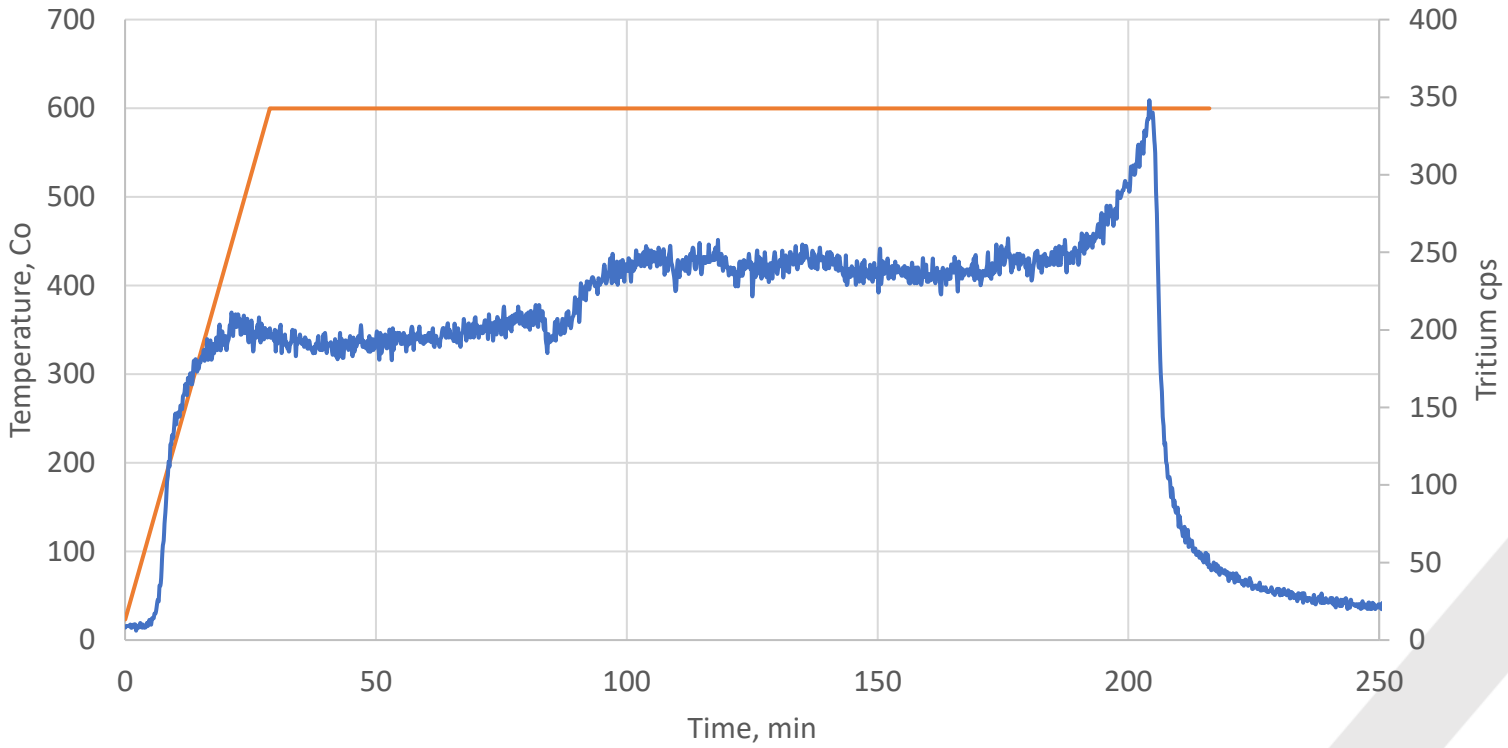
$$\alpha = k + S_0 \frac{8}{\pi^2} \sum_{n=0}^{\infty} \frac{\exp(-\pi^2 (2n+1)^2 \, Dt/l^2)}{(2n+1)^2}$$

Results - tritium outgassing (HTO) purging with dry air





Results - tritium thermal desorption



Summary

- Tritium absorption in concrete materials is considerably higher if exposed to tritiated water vapor (HTO) that tritium in a gas form (HT)
- Tritiated water (HTO) outgassing from material is slow and purging with dry air has not demonstrated considerable facilitation of the process
- At elevated temperature HTO release is taking place, however, higher temperature that 600^{o}C could be required to ensure full detritiation