KEP Nuclear eNewsletter:

Tritium Measurement

Tritium Origins and Issues

Tritium is one significant radioactive isotopes released to the environment by the nuclear industry:

- light water reactors by ternary fission and release during fuel failure,
- heavy water reactors by neutron capture in the moderator (heavy water),
- tritium production facilities for nuclear weapons,
- fusion reactor as fuel (deuterium-tritium).

![Figure 1. Comparison of aqueous tritium levels found in the nuclear industry](http://energy.gov/sites/prod/files/2013/07/f2/hdbk1129.pdf)

Tritium is used in the manufacture of luminous devices or in the production or assay of radio pharmaceuticals. Other applications include the manufacture of neutron generators used in industry or scientific studies of the physics and chemistry of tritium.

Tritium is chemically identical to the isotopes of hydrogen. It can be found in any chemical combination normally associated with hydrogen, forming HT, DT or T₂. When combined with oxygen, it forms HTO, DTO or T₂O. This form is indistinguishable from ordinary water which poses radiological health hazards.

The measurement of tritium is an important challenge due to its low energy beta emissions (E_max = 18.6 keV) and low half-life (12.33 years). Most measurement methods relied on sampling and laboratory analysis by liquid scintillation counting methods. Detection methods depend on the forms of tritium to be measured but chemical and physical process allow “converting” solid or gas sample into liquid form.

KEP Nuclear offers different technics (standard methods or under development) for tritium content measurement or on line system for gas or liquid.
### Calorimetric assay for tritium content in wastes

**Principle**
A calorimeter measures the thermal energy from the beta decay of tritium. The tritium mass is obtained from the heat measurement thanks to the specific power data (thermal power of 324 mW per gram of tritium).

<table>
<thead>
<tr>
<th>Sample form</th>
<th>Detection limit</th>
<th>Advantages</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas, liquid, solid.</td>
<td>100 GBq for 3-20 L sample. 1000 GBq for 200 L sample.</td>
<td>Calorimetric assay is a non-destructive and non-intrusive technique. Calorimetry is insensitive to sample inhomogeneity, to the presence of impurities and the nature of the measurement. It is insensitive to radioactive background.</td>
<td>Calorimetry is considered as an “expert” tool for nuclear material or wastes. New calorimeter µLVC based on a new design and system allows low detection limits (around 10 GBq for 40 L sample).</td>
</tr>
</tbody>
</table>

**He-3 in grow Method for tritium content in wastes**

**Principle**
He-3 in grow technique is based on the mass spectrometric measurement of the tritium decay product He-3 accumulated in a sampling device during a given in-grow-time.

The amount of tritium enclosed inside a wastes drum can be determined by the measurement of the leak rate of He-3 of this latter.

**Sample form**
Gas, liquid, solid.

**Advantages**
He-3 in grow technique is a non-destructive technique. It is insensitive to sample inhomogeneity, to the presence of impurities, and the nature of the measurement. It is insensitive to radioactive background.

**Comments**
This method can be used for the low level waste (detection limit lower than calorimetry).

### Plastic scintillator

**Principle**
The use of solid scintillators for tritiated liquid or gas measurements is well adapted for in on-line assay. The plastic scintillator absorbs the tritium β particle and converts it into visible light which is then...
measured by means of a photodetector.

<table>
<thead>
<tr>
<th>Detection limit</th>
<th>MBq/liter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample form</td>
<td>Liquid, gas.</td>
</tr>
<tr>
<td>Advantages</td>
<td>On-line measurement.</td>
</tr>
<tr>
<td>Comments</td>
<td>Different designs for flowing streams measurement have been studied, piping made inside plastic scintillator, crushed solid scintillator interposed between photodetectors, etc. KEP Nuclear is also developing its own system based modelling optimized design and new photodetectors.</td>
</tr>
</tbody>
</table>

### BIXS detector

BIXS detector is based on the detection of X-rays produced during interaction of the tritium’s beta particle with a material (tritiated material or target material in contact with tritiated gas or liquid).

<table>
<thead>
<tr>
<th>Detection limit</th>
<th>MBq (gas pressure between 1 and 60 Pa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample form</td>
<td>Gas, liquid, solid.</td>
</tr>
<tr>
<td>Advantages</td>
<td>The BIXS technique is well adapted for on-line measurement. The technique can be adapted for gas, liquid or solid analysis (best performances are obtained for low pressure gas analysis). In case of tritiated solid sample, the tritium content and depth distribution can be determined by measuring the continuous bremsstrahlung X-ray spectrum and characteristic X-rays (the technique can reach to 100 μm for low-Z metallic materials).</td>
</tr>
</tbody>
</table>

Depending on the application and the environment, KEP Nuclear can help you to choose the right technology taking into account parameters such as sample type, detection limit, precision and measurement time.