C6K validation tasks to be outsourced

P. Gorbounov, 25/06/2015, PFC-Alternative(s) General Meeting

Global validation tasks/problems

- Initial coolant composition and water contamination effects
- Radiation effects
- Compatibility with materials
- Purification methods
- Monitoring (sampling, online) – *at CERN*?

- What if C6K fails to be validated (other Novec fluids?)

General remarks

- Validation program depends on the cooling scenario assumptions
  - (C6F14 study, PG) – stress on initial and online purification
  - (The community) – stress on the compatibility of the system materials with hydrolysis and radiolysis products
  - Accept big liquid water accidents or not?
- The requested actions should be not over-defined, some degree of freedom (element of R&D) should be left to contractors
  - Methods of composition analysis (spectro- , chromo- …)
  - Test setup configuration
- Currently have established contacts with: 3M (USA), 3M (Switzerland), Dynalene (USA, coolants, filters, corrosion study), ILK (Dresden)
- To be done: contacts with Swiss academic labs

Composition and water-related effects (I)

Water: the contaminant that will have detrimental effects both for low- and high-dose application (C6F14 study, cooling experts, my presentation of 18.06 “C6K and Water”)

C6K
- a) Standard (as provided)
- b) Purified in situ (activated carbon, silica gel, Drierite) at room T
- c) Purified and partially and fully saturated with humid air (e.g., 10 ppm and 20 ppm)
- d) Purified, “saturated” with liquid water (to achieve pH=1 in the aqueous phase)

Water
- e) Aqueous phase after d)

Gas
- f) Head space after d)

<u>Actions</u>:

- Detailed spectrometric (IR, FTIR, UV-VIS, NMR etc) and/or chromatographic (GC, GC/MS, GC/??, HPLC etc) of a) and b), with identification of C6K and all contaminants
- Identification of all C6K hydrolysis products (PFPrA, HFC-227ea) + fluoride and HF in c)…f)

Composition and water-related effects (II)

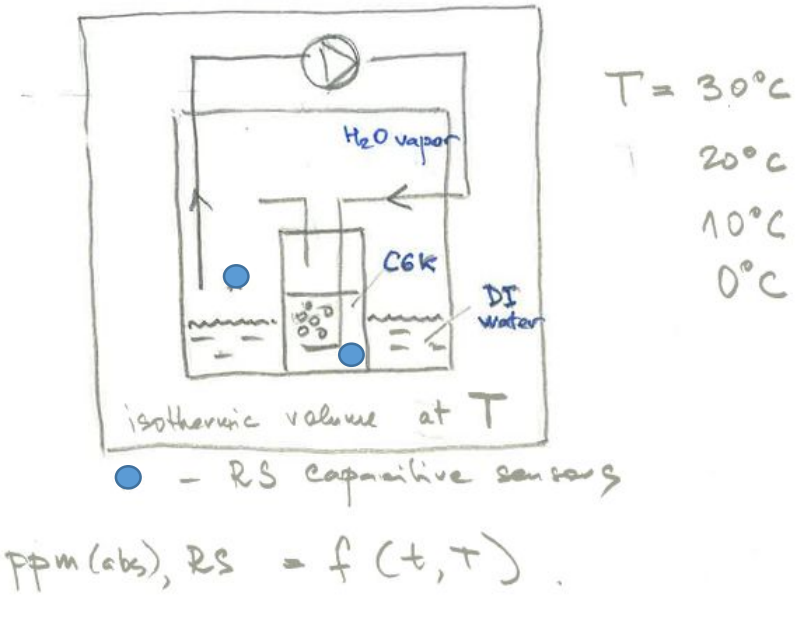
Study of water solubility and methods of moisture monitoring

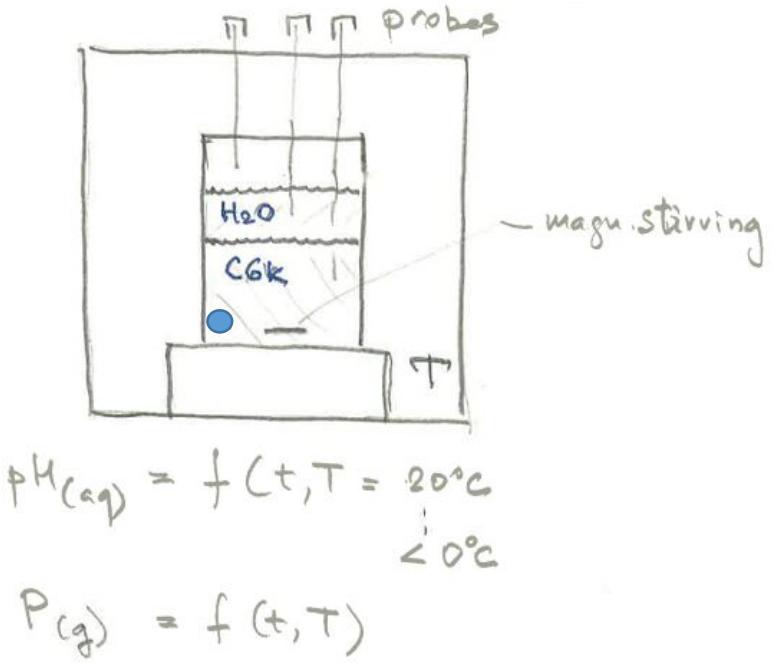
a) Absolute water content (ppm) and Relative water saturation, as functions of time and T

b) Effects of direct contact with liquid and solid water phase

c) Test usability of capacitive humidity sensors/probes with C6F14 and C6K

<u>Actions:</u>





Radiation effects

Actions:

- Detailed spectro- and/or chroma- composition analysis, with identification in all contaminants in irradiated samples and corresponding head space gas
- Comparison with the corresponding initial (non-irradiated) samples

Doses (γ): 0 Gy (in vials), 500 Gy (typical of low-dose apps), 5 kGy, 20-50 kGy

Samples: Purified C6K and standard (option: purified vapour-saturated)

Redundancy: x2

3M has already expressed an interest in performing this study at St. Paul (USA)

Material compatibility (I)

Accelerated “ageing” tests according to industrial standards, e.g. AST-MD-471-72 (like with C6F14). 1000 h at 80°C under pressure (or relaxed: 500 h at 50°C)

Material list (compiled by Dina)

1) Polyethylene high density (UHMWPE))
2) NBR (Nitrile Butadien Rubber)
3) Graphite
4) Stellite
5) Peek
6) gylon

Pipes (compiled by Dina)

7) brass
8) stainless steel 304 %306
9) titanium (Gr. 5!)
10) copper
11) steel
12) multilayer pipe (geberit or Alupex)
13) polyethylene

Extra materials (proposed by PG)

- High-purity, platinum-cured, non-plasticized silicone
- ???

Fluids

- C6K as provided (99.8%)
- C6K fully saturated with water vapour
- PFPrA aqueous solution at pH=1

Remark: not all plastics or elastomers are usable at <-40°C

Material compatibility (II)

Actions (tests after the exposure)

- SEM surface inspection for metals and hard plastics
- Volume and weight change
- Hardness (and elongation for elastomers)

ILK (Dresden) and any industrial certification lab (CETIM-CERMAT, SGS …) can do this.

Purification

Coolant and the expansion tank head space!

Potential contractors: 3M, Dynalene, academic labs

Actions

- Study molecular sieves (MS) compatibility with C6K (at 25, -30, -50°C)
- Study ion-exchange resins (IER) performance and usability at low temperatures. IER can be an alternative to MS, are ~compatible with C6K (evidence by 3M!), can be efficient desiccants (cation types) and acid removal agents (anionic types)
- Validate common desiccants: Drierite, silica gel (recommended by 3M)
- Close-circuit venting of expansion tank with dry N2 (through head space only, or through liquid + head space), with filtration (*membrane*?) – to remove H2O, O2, HF, COF2. The solution has to prevent C6K vapor removal!