[Form 2 (to be reported to Committee on Countermeasures for Contaminated Water Treatment and to be disclosed to public)

Technology Information	
Area	2 (Select the number from “Areas of Technologies Requested”)
Title	**Geopolymer for conditioning of secondary waste from the wastewater treatment at Fukushima Daiishi**
Submitted by	Forschungszentrum Juelish GmbH, Institute IEK-6 (and Westinghouse Electric Germany GmbH)

1. Overview of Technologies (features, specification, functions, owners, etc.)

Geopolymers are a class of three-dimensionaly cross-linking binder materials based on alumininosilicates. They are produced in aqueous solution by reaction of aluminosilicate-containing powders (e.g. fly ashes and/or reactive clays) with alkali metal silicates or hydroxides. Thereby a complex reaction (polycondensation) takes place known as Geopolymerisation. Geopolymers are purely inorganic substances and do not contain any organic polymers.

After hardening Geopolymer is similar to an artificially produced zeolite with characteristics of a "super cement" , which are a higher mechanical stability, a higher leaching stability and an advanced long-term stability. According to literature, the leaching rates of cesium embedded in Geopolymer are 40-50 times (!) than for below ordinary (typical) cement. Also there is evidence for a much higher resistance to radiolysis.

Geopolymer has the great advantage over ordinary cement to have thixotropic properties during processing. This means that by introduction of mechanical energy (vibration or shaking) already stiffened Geopolymer can be made liquid again and remains in this physical state during a certain relaxation time. Thus Geopolymer can easily be pumped through small-diameter pipes, which is not the case for ordinary cement or concrete. Accordingly cavities can be filled completely with Geopolymer leading to a high-quality and homogenous waste product.

For mixing and processing Geopolymer as well as for the production of Geopolymer waste products the same (standard) equipment as used for concrete is required only.

2. Notes (Please provide following information if possible.)
- Technology readiness level (including cases of application, not limited to nuclear industry, time line for application)

Existing applications - Immobilization of NORM-waste from oil and gas industry in Germany
Heavy metal containing and radioactively contaminated residues from uranium-mining

Merit
1. technology and process equipment comparable to cementation
2. hardening at room temperature
3. no calcium in the composition
4. closes "gap" regarding immobilization properties between cementation and vitrification
5. proven long term stability (mechanical, structural, chemical, microbiological)
6. formula is robust regarding variations in waste properties/characteristics
7. Geopolymer can be classified as cold hardening ceramics
8. no heat dissipation (exothermic reaction) during mixing and hardening of Geopolymer
9. thixotropic properties during processing
10. lower costs than for vitrification
11. fully applicable as alternative to vitrification and ordinary cementation

May be developed into an applicable technology for Fukushima within 5 years.

Challenges
Qualification of the waste product to be conducted based on a laboratory program (e.g. radiolysis, leaching stability, mechanical strength)
Technical process and process management to be developed or optimized
Tests with simulated Fukushima secondary waste and/or real waste to be conducted

- Others (referential information on patent if any)

To treat or to condition secondary waste from water processing at Fukushima Daiishi for long-term storage or final disposal the production of cemented waste products is considered.
Unfortunately normal concrete (e.g. from Portland cement) is not considered to be stable over a long period due to radiolysis caused by the high Cs-137 activity concentration, especially in combination with the high salt content of the seawater.
As an alternative IEK -6 suggested the use of Geopolymer as inert matrix material. The "Geopolymer Technology" has been used successfully in Germany, for example, in the solidification of radioactive and heavy metal- containing residues (sludges) of the WISMUT AG/Germany (Uranium mining) and could be considered to be promising regarding to the resistance of the waste product towards radiolysis and leaching.
In this context contacts have been establish in 2011 between the Japanese Radioactive Waste Management Funding and Research Center (RWMC) and the institute IEK-6 of the Forschungszentrum Juelich GmbH (FZJ).
In preliminary tests performed by IEK-6 zeolites of the type used at Fukushima were loaded with simulated seawater and solidified in Geopolymer. The corresponding samples were mechanically stable. The samples have been given to the RWMC in 2011 for further testing in Japan. Subsequently the application of Geopolymer was tested in Japan by the Japanese Atomic Energy Agency (JAEA). Based on the results in 2012 the RWMC expressed its interest in a scientific and technical cooperation with IEK-6/FZJ. TEPCO and METI have been requested in 2012 to finish a long-term program on R&D of waste treatment and disposal technologies for Fukushima until March 2013.
RWMC recommended a collaboration between IEK-6/FZJ and Toshiba (TSB). Contacts have been established via Westinghouse Electric Company Germany (WEG) which belongs to TSB. In July 2013, TSB presented six possible candidate technologies for the conditioning of secondary waste from the wastewater treatment system at Fukushima to TEPCO. One of them was the technology based on Geopolymer. TEPCO would like to have access to these technologies within 5 years. This could be achieved for the Geopolymer-Technology.
.
Geopolymer could be applied for the solidification ("cementation") of secondary wastes, particularly spent inorganic ion exchangers type (modified zeolites), as well as for sintered zeolites and for products from a low-temperature vitrification process developed by TSB.

【Areas of Technologies Requested】

1. Accumulation of contaminated water (Storage Tanks, etc.)
2. Treatment of contaminated water (Tritium, etc.)
3. Removal of radioactive materials from the seawater in the harbor
4. Management of contaminated water inside the buildings
5. Management measures to block groundwater from flowing into the site
6. Understanding the groundwater flow