

## KSTAR HELIUM REFRIGERATION SYSTEM DESIGN AND MANUFACTURING

**Pascale DAUGUET**, Pierre BRIEND, Isao ABE, Eric FAUVE, Jean-Marc BERNHARDT, Frederic ANDRIEU, Jerome BEAUVISAGE

Air Liquide Advanced Technology Division - BP 15 - ZI Les Ingenieres 38360 Sassenage FRANCE

The tokamak developed in the KSTAR (Korean Superconducting Tokamak Advanced Research) project makes intensive use of superconducting magnets operated at 4.5K. The cold components of the KSTAR tokamak require forced flow of supercritical helium for magnets/structure, boiling liquid helium for current leads, and gaseous helium for thermal shields. The cryogenic system will provide stable operation and full automatic control. A three-pressure helium cycle composed of six turbines has been customized design for this project. The "design" operating mode results with a system composed of a 9 kW refrigerator (including safety margin) and using gas and liquid storages for mass balancing. During Shot/Standby mode, the heat loads are highly time-dependent. A thermal damper is used to smooth these variations and will allow stable operation.