# SIGNATURE AWARD PRESENTATION

## NEUTRON RADIOGRAPHY FOR STUDYING THE DYNAMICS OF FLUID FLOW

S. S. Glickstein, J. H. Murphy and H. Joo

April 11, 1996

If you were boiling water in a glass teapot, it wouldn't be too difficult to take pictures of the boiling phenomenon. All you would need is enough light and a video camera to record what was occurring. You know what you would see. Lots of bubbles with violent agitation of the liquid and the vapor. From these video pictures you could probably figure out how to measure the size of the bubbles, determine the velocity of the liquid as well as the relative amounts of vapor and water inside the teapot.

That is basically what we have accomplished. Unfortunately our circumstances were just a little bit more, complex. Instead of a glass teapot we had to contend with a metal pot or in reality a channel made out of metal so that you couldn't see inside. Because the channel was under high pressure the supporting structures surrounding the channel had to be very thick. Standard viewing techniques don't work........Now you have a problem.

To the rescue came neutrons. We used neutrons from the nuclear reactor they have at the Penn State University campus at Happy Valley. The neutrons act as the light source. They are able to penetrate the thick metal wall and "see through" the pot. Penn State also has a unique neutron radiography camera that is capable of transforming the neutron pattern to a TV picture that could be recorded with a standard video camera. With this setup the dynamic behavior of water boiling and flowing inside a thick metal channel could be captured on videotape.

From the video recording were are able to do all I said...watch the dynamic motion of the liquid and the vapor. Most importantly we could do something that has not been done before, determine from the video data quantitative values for the fraction of liquid and vapor that is present under conditions that simulate a reactor core channel at high pressures and temperatures. This quantitative data undergoes mathematical corrections and is then used by our analysts who are currently developing computer models for predicting precisely this behavior.

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**The best way to describe our experiment is to ask you to visualize what you would see if you were able to watch water boil inside a glass teapot. Lots of bubbles rising to the top with violent agitation between the liquid and the vapor. We built an experimental system to observe just such phenomenon occurring inside a rather expensive teapot made out of metal, totally enclosed with water flowing and boiling under conditions of very high pressures and temperatures.**

**You can't use ordinary light or even x-rays to see inside this teapot. The experiment is set up at the Penn State University Campus located in happy valley. We had to go there to use use neutrons produced by their nuclear reactor as the light source that impinges on this teapot. Employing their unique neutron camera that is capable of transforming the neutron pattern to a TV picture we are able to capture the behavior of water boiling inside this teapot on videotape. The ability to record and interpret the dynamic behavior of fluid inside such an experimental conditions is very unique and innovative. There are a very limited number of facilities in the world that is capable of doing such experiments. We are the only ones that I know of that are studying such fluid flow behaviour under pressure and temperature operating conditions that our experiments are capable producing.**