

APEX-6/FHPD Workshop

Plan of Thermofluid Safety Experiments for Fusion Reactors

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Ingress of Coolant Event (ICE)

Break of coolant channels



Water ingress into a plasma chamber

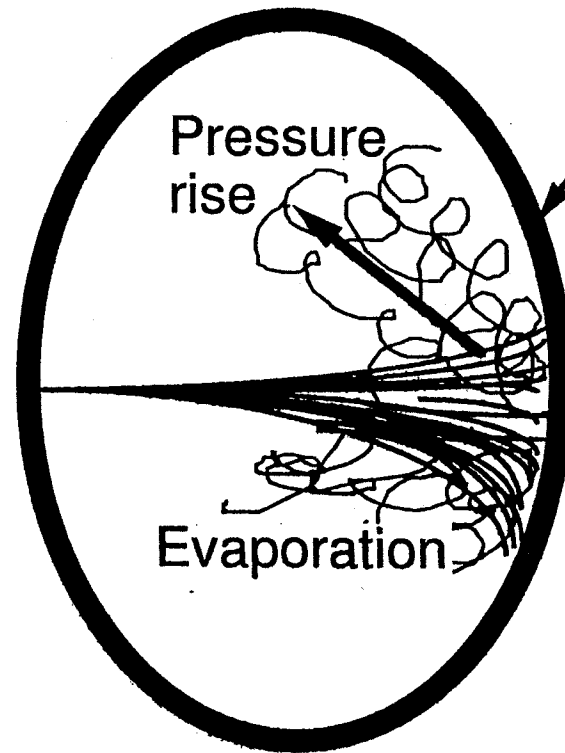


Water evaporation on a heated surface



Pressure rise

Water injection



Pressure rise

Plasma chamber

Design pressure
=0.5 MPa

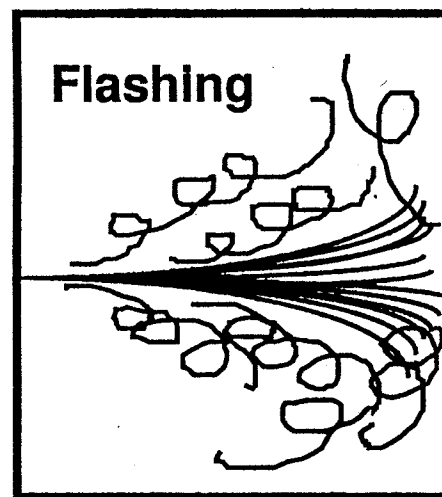
Evaporation

- Beyond a design pressure of the plasma chamber?
- No experimental data under vacuum conditions

1st Step's Thermofluid Safety Experiments

As the 1st step, preliminary thermofluid experiments were carried out to investigate ***physical phenomena*** under the condition that ***a small amount of water*** was injected into the plasma chamber.

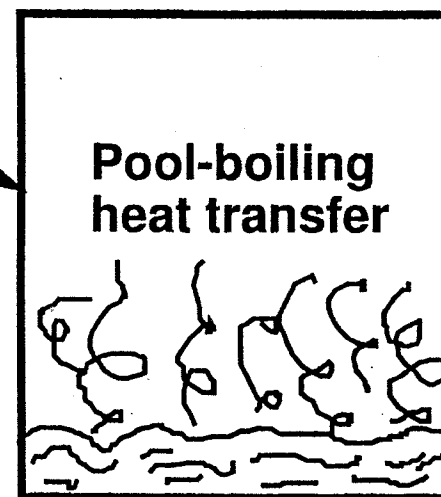
Main controlling factors on pressure rise:



During water injection

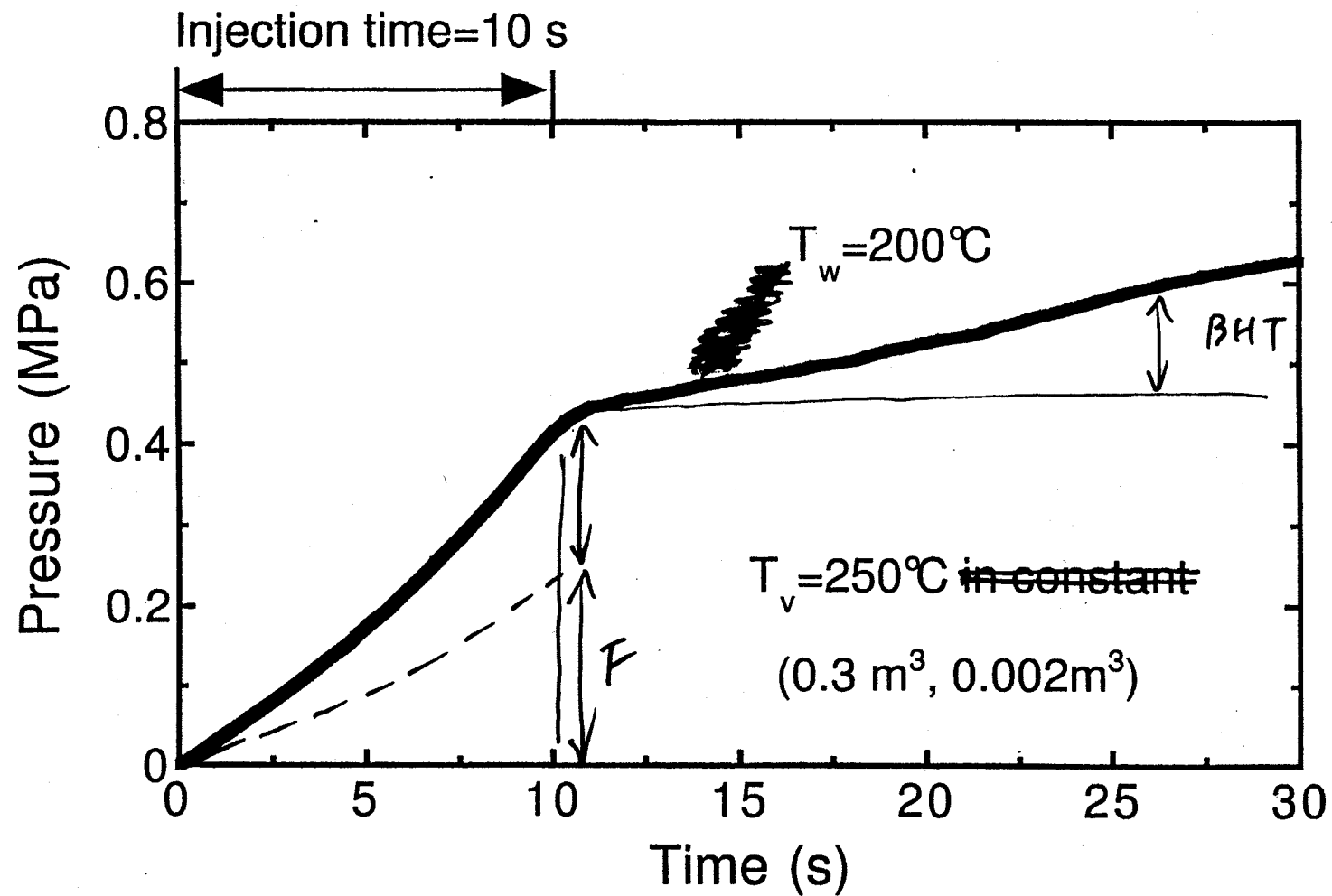
Small-scale
plasma chamber

Impingement
-jet heat
transfer



During and after water injection

An example of pressure transient during the ICE event

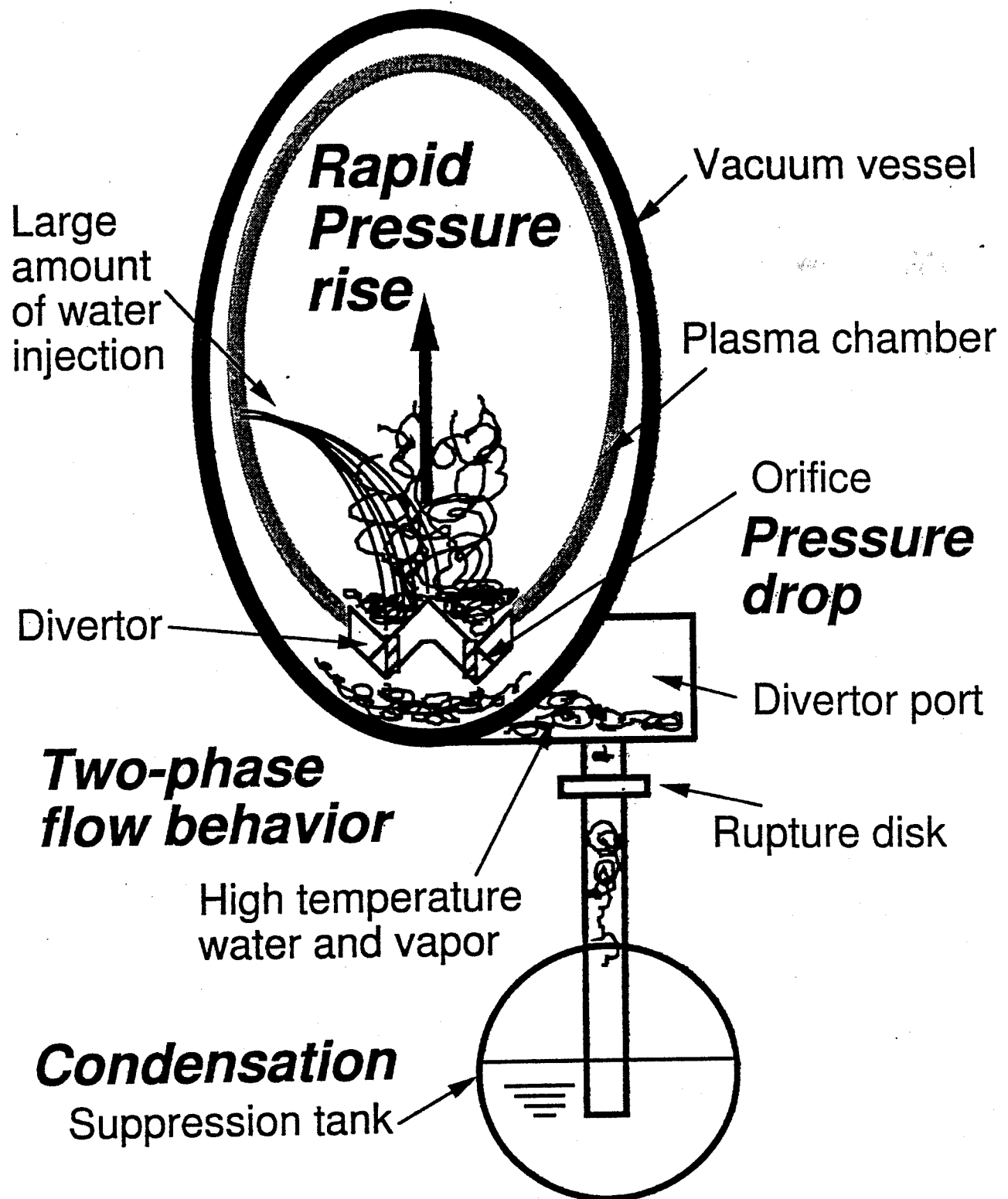


Pressurization due to flashing

$$p(t) = \frac{c_p \dot{m} R}{\dot{m} M} \int_0^t \frac{T_{sat}(t) \{T_w - T_{sat}(t)\}}{V_v(t) h_{fg}(t)} dt$$

Where, P: pressurization due to flashing;
 t: time;
 c_p : specific heat capacity of water;
 \dot{m} : injected water flow rate;
 R: universal gas constant;
 M : molecular weight of water;
 T_w : water temperature;
 T_{sat} : saturation temperature;
 V_v : volume of the vapor in the VV;
 h_{fg} : latent heat of evaporation.

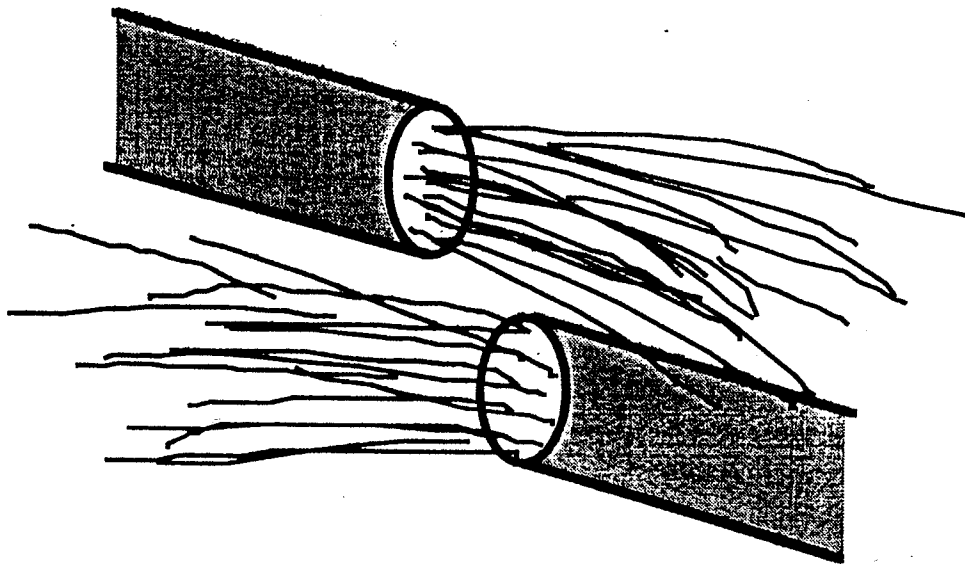
Key Phenomena at ICE Events



Integral performance of safety systems

Scaling of Test Facility

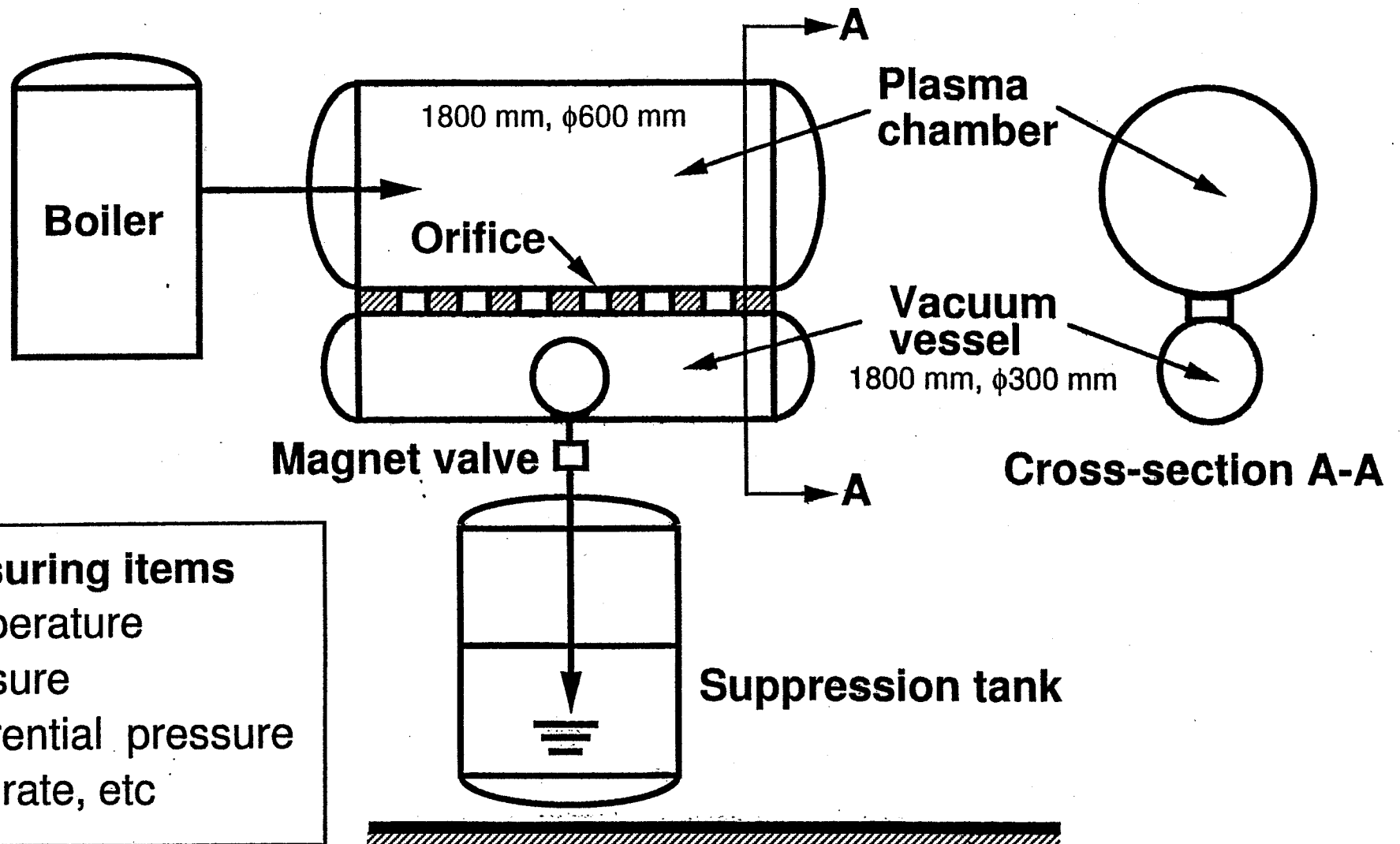
Simulation of a double-ended pipe break



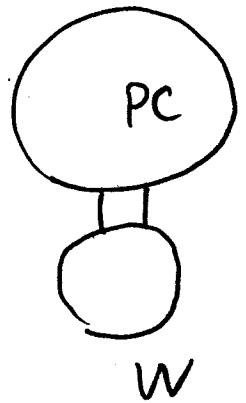
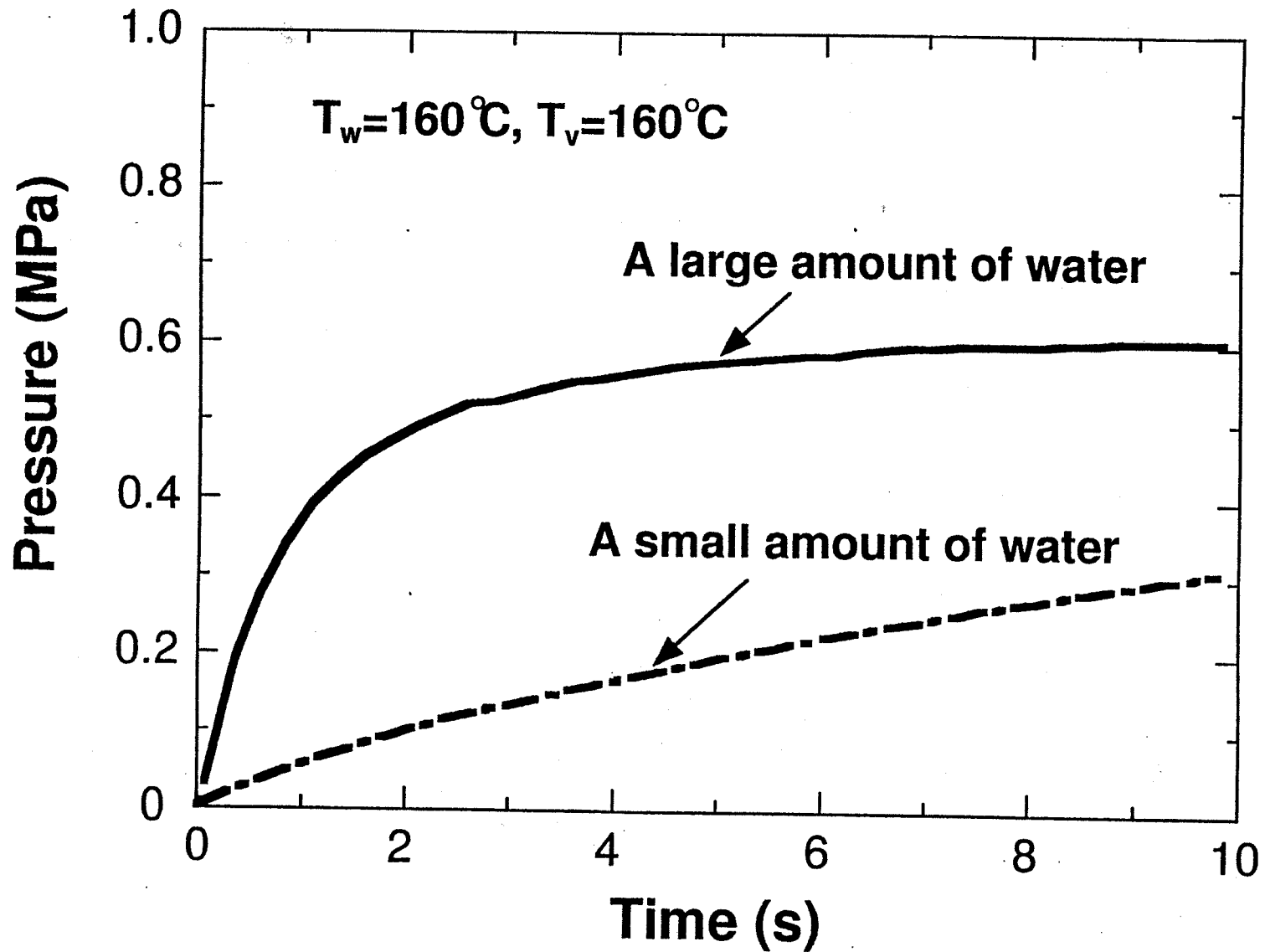
- Coolant channel diameter:
 $\sim 10 \text{ mm}$
- Injected flow rates:
 $\sim 0.05 \text{ m}^3$
- Volume of plasma chamber:
 $\sim 0.5 \text{ m}^3$

Injected flow rates in ITER under multiple-pipe break conditions:
around 1/10 of volume of the plasma chamber

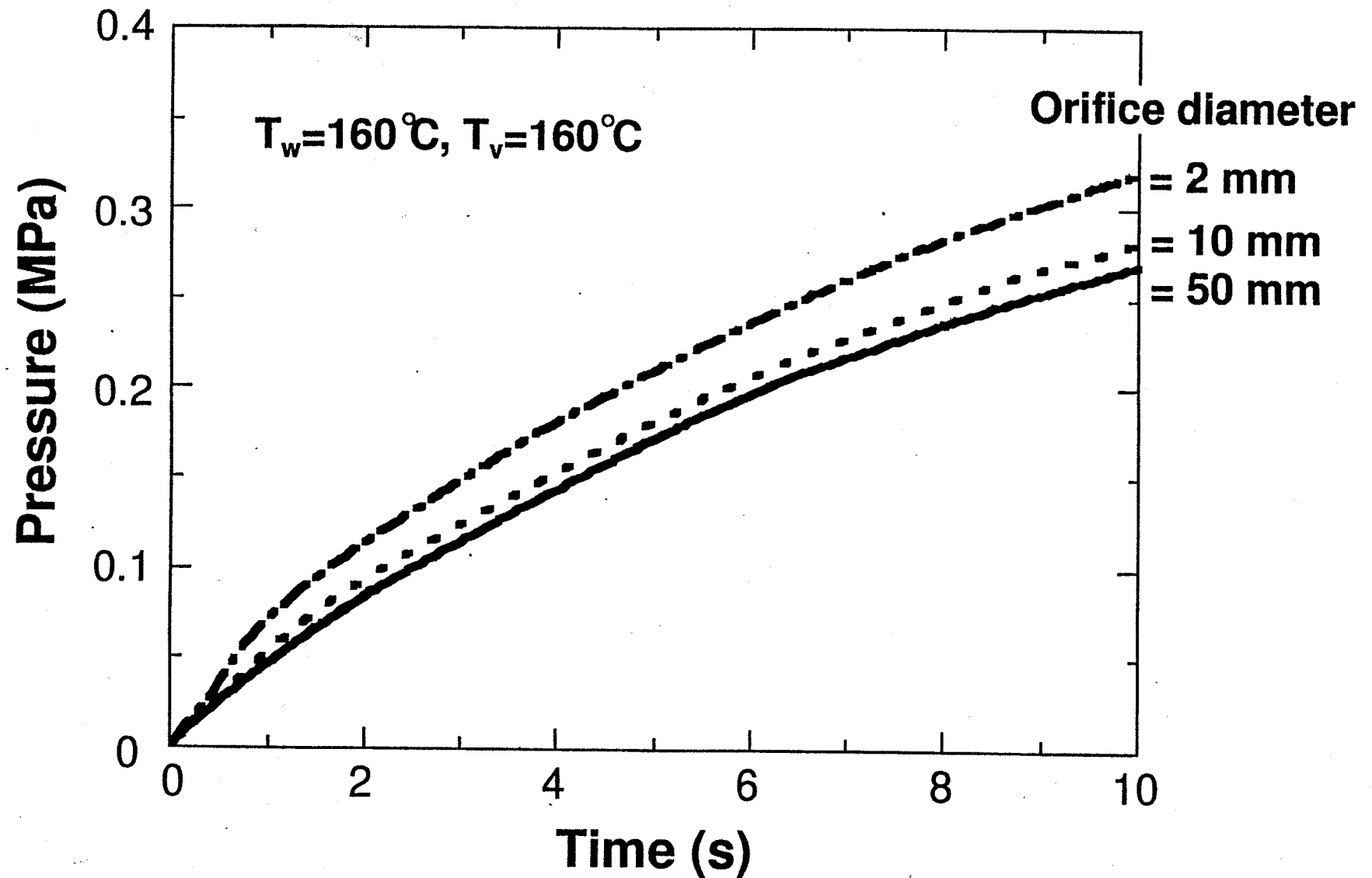
Outline of Test Facility



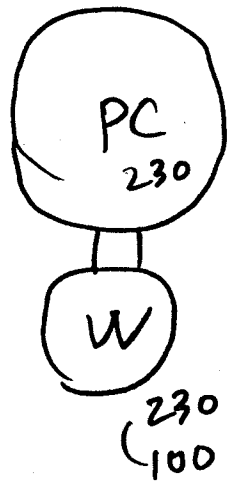
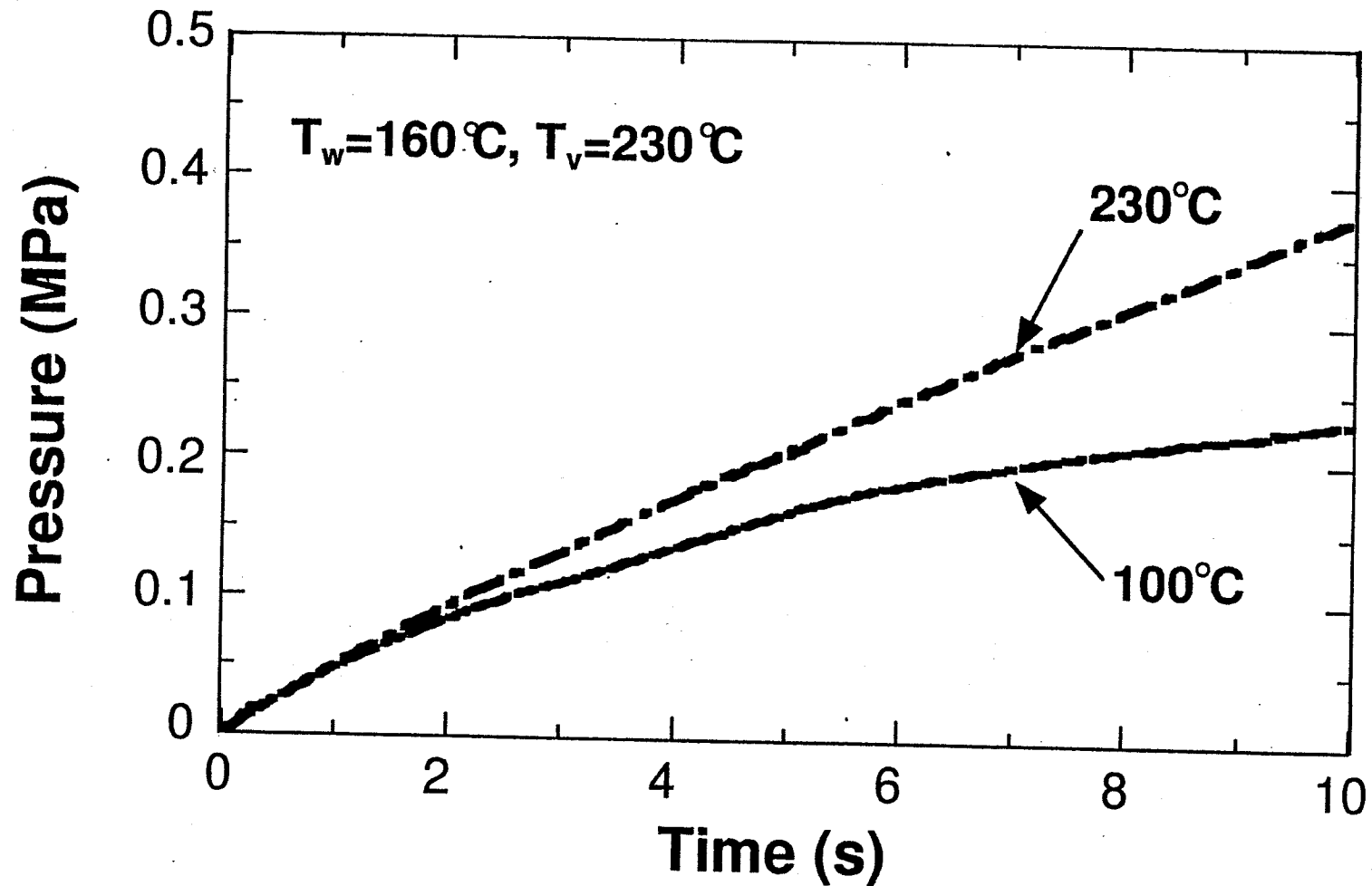
Effect of injected flow rates on pressure rise



Effect of orifice size on pressure rise



Effect of VV temperature on pressure rise



Summary

- Construction of a new thermofluid test facility will be completed by the end of 1999.
- Experimental parameters will be set based on ITER-RCO (Reduced Cost Option).
- Integral performance of fusion safety systems will be tested under ICE conditions.
- Test data will be used for validation of fusion safety analysis codes.