High Heat Flux He-cooled PFCs

A brief summary of work by Sandia, Thermacore and GA

presented by Richard Nygren

contributors

HHF testing: Dennis Youchison (Sandia)

Design/fab: John Rosenfeld & Mark North (Thermacore)

GA: Clement Wong, Chandu Baxi, DIII-D staff

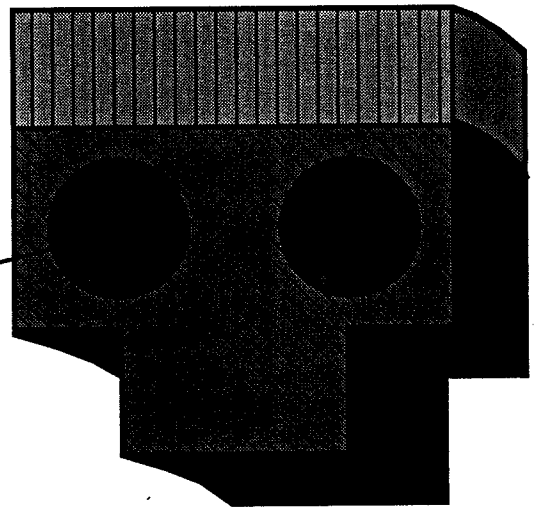
(also ORNL R&D on Faraday shield development)

APEX Meeting, UCLA May 1998

Sandia National Laboratories

US T222 mockup redesign

- dual coolant channel
  lower cost
- helical wire insert
  equal or improved CHF



gun drilling single unit eliminated

- detailed machining of fins
- fine tolerance "race track" e-b weld (top to bottom of HV)

development of W brush armor technology enabled

- joining of continuous or block form of W brush
- self HIP can and easy alignment of armor

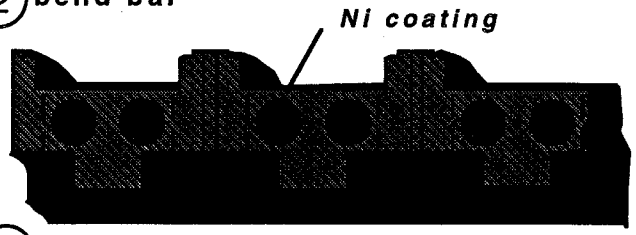
Sandia National Laboratories

fabrication sequence

CURVED CHANNELS

1 gun-drill bar, braze spiral wire

2 bend bar



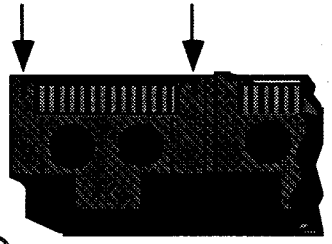
3 machine, Ni coat bottom of trough

HOLD FOR INSPECTION: DIMENSONS, ARMOR FIT

ARMOR

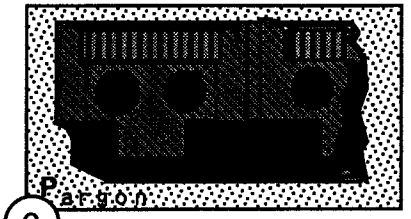
4 machine can lids

pack/embed W rods



5 HIP can EB weld

HOLD FOR INSPECTION:
VACUUM LEAK CHECK



6 HIP

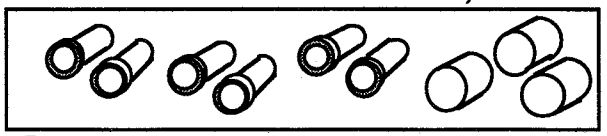
HOLD FOR INSPECTION:
BOND QUALITY, DIMENSIONS

Sandia National Laboratories

US T222 Medium Scale Mockup

fabrication sequence continued

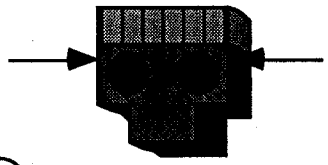
INLET/OUTLET PIPES, PLUGS



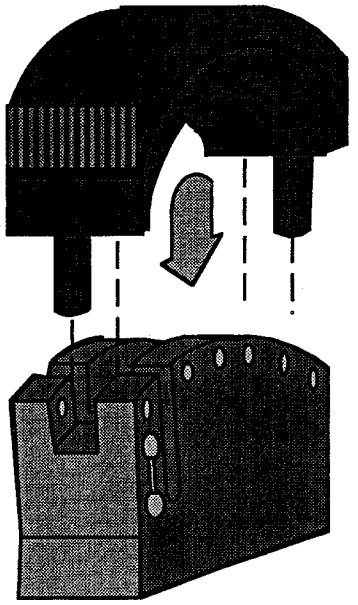
(8) **trim pipe stubs (supplied)**

(9) **weld plugs & pipes**

HOLD FOR INSPECTION:
WELD QUALITY



(10) **machine sides**



(11) **MACHINE BACKING PLATE**

(12) **FIT WITH BACKING PLATE AND DRILL PIN HOLES**

HOLD FOR INSPECTION:
DIMENSONS, CHANNEL FIT

Sandia National Laboratories

US T222 Medium Scale Mockup

Testing issues

- We need HHF tests with areas >50cm^2 to assess realistic capabilities
- Future tests should assess reaction to hot spots and any flow instabilities

Conclusions

- He-cooled HXs have adequate heat handling for FW applications and maybe for divertors.
- Planned expansion of Sandia's He flow loop will make larger area HHF tests possible.

Sandia National Laboratories

Sandia Tests of He-cooled PFCs

1993 SNL tested several He-cooled PFCs

1. Creare, Inc. micro (~100 μm) channel HX
2. GA divertor mockup (0.46 mm channels)
3. Thermacore porous metal HX
   (40% porosity, 0.43 mm dia.)

1994 SNL tests

4. Thermacore dual channel porous metal HX
5. Retest of GA mockup, higher heat loads

1996 SNL tests

6. Creare Phase-II porous metal HX
7. GA vanadium HX

1997 SNL tests

8a. Thermacore Faraday shield

8b. Thermacore Divertor mockup

1998 SNL tests

8a. Thermacore 2nd Faraday shield

8b. Thermacore 2nd Divertor mockup

11 modules tested

order of magnitude improvement in heat load (~35MW/m2)

Sandia National Laboratories

PMTF possesses a closed Helium flow loop.

•Operating Pressure:	0-4.1 MPa (600 psi)
•Maximum Allowable Pressure:	4.8 MPa (700 psi)
•Helium Temperature:	20 ˚C (230 ˚C)
•Helium mass flow rate:	0-22 g/s @ 4.0 MPa*
•pressure drop:	0-7.5 psi @ 4.0 MPa*

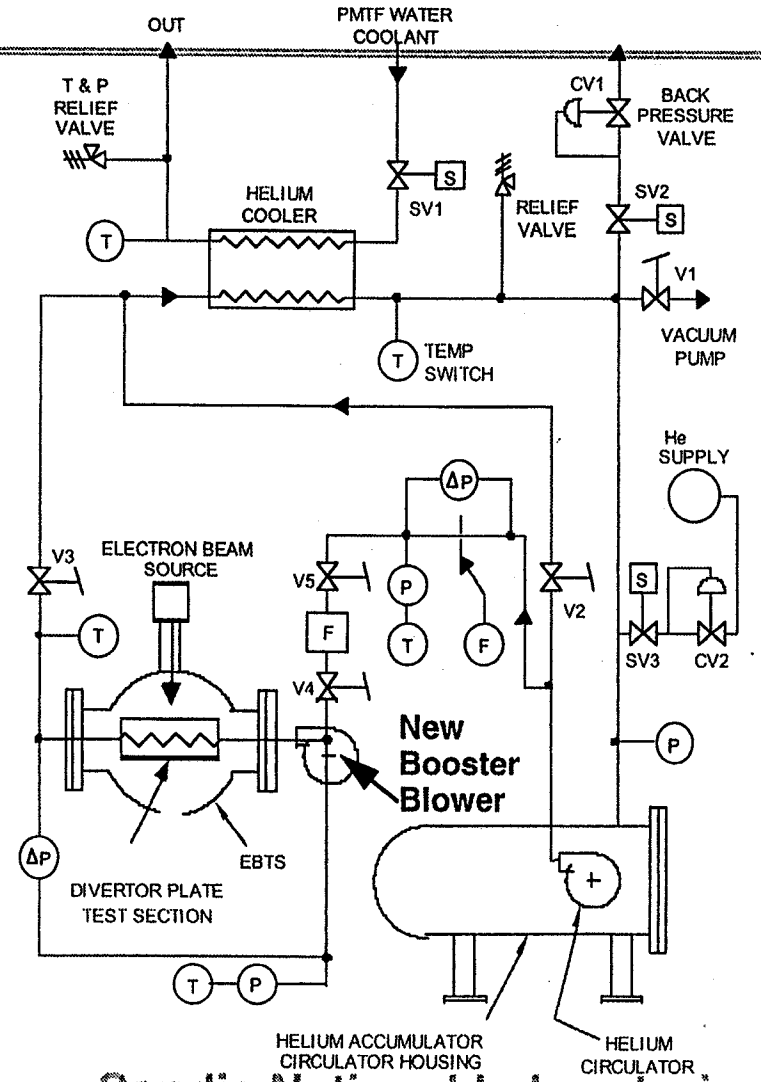
*Present blower: 22 g/s, DP=52 kPa @ 4.0 MPa

Blower upgrade: 35 g/s, DP=100 kPa @ 4.0 MPa

Booster blower with new 14000 rpm motor and controller will be installed 10/97, $5k.

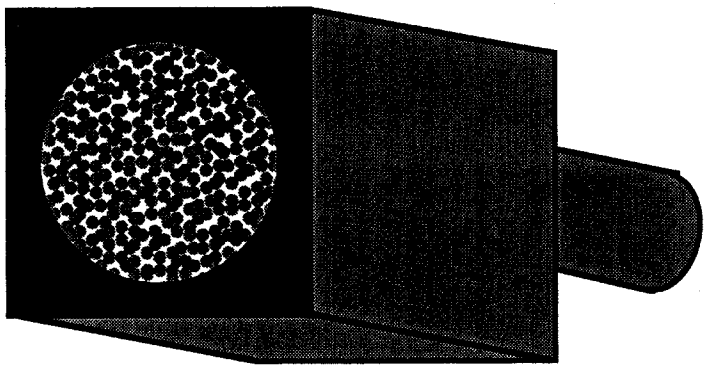
5932.110-09/17/97
dly:DOE-ProgRev'97

Closed Helium Flow Loop

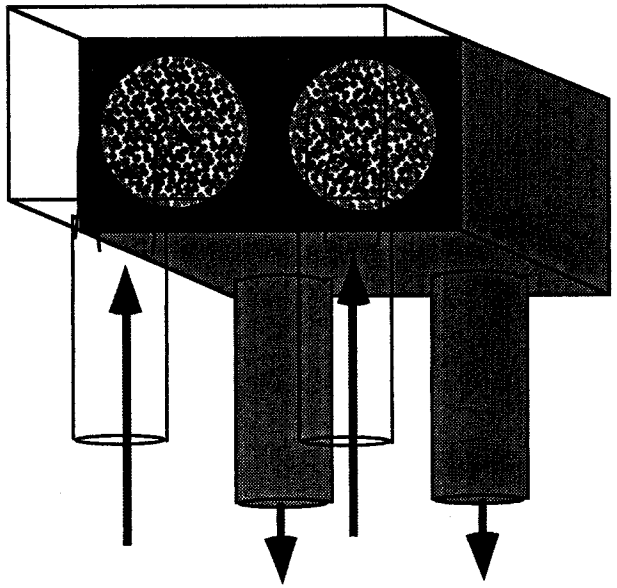


5932.110-09/17/97
dly:DOE-ProgRev'97

Thermacore concepts
1993-94 test results



1993 SNL tests
40% porosity in porous core
16MW/m^2(1cm^2), 1 g/s He, 4.0 MPa
h=3000-5000 W/m^2-K [J. Rosenfeld]
high pressure drop (45-65 MPa)

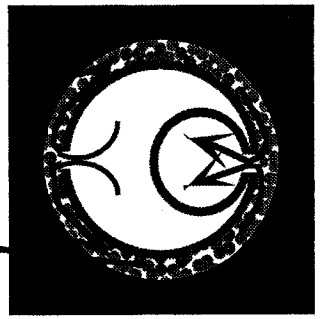


1994 SNL tests
flow in one channel
14MW/m^2(1cm^2), 8 g/s He, 4.0 MPa
h=~20,000 W/m^2-K [J. Rosenfeld]
pressure drop ~60 MPa

Sandia National Laboratories

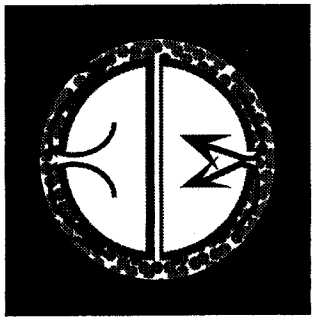
"Thermacore designs"

DIII-D RF Faraday shield ('97) with porous medium 2.54cm channel with 0.32 cm thick annulus filled wtih 0.1cm metal particles



tube-in-tube

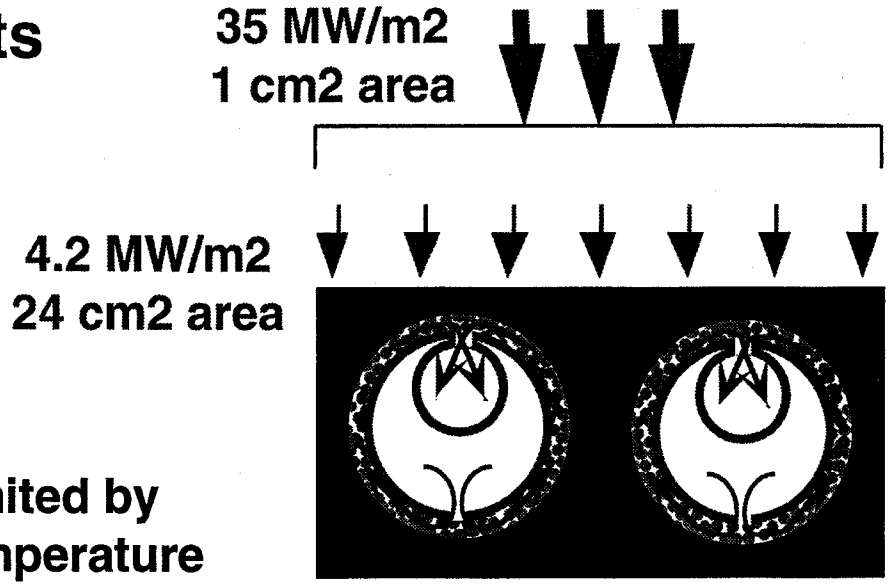
John Rosenfeld and Mark North, Thermacore, Inc., Lancaster Pa, developed this porous channel concept with SBIR funding and collaborations with GA, ORNL and Sandia.



D-tube

Sandia National Laboratories

Divertor concept March 1997 tests

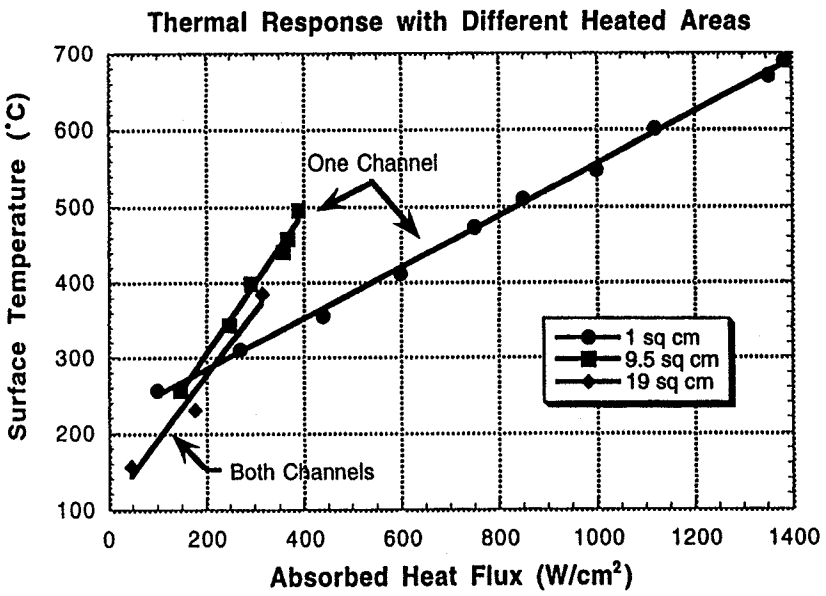


- Tests are typically limited by maximum surface temperature approaching 700C.
- He flow and beam power also limit available test conditions.

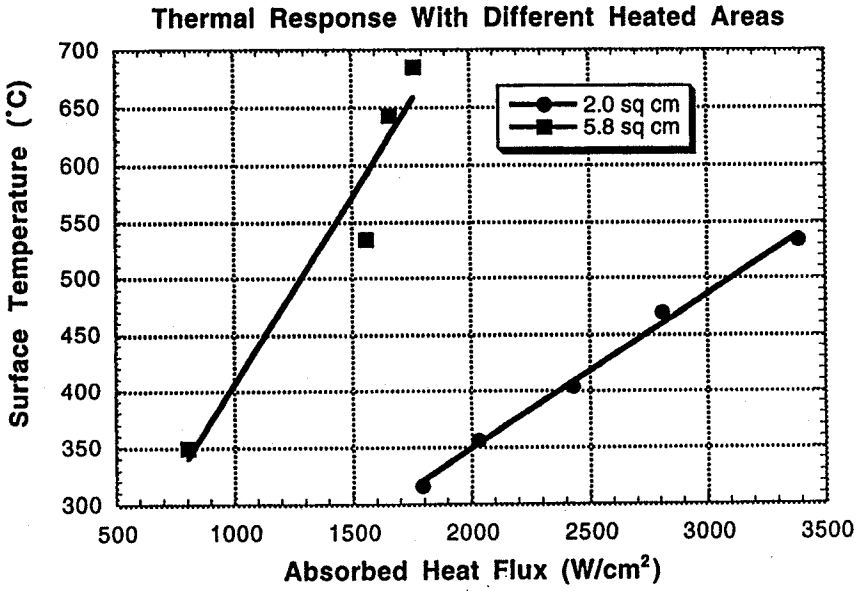
Sandia National Laboratories

Attainable heat fluxes with helium also dependent on heated area.

Thermacore phase II



GA Helium Module test 2

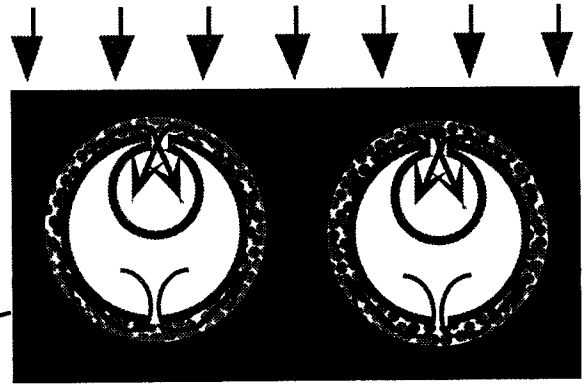


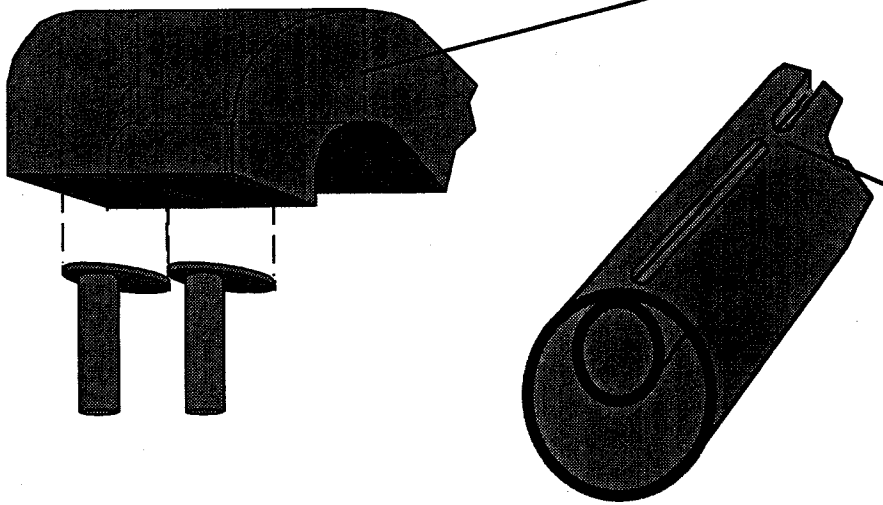
Sandia National Laboratories

5932.110
05/95 dly:DOEprogrev

Thermacore divertor concept

- Dual 1 cm channels for ITER divertor design
- formable: DIII-D Faraday shields had 90° bends in a single channel





- Flow from bottom to top reduces pressure drop.
- Slots with ligaments maintain tube shape.

Sandia National Laboratories