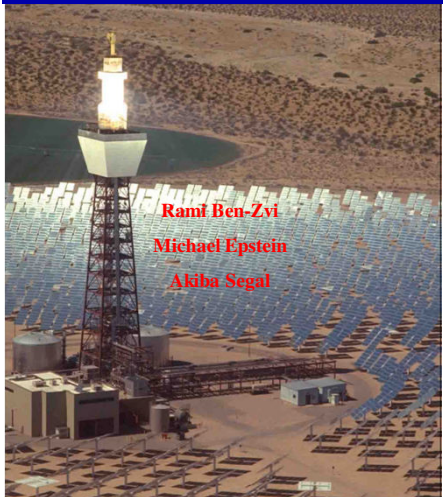
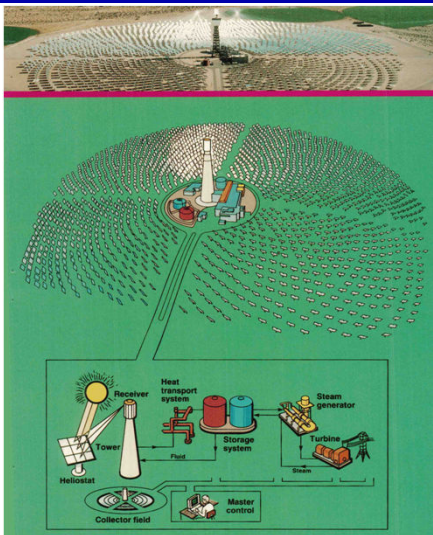


### Simulation of an Integrated Solar Steam Generator

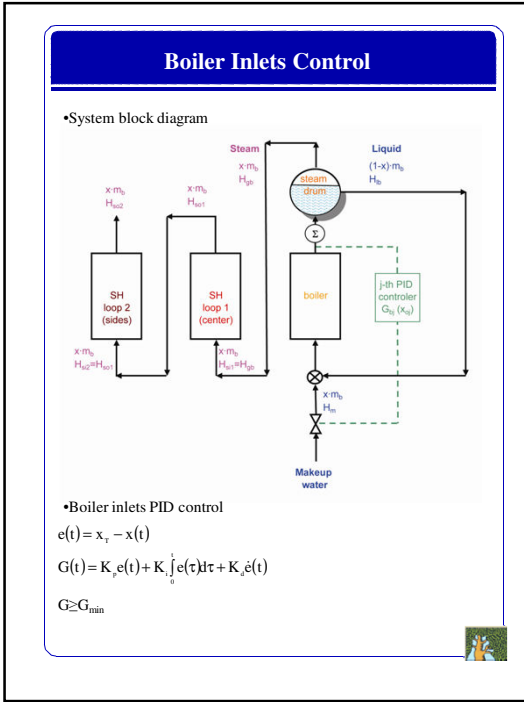
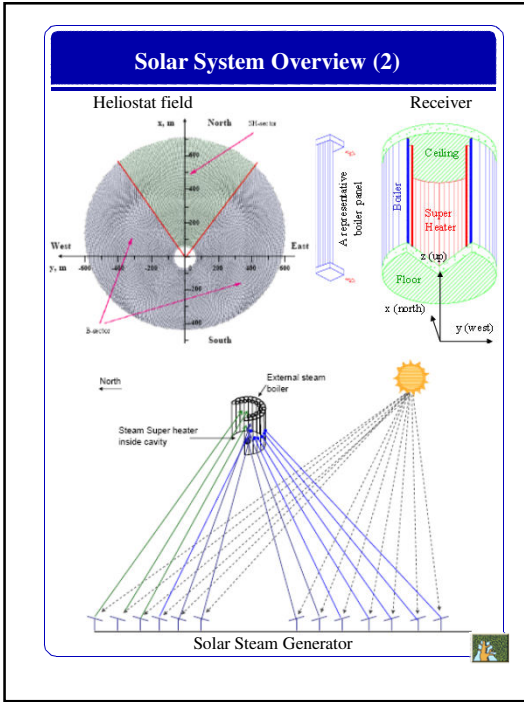


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### Solar System Overview (1)



Barstow Solar-II



### Properties

**Boiler:** SA-192 (carbon steel)

$\sigma_{\text{ensile}}$  = 325 MPa  
 $\sigma_{\text{yield}}$  = 180 MPa  
 $T_{\text{allowable}}$  = 510C = 783K

**SH:** SA-213TP304H (18Cr-8Ni)

$\sigma_{\text{ensile}}$  = 517 MPa  
 $\sigma_{\text{yield}}$  = 206 MPa  
 $T_{\text{allowable}}$  = 760C = 1033K

•The pipes are coated with a high-temperature black coating (Pyromark,  $\epsilon = 0.95$ )

**Insulation:** Kaowool / DuraBlanket / DuraBoard (ceramic)

Typical values used:  
 $k = 0.1 \text{ W/m-K}$   
 $\epsilon = 0.2$

**Steam:** Wagner's IAPWS-95 package

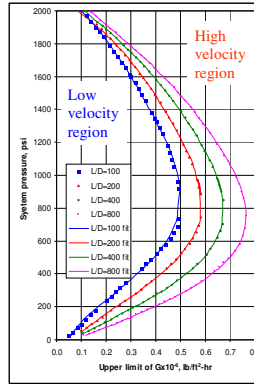
### Critical Heat Flux (CHF) (1)

L.A. Payan-Rodriguez *et al.*, *International Journal of Thermal Sciences* **44** (2005) 179–188.

Water flow boiling patterns.
Sublayer dryout model

## Critical Heat Flux (CHF) (2)

B. Thompson and R.V. Macbeth, Boiling water heat transfer burnout in round tubes: a compilation of world data with accurate correlations. *AEW-R356* (1964).



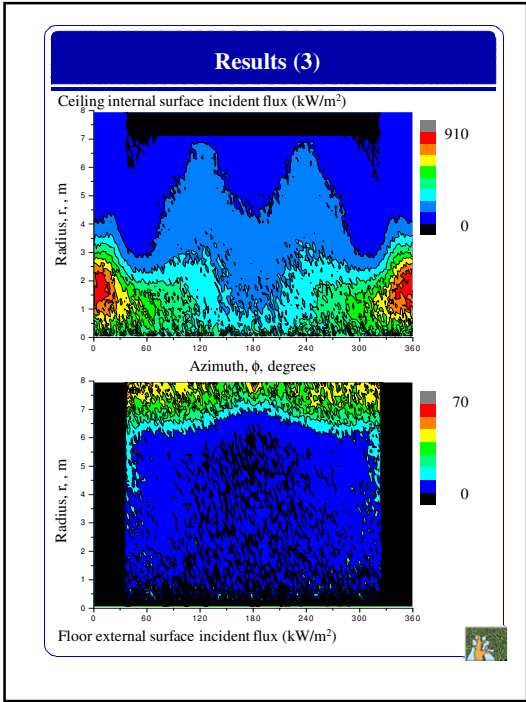
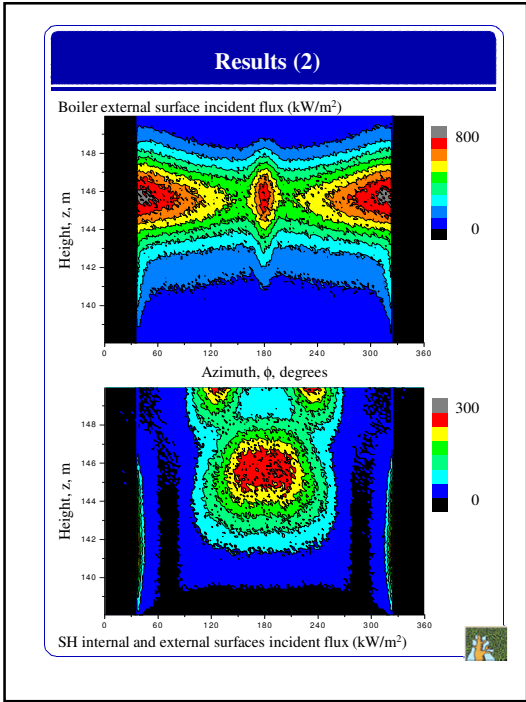
In our case:  $P=15\text{MPa}=2176\text{psi}$   
 $G=500\text{--}1100\text{ kg/m}^2\text{-s}\sim 0.3\text{--}0.8\text{ lb/ft}^2\text{-hr}$   
 $L/D=12/0.025=480$

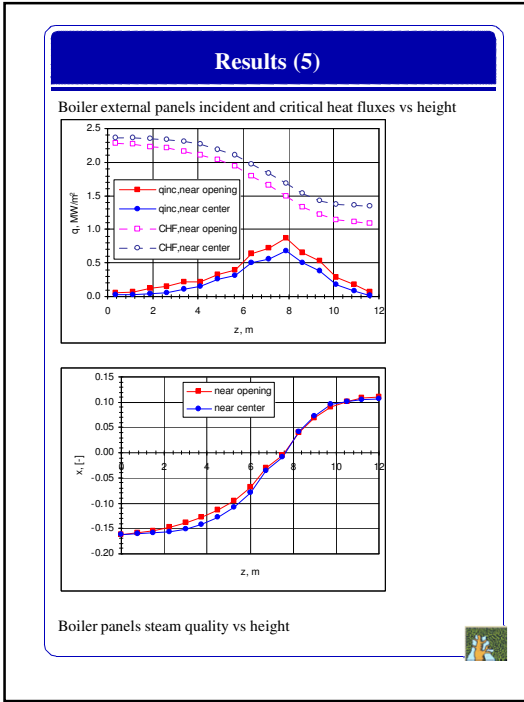
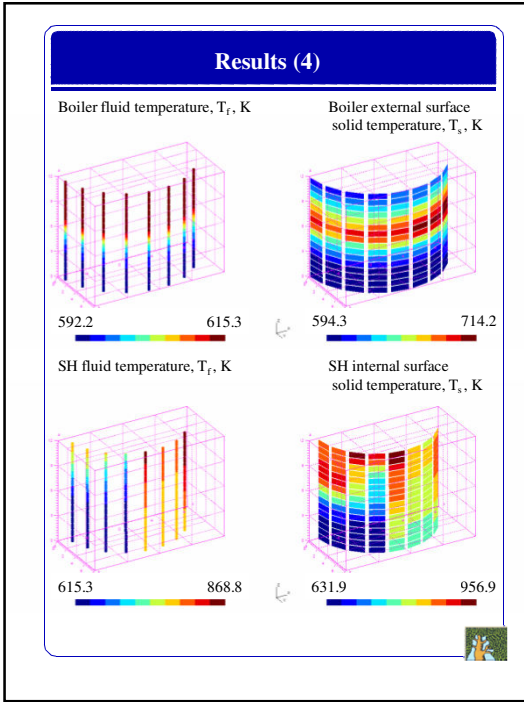


## Results (1)

<b>Geometry:</b>	Receiver height	12m
	Boiler diameter	16m
	SH diameter	14m
	Opening angle (both)	72°
	Pipes diam. (both)	3/4" schedule 80 (OD=26.7mm, ID=18.7mm)
	No. of pipes	1506 boiler 1318 SH
<b>Optics:</b>	Date, time	Equinox, 12:00
	Insolation	850W/m <sup>2</sup>
	Heliostat dimensions	4m x 4m
	Heliostat reflectivity	0.9
	No. of heliostats	3,652 for the SH 14,340 for the boiler
	Tower height	138m
	Total incident power	172.8MW
<b>Other data:</b>	Pressure	15MPa
	Wind speed	0m/s
	Boiler steam quality	10%
<b>Integral results:</b>	Total flow rate	441.6kg/s
	Total effective power	144.2MW
	Efficiency	83.5%
	Receiver head loss	12.8kPa
	Major losses	
	•Boiler external radiation	10.4MW
	•Cavity re-radiation	5.9MW
	•Boiler external convection	2.1MW
	•SH internal convection	2.1MW

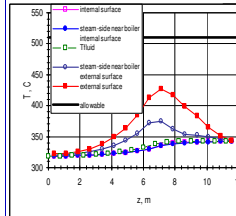




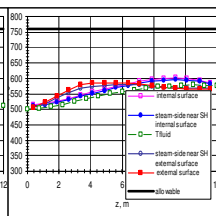
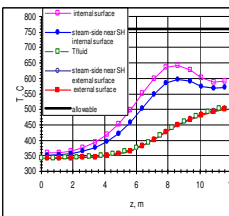
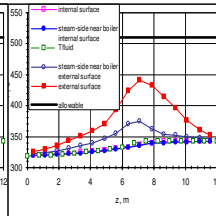


## Results (6)

Boiler temperatures  
near center vs height



Boiler temperatures  
near opening vs height



SH temperatures near  
center vs height

SH temperatures near  
opening vs height

