

TASK CLOSE OUT DOCUMENT

Task Scope CHEEN SHRINKAGE CALCULATIONS
FOR INPUT TO EMERGENCY
PROCEDURE 32

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Task No. 40

Date Complete 5/2/79

Reason felt task is complete:

Calculations complete and pressurizer water
levels recommended.

Members of Committee

WOOD STANIS

Wood Stan
Signed
Committee Leader

REVIEW OF SHRINKAGE CALCULATIONS

Fred Sears who is revising Emergency Procedure 32 requested that I recheck the shrinkage calculations for a sudden cooling of the primary system from near saturation conditions. The calculations are attached.

The conclusion is that if the system heats to near saturation conditions water level can be prevented from dropping below the heater even if the total system final temperature is 100°F -- which is extremely conservative.

<u>Pressure of Primary System</u>	<u>Saturation Temp</u>	<u>Specific Volume</u>	<u>Shrinkage</u>	<u>Heater Level</u>	<u>Minimum Initial Water Level</u>
1000 psi	532°F	0.0223	~ 325"	72"	400"
500 psi	467°F	0.01975	~ 250"	72"	325"
	100°F	0.01613		-	

Review of Shrinkage Calculations P.1

I. Assume core heated to 532°F when pumps turned on

$$\text{Mass} = K = \frac{V_1}{N_1} = \frac{V_2}{N_2}$$

(1) = 532°F initial core temp.
 (2) = 230°F final system temp.

$$V_2 = \frac{N_2}{N_1} V_1$$

$$V_2 = 4000 \text{ ft}^3 \text{ of core}$$

$$N_1 = .02123 \quad N_2 = .016849$$

$$V_2 = \frac{.016849}{.02123} (4000)$$

$$V_2 = 3174$$

7.48 ~~ft~~ ³

$$V_1 - V_2 = 826 \text{ ft shrinkage (7.48)} = 6178 \text{ gal}$$

Pressurizer volume
 is 24 gal/in.

~~6178 gal~~
$$\frac{6178 \text{ gal}}{24 \text{ gal/in}} = 260'' \text{ shrinkage}$$

~~The assumed final primary system temperature~~

2004 324

~~is 230°F a reasonable final temperature:~~

II. Assume final primary system temperature is 100°F

$$N_{100} = .016130$$

$$V_2 = \frac{.016130}{.02123} (4000) = 3039$$

$$\Delta V = 964 \text{ ft}^3 \text{ 3324}$$

$$\frac{96 \text{ ft}^3 \times 7.48 \text{ gal/ft}^3}{24 \text{ gal/in}} = 300'' \text{ shrinkage}$$

III: Assume Vessel volume @ 532°F

	Initial Temp	Final Temp	Volume
OTS6 Primary side @	532°F	100	4010 ≈ 4000
Cold leg @	125°F		4034
Hot leg @	125°F		950 ft ³
	250°F		938 ft ³ ≈ 1000

Ignore pressurizer volume

$$\text{Vessel Volume Shrinkage} = 96 \text{ ft}^3 \approx 300'' \text{ shrinkage}$$

$$\text{Cold leg } \Delta V = 5000 \left(1 - \frac{.016130}{.016225} \right) = 30 \text{ ft}^3$$

$$\Delta h = \frac{\Delta V \times 7.48}{24} = \frac{30 \times 7.48}{24} = 9''$$

$$\text{Hot leg } \Delta V = 1000 \left(1 - \frac{.01613}{.017006} \right) = 52 \text{ ft}^3$$

~~Total Shrinkage = 360''~~

$$\Delta h = \frac{52}{24} \times 7.48 = 16''$$

7.48 gal/ft³
24 gal/in of pressure height

$$\text{TOTAL SHRINKAGE} = 325''$$

for final temp. 100°F

IV. Assume final temp is 125°F

	Initial Temp	Final Temp	Vol
Vessel	532	125°F	4000
Cold leg + 0.5% Brines side	150	↓	5000
Hot leg	250		1000

Vessel ~~4000~~

$$\Delta h = V_1 \left(1 - \frac{V_2}{V_1}\right) \left(\frac{7.48}{2.4}\right) = .31 V_1 \left(1 - \frac{V_2}{V_1}\right)$$

$$\Delta h = 4000 (.31) \left(1 - \frac{.016225}{.02123}\right) = \textcircled{292''}$$

$$\text{Cold leg } \Delta h = 5000 \left(1 - \frac{.016225}{.016773}\right) .31 = \textcircled{11''}$$

$$\text{Hot leg } \Delta h = 1000 \left(1 - \frac{.016225}{.017006}\right) .31 = \textcircled{14''}$$

Total Shrinkage² $\textcircled{317''}$
for final temp 125°F

V. Dropping pressure from 9000 to 500 psi will change the saturation temperature and specific volume from 2004 326 532°F & .02123 ft³/lb_m to 467°F and 0.01975. This

will reduce the shrinkage by about 24% to $\approx \underline{\underline{250''}}$

$$\left(1 - \frac{.01623}{.02123}\right) = .240 \quad \left(1 - \frac{.01623}{.01975}\right) = .173$$

At 500 psig even if the vessel inventory is raised to saturation (assuming cold leg temp = 125°F and hot leg at 250°F) the total shrinkage is about 250" (except pressure) . Even if all primary inventory is cooled to 100°F the heaters will not uncover if water level is ~~not~~ maintained at 350" or greater. The heaters are at about 70". The shrinkage from 350" would be to 100".

Conclusion: Prior to restarting recirc pumps, jogging pumps or reinitiating natural circulation assume that water level is greater than 350".