

Enclosure 7

Reactor Experiments, Inc., Sunnyvale, CA, Catalog No. 277 Shielding  
Bulletin S-73N, August 1991.  
(1 paper copy)



## CATALOG NO. 277 SHIELDING

**Heat Resistant • Borated • Hydrogenated**

Catalog No. 277 is available as a castable dry mix or as pre-cast blocks.

### TECHNICAL DATA (PROPERTIES)

Hydrogen:  $3.4 \times 10^{22}$  atoms/cc

Boron:  $1.43 \times 10^{21}$  atoms/cc

Weight Percent Boron: 1.56%

Macroscopic Thermal Neutron Cross Section,  $\Sigma = 1.1 \text{ cm}^{-1}$

Density: 1.68 g/cc (105 lbs/cu ft)

Recommended Temperature Limit: 350°F (177°C)

Machinability: Fair, can be sawcut and drilled.

Thermal Conductivity,  $k = 0.3 \text{ BTU-ft/(hr)(ft)}^2(\text{°F})$   
 $= 1.24 \times 10^{-3} \text{ cal-cm/(sec)(cm)}^2(\text{°C})$

Specific Heat = 0.22 cal/g °C

Coefficient of Thermal Expansion =  $8 \times 10^{-6}$  inches per inch per °F  
 $= 1.4 \times 10^{-5}$  cm per cm per °C

Compressive Strength = Approximately 1000 psi

Tensile Strength = Approximately 100 psi

Radiation Resistance, gammas:  $1 \times 10^{11}$  Rads

Radiation Resistance, neutrons:  $5 \times 10^{19}$  n/cm<sup>2</sup>

### TYPICAL ELEMENTAL ANALYSIS

<u>Element</u>	<u>Weight Percent</u>
Oxygen	58.65%
Aluminum	23.91
Calcium	8.83
Hydrogen	3.37
Silicon	2.13
Boron	1.56
Sodium	0.59
Magnesium	0.50
Iron	0.27
Sulfur	0.19

Recommended shelf life for Catalog No. 277 under dry-storage conditions is 6 months.

## THERMAL TESTS AND CHARACTERISTICS

### 1) Effect of Excessive Temperature

A 2" (51mm) cube of Catalog No. 277 was held at 1900°F (1040°C) for two hours. At the end of this period it had maintained its physical integrity. It still retained a compressive strength of 300 psi, reduced from the original of 1000 psi.

### 2) Hydrogen Content as a Function of Temperature

Figure 1 shows the percent of hydrogen remaining in Catalog No. 277 after continuous heating at successively higher temperatures. The material was held at each temperature until it reached constant weight--this generally required 24 to 48 hours. The results show that 82% of the hydrogen remained up to 300°F (150°C). Above this temperature, the hydrogen content dropped from 82% to 15% at 550°F (290°C). At this point, the percentage of hydrogen again leveled off until 650°F (345°C) was reached. From here to 1000°F (540°C), the hydrogen level gradually dropped from 14% to zero.

It is interesting to note that because of its high initial hydrogen content, Catalog No. 277 will contain as much hydrogen at a temperature of 460°F (238°C) as normal concrete does at room temperature.

### 3) Extended Heating in Air at 310°F (155°C)

To test the effect of extended heating periods, Catalog No. 277 was heated in air at a temperature of 310°F (155°C) for a period of 32 days. Figure 2 shows that the hydrogen content dropped to about 80% of the original content within 5 days. After an additional 15 days, it had lost only an additional 2%, at which point it leveled off.

After the heating test was completed, the samples were left in air at room temperature to see whether they would re-absorb any moisture. They started to gain weight immediately and regained 3.5% within 13 days. The material continued to slowly gain additional weight after this period.

### 4) Simulation of Loss of Coolant Accident (LOCA)

In the event of a LOCA, it is presumed that the material could be submerged in a high concentration boric acid solution. It is also assumed that the solution could be pressurized as high as 67 psia which would permit a maximum temperature of 300°F (150°C) for a period as long as 30 days. This situation was therefore simulated by placing Catalog No. 277 samples in water containing 2500 ppm of boron as boric acid adjusted to a pH of 10. This solution was contained in test "bombs" and heated to 300°F (150°C) which would produce 67 psia for a period of 30 days. At the end of 30 days, the blocks showed slight surface pitting. There were no hairline cracks or other indications of damage. The compressive strength of the blocks was still 70% of that before the test.

### 5) Effects of Submersion in Water

Samples of Catalog No. 277 were submerged in 70°F (21°C) water for 7-1/2 months and in boiling water for 7 hours. There were no significant effects on the blocks in either case.

FIGURE 1. PERCENT HYDROGEN REMAINING AS A FUNCTION OF TEMPERATURE FOR CATALOG NO. 277 SHIELDING

Note: Samples were held at each temperature until constant weight was obtained. Typically, this ranged from 24 to 48 hours.

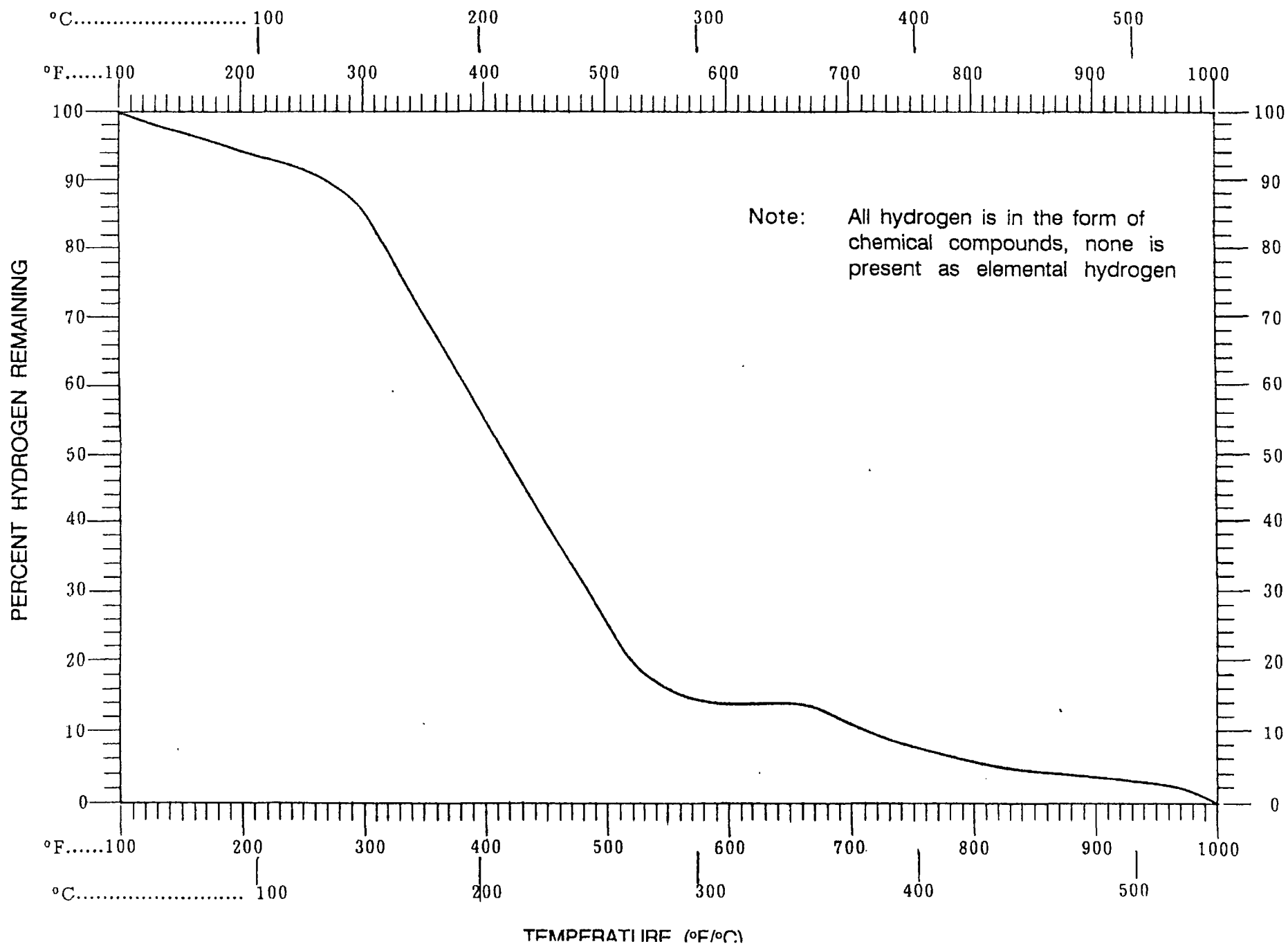


FIGURE 2: PERCENT HYDROGEN REMAINING VS. TIME AT TEMPERATURE FOR CATALOG NO. 277 SHIELDING

Heating test 310°F (154°C) for 32 days  
followed by air exposure for 77 days

