

The Hot Topic of Carabiners

Temperature
Soak Time
Water Quench
Air Cool

Professional Heat Treaters use these words when talking about thermal treatment of aluminum.

Professional Firefighters use similar terms when they talk about their work.

Are Professional Firefighters also amateur Heat Treaters?

Should you hang your life on a carabiner that has been heat treated by an amateur?

About the Presenter

Garin Wallace is SMC's Director of Manufacturing. During his 18 years with SMC he has been involved with all aspects of manufacturing including product design, improvements and testing. In addition to his on the job education, he has studied computer science and mathematics at Central Washington University.

Presentation Summary ITRS 2003

For discussion purpose only

Carabiners the Hot Topic

Exploring effect of normal heat exposure on aluminum Carabiners.

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Practical Application

Whatcom County Fire
Department

Training Exercise May 2003

Inside safety wore the same 2 carabiners for each of 5 live burns.

Each member of attack teams wore 1 carabiner on their SCBA strap

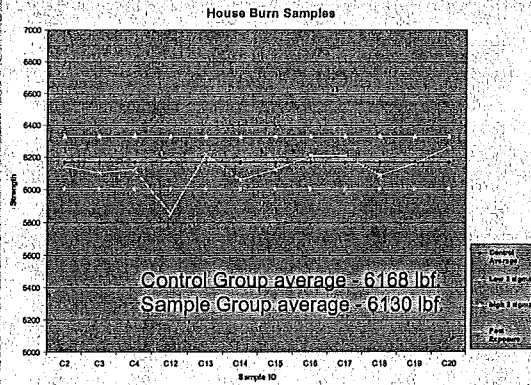
Thermocouples
In burn room

1' from floor
2' from ceiling

Fluke meter
Fuel was pallets

Burn #	Exposure time	Lower Sensor		Upper Sensor	
		Min	Max	Min	Max
1	12.0	128	160	300	1130
2	12.0	160	354	600	1100
3	10.5	350	1000	1100	1700
4	11.0	100	140	400	758
5	12.0	104	154	722	1358

Practical Application



Practical Application

Observations

Carabiners were removed about 15-30 seconds after leaving building. None were more than warm to touch.

Sample C12 (5850 lbf.) was of interest. It was part of burn 3 which got too hot for attack team to stay in room. However, samples C13 (6218 lbf.) & C14 (6060 lbf.) were also in burn 3.

Sample C3 (6106 lbf.) was on back of inside safety's helmet for all 5 burns. Front of his helmet was lightly singed.

Semi-lab Test

Locking D carabiners heated in our small oven.

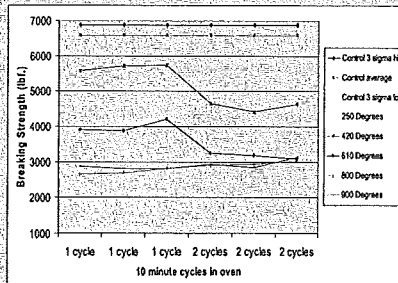
Either a single 10 minute cycle or two 10 minute cycles with about 1 minute cooling in between.

Chose the following range 250 °F to 900 °F

Static pull tests were done when parts were cool enough to safely be loaded in tester.

Semi-lab Test

	Control 3 sigma high	Control average	Control 3 sigma low	250 Degrees	420 Degrees	610 Degrees	800 Degrees	900 Degrees
1 cycle	6882	6576	6269	6630	5574	3903	2659	2868
1 cycle	6882	6576	6269	5850	5710	3872	2689	2806
1 cycle	6882	6576	6269	5753	5730	4202	2812	2805
2 cycles	6882	6576	6269	6924	4648	3241	2898	2932
2 cycles	6882	6576	6269	5864	4420	3180	2928	2842
2 cycles	6882	6576	6269	5643	4639	3084	3024	3139



Drawing conclusions?

"Normal" heat exposure may be a problem for aluminum gear.

Aluminum carabiners inside turnout gear **should** be OK

Aluminum carabiners outside turnout gear **might** be OK

Don't use aluminum carabiners that have been directly exposed to the heat of a fire.

Consider the virtues of lightweight steel products

Never use gear without knowing its history

Amateur Metallurgy Part 1

Aluminum is used widely throughout the rescue industry because it is light and can be made very strong.

Ladders
Carabiners
Pulleys
Tripods
Descenders
etc...

Amateur Metallurgy Part 2

Aluminum is designated by a four digit number based on their major alloying elements.

Type	Elements	Examples
1xxx	- 99% or greater aluminum	1050, 1145
2xxx	- Copper	2011, 2024
3xxx	- Manganese	3004, 3105
4xxx	- Silicon	4032, 4343
5xxx	- Magnesium	5052, 5456
6xxx	- Magnesium & Silicon	6061, 6262
7xxx	- Zinc	7005, 7075

Amateur Metallurgy Part 3

Aluminum can also be grouped into 2 major categories:

Heat Treatable

Can be thermally treated to soften (workable)
also thermally treated to harden (stronger)

Non-Heat Treatable

Can be thermally treated to soften
but only work hardened to make stronger

Amateur Metallurgy Part 4

Thermal Treatments 7075 Aluminum

Heat Treat

Heat to 915 °F
Quench in <100 °F water
Artificial Age 250 °F for 24 hours

Full Anneal

Heat to 775 °F
Air cool to 400 °F hold at 400 °F for 4 hours

Partially remove effects of Heat Treatment

Heat to 650 °F
Air cool at uncontrolled Rate

per Aluminum Association Standards

Amateur Metallurgy Part 5

Relative tensile strength of 7075-T6 at various temperatures

-18 °F	104%
73 °F	100%
212 °F	84%
300 °F	37%
400 °F	19%
500 °F	13%
600 °F	10%
700 °F	7%

per Aluminum Association Standards