


High Cycle Fatigue Testing

Presented By

Garin Wallace


ITRS 2009



"...we were born to die."

Romeo and Juliet - Act 3, Scene 4 by William Shakespeare

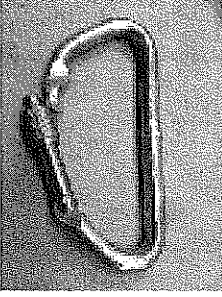

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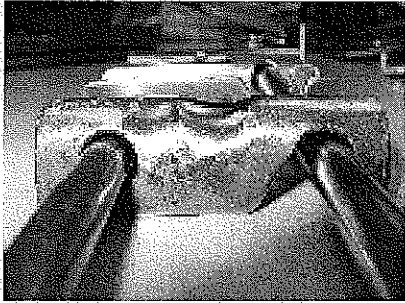
**Use your gear
and
it will die.**

But when?

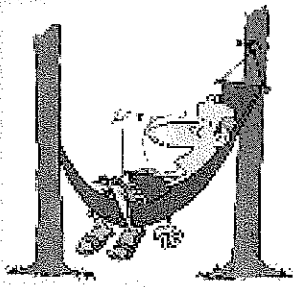
Dead or
Alive?



Dead or
Alive?



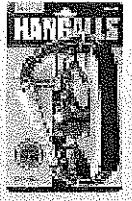

Dead or
Alive?



Dead or
Alive?



Dead or Alive?



What do you think the horse in the picture is? Is it a horse or a person? Write your answer in the space below.

52 JUNE 2008

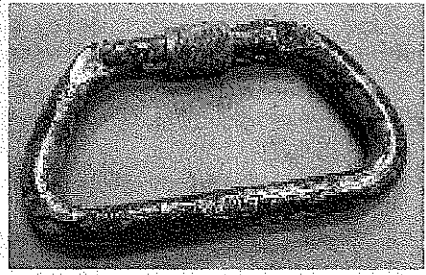

NAME: _____

CLASS: _____



DATE: _____

TEACHER: _____

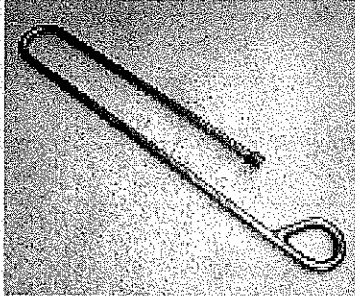
Dead or Alive?



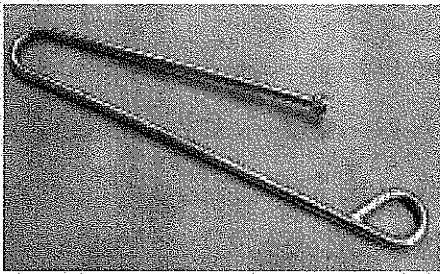
Dead or Alive?



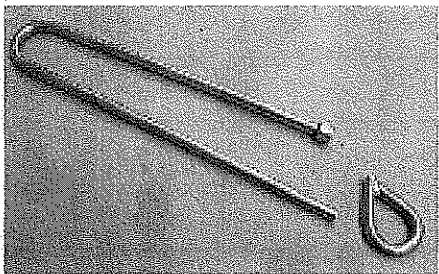
Dead or Alive?




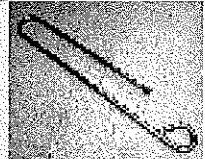
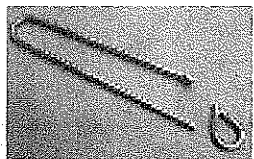
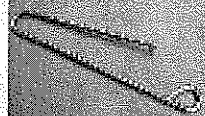
Dead or Alive?



Dead or Alive?




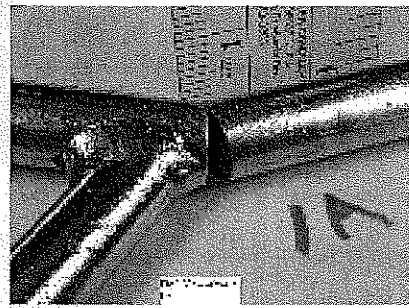
Dead or Alive?


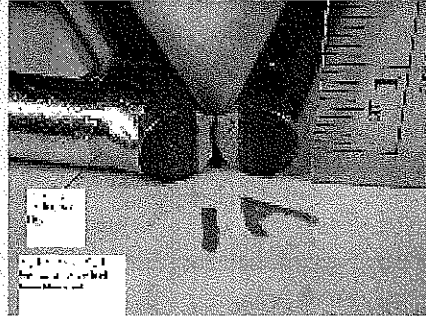
All from same cache

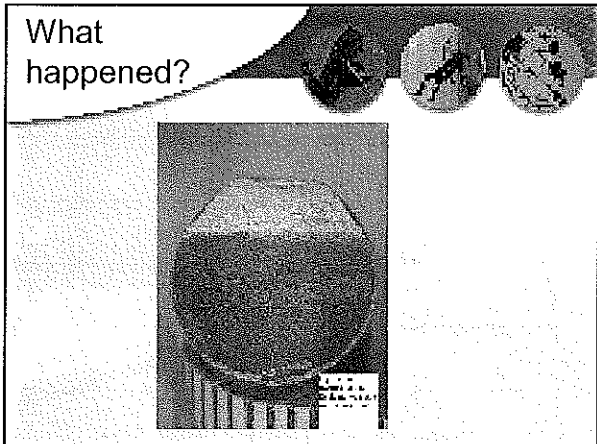
Now which rack is dead?

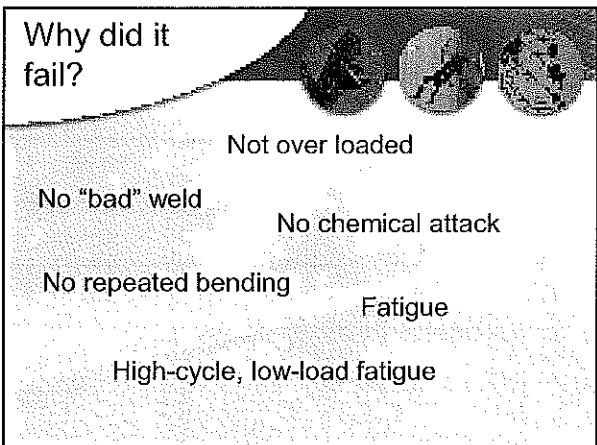
What happened?

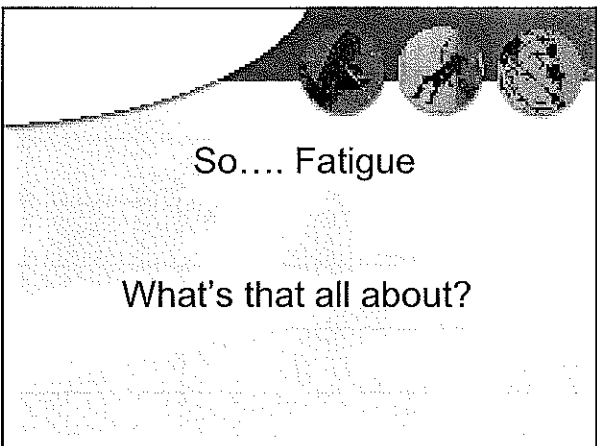



What happened?







Fatigue:

- The effect on metal of repeated cycles of stress.
- The insidious feature of fatigue failure is that there is no obvious warning, a crack forms without appreciable deformation of structure making it difficult to detect the presence of growing cracks.
- Fractures usually start from small nicks or scratches or fillets which cause a localized concentration of stress.
- Failure can be influenced by a number of factors including size, shape and design of the component, condition of the surface or operating environment.

Fatigue is not this gorilla tearing your gear limb from limb



Tensile

- The Gorilla is Tensile
- The force it takes to break things.
- We see tensile in NFPA, ASTM, ANSI as MBS or 3-sigma
- Tensile is measured in psi.
- When tensile psi. is exceeded, things break.
- Stainless tensile is ~120,000 psi.



Science Class

- Example - I weigh 250 lbs

Foot on floor:

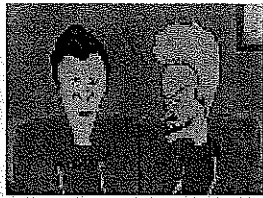
$$250 \text{ pounds} / 12" \times 4" = 5.2 \text{ psi}$$

Foot on nail:

$$250 \text{ pounds} / (.010" \times .010") = 2,500,000 \text{ psi} \rightarrow \text{ouch}$$



Fatigue is not
these guys with a
box of paper clips



Yield

- Bending is material yielding.
- Yield is referred to as Deformation in NFPA, ASTM, ANSI
- Stainless yields at about 80,000 psi.

Fatigue is like a mouse

A very persistent little mouse

Fatigue

- Fatigue Limit is a pressure below which fatigue will not occur.
- Fatigue not in NFPA, ASTM, ANSI
- Stainless has a fatigue limit ~35,000 psi
- Fatigue has a cumulative effect.

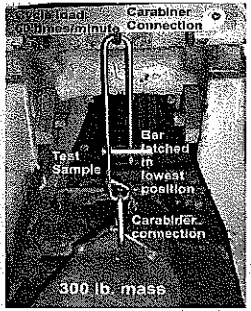
Use your gear and it will die

Isn't there something we can do?
Yes, there is something we both can do.

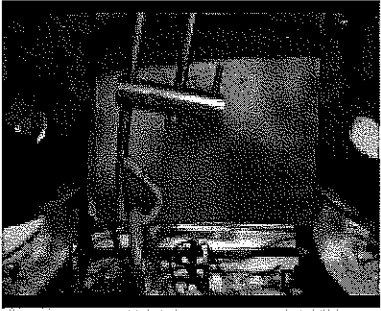
We continue:

- Incorporating wear and fatigue testing into product development.
- Taking advantage of the better design and analysis tools available today.

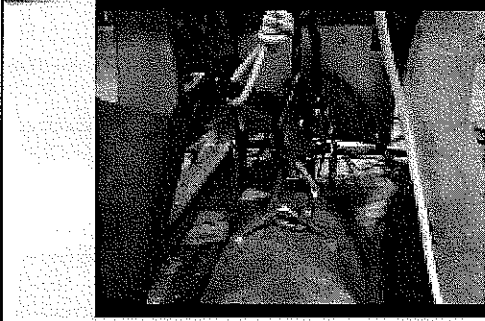
Cycle Tester Extreme
Designed to break gear



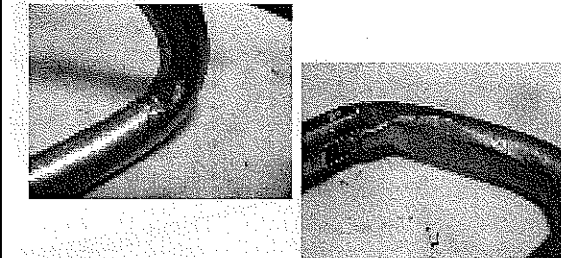
Rappel Rack



Spider



Carabiners



TerrAdaptor

Loaded to 5000 lbf.
after
2000 cycles at 3000 lbf.



Now simulations

Simulations



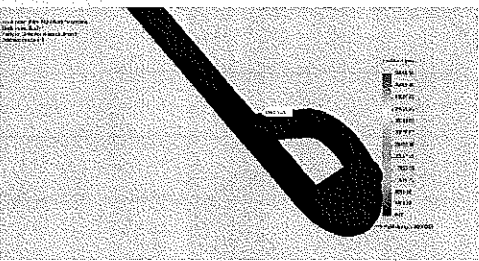
- Don't tell us when your gear will break
- Don't allow us to extrapolate from window washer to caver, to firefighter, to trainer
 - No, there is no practical means of collecting data.
 - The data would be too complex to digest.
- Don't tell us if your gear is dead.

Simulations



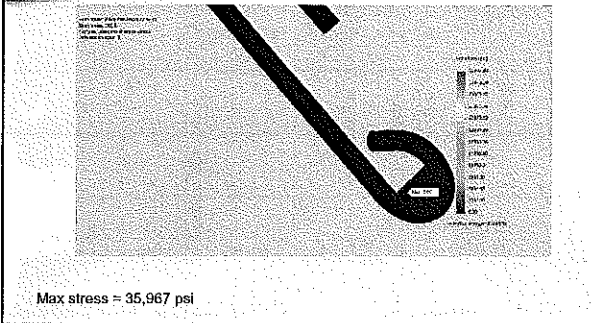
- Do help us design higher performance gear
- Do help us to identify areas that might be more prone to breaking, bending, or fatigue.

6-Bar Flat Rack 200 lbf.

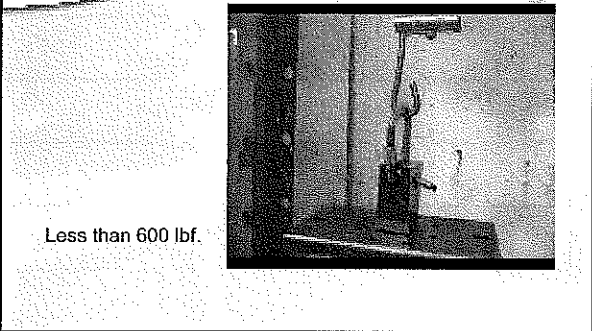


Max stress = 52,866 psi

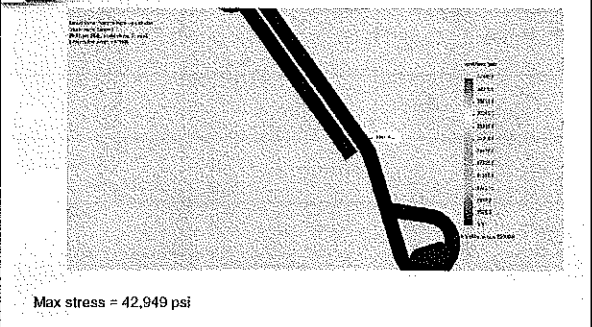
6-Bar Flat Rack no weld
200 lbf.

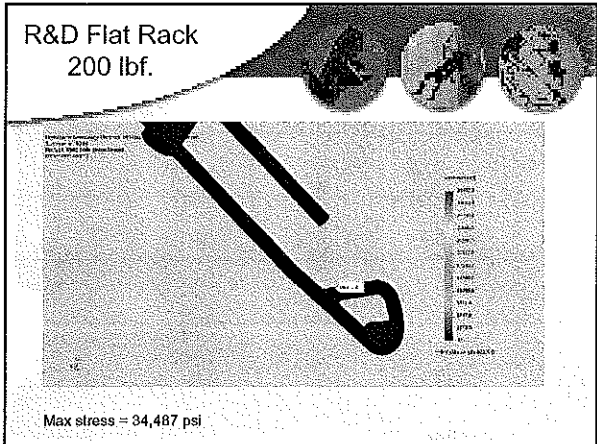


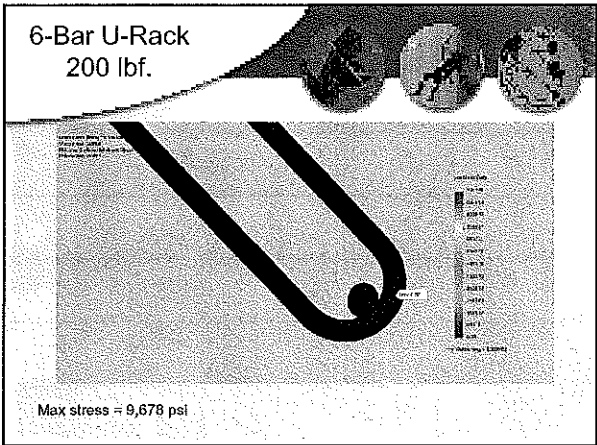
Why weld?



Twisted Rack
200 lbf.







Comparisons

	Max simulated stress w/ 200 lbf. (psi)	Extreme Tester (cycles to fracture)
Standard 6 Bar Flat Rack	52,866	18,700-37,200
R&D 6 Bar Flat rack	34,487	50,000-55,000
Unwelded rack*	35,967	>100,000
Twisted 6 Bar Flat	42,949	>100,000
6 Bar U Rack	9,678	>100,000

*not safe

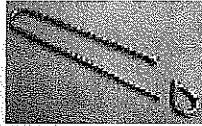
What you can do

- Ignore any issues - ostrich
- OUT program- One Use and Toss
- Down grade duty
 - Non live training
 - Utility
 - Clearly mark downgraded gear



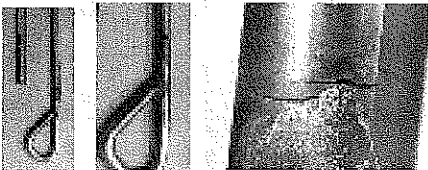
What you can do

- Inspection frequency
 - Never
 - Annually
 - Periodically
 - With each use
- Improve inspection practices
 - Clean before inspect
 - Perform inspections
 - Closer than arms length



What you can do

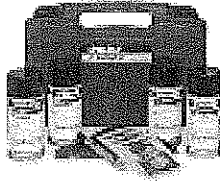
- Visual aids
 - Loupe ~ \$30 and up
 - Digital images



What you can do



- Die penetrant kits - ~\$75



Last word about fatigue

- Gear Retirement program
 - Have one in place.
 - Use it.



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Use your gear
and
it will die.

Quit using it before it is dead!
