
INSPECTOR PROTECTOR
AND THE
COLOSSAL CORROSION FIGHTERS
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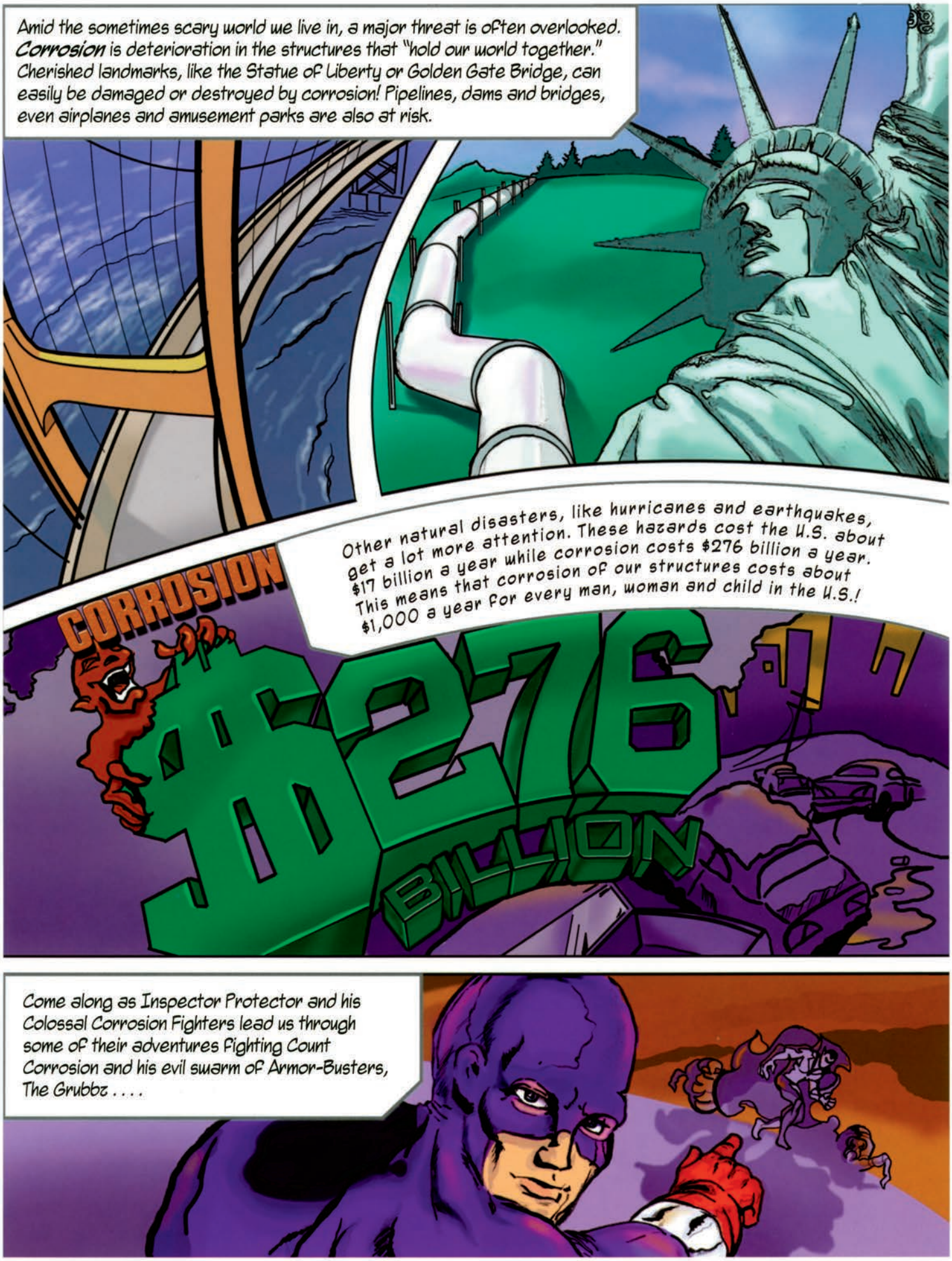
AND THE COLOSSAL CORROSION FIGHTERS

How Corrosion Strikes at the Fabric of Our World!!!

Definitions for technical words depicted in **bold** can be found in the glossary section.


Amid the sometimes scary world we live in, a major threat is often overlooked. *Corrosion* is deterioration in the structures that "hold our world together." Cherished landmarks, like the Statue of Liberty or Golden Gate Bridge, can easily be damaged or destroyed by corrosion! Pipelines, dams and bridges, even airplanes and amusement parks are also at risk.
Other natural disasters, like hurricanes and earthquakes, get a lot more attention. These hazards cost the U.S. about $17 billion a year while corrosion costs $276 billion a year. This means that corrosion of our structures costs about $1,000 a year for every man, woman and child in the U.S.!
CORROSION
$276
BILLION
Come along as Inspector Protector and his Colossal Corrosion Fighters lead us through some of their adventures fighting Count Corrosion and his evil swarm of Armor-Busters, The Grubbz . . . .

MEET THE CHARACTERS

Inspector Protector is our teacher and the commander of all the Colossal Corrosion Fighters.

Dr. Forbidden -
the Great Inhibitor

Super Coat -
the **Coatings** gal

Captain **Cathode** and
his Awesome **Anodes** -
the **Cathodic Protection** Team

Smart Pig - team mascot
and pipeline inspector

Count Corrosion -
the Arch-Enemy of our story

Grubbz - the evil team
of Armor-Busters


...and so when products are constructed from metals or concrete, it's natural for them to corrode. We must never let down our guard - it's a constant battle.
You mean materials are always trying to change back to their original form? For example, when the steel on a car rusts, it's really just trying to turn back into the pile of iron oxide it was made from?
You're right, Captain. And Count Corrosion likes to destroy things even faster.
And he uses lots of different weapons, depending on what it is he and his Grubbz are going after!
BEEP
BEEP
BEEP
My sensors tell me they're after the Statue of Liberty, again. We'd better get out there right away!


Yep, that Lady's gone green already! I'll go, Inspector! I can handle this job in no time!
Easy there, Pig. A lot of statues are made of copper because it's easy to shape and it **oxidizes** to a beautiful green color. She's supposed to look like that!
I'll send Super Coat on this job, Pig. This is her specialty.
The danger is when **atmospheric corrosion** goes too far. And there's a lot of humidity on that island. Structures are always in danger when moisture, salts, or pollution are present. Looks like the Grubbz are contaminating the air around the Statue, trying to get her to break down.
I'll blast the Grubbz from here to kingdom come!


SPLAT!
WHOOPS!
SPLOOSH!
THWACK!
Obviously the situation could have been worse. The builders of this Lady put a lot of thought into **materials selection** and made sure she could resist whatever nature
...or her enemies...
...decided to throw at her!
Curses! You ridiculous, under-handed Corrosion Fighters!!! We'll take this battle to where all your sensors and alarms won't help you at all! We're going..
...somewhere you'll never even think to look for us!

TRIVIA GAME

Lots of COOL information about Lady Liberty can be found at:

http://www.nps.gov/stli/

Look online and see if you can answer the questions below:

a) What is the statue made of? _____

b) How many sheets of copper were used for the statue? _____

c) Where did the sculptor get the copper for the statue? _____

d) How thick is the copper sheeting? _____ of an inch (about the thickness of _____ copper pennies)

e) How much does the statue's copper weigh? _____

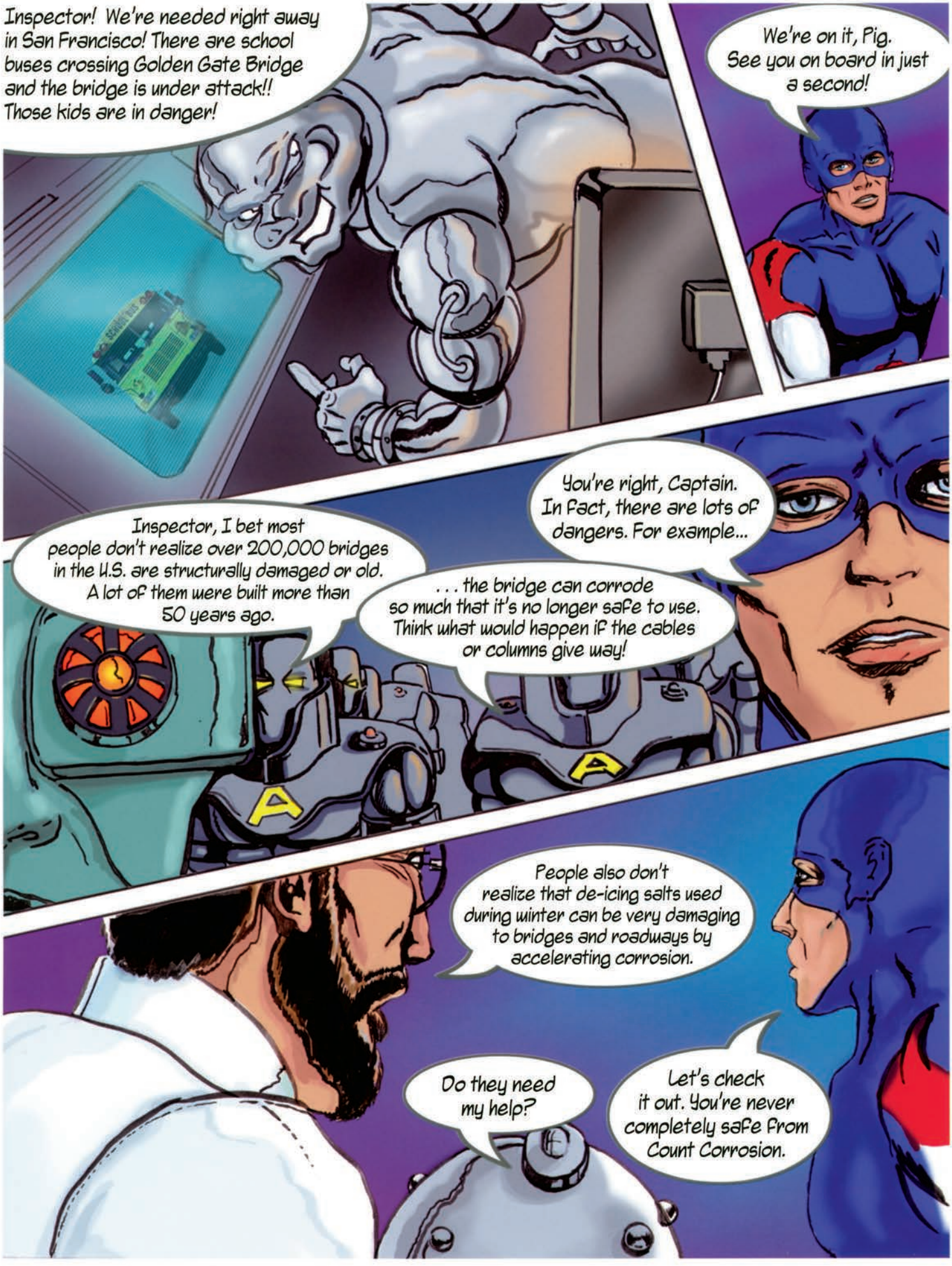
f) Who built the statue's interior framework and what else was he known for?

_____

g) Has any part of the Statue of Liberty been rebuilt as a result of corrosion?

_____

Answers to Trivia: a) copper over a frame of iron and steel; b) 300 sheets of copper; c) Norway; d) 3/32 of an inch - 2 pennies; e) 450,000 pounds; f) Gustav Eiffel - the Eiffel Tower; g) Yes, a corrosion resistant alloy was recently used to replace the statues' interior support structure and the metal securing the seven spikes of her crown.


Inspector! We're needed right away in San Francisco! There are school buses crossing Golden Gate Bridge and the bridge is under attack!! Those kids are in danger!
We're on it, Pig. See you on board in just a second!
You're right, Captain. In fact, there are lots of dangers. For example...
Inspector, I bet most people don't realize over 200,000 bridges in the U.S. are structurally damaged or old. A lot of them were built more than 50 years ago.
. . . the bridge can corrode so much that it's no longer safe to use. Think what would happen if the cables or columns give way!
People also don't realize that de-icing salts used during winter can be very damaging to bridges and roadways by accelerating corrosion.
Do they need my help?
Let's check it out. You're never completely safe from Count Corrosion.


CRUNCH!
CHOMP!
Count Corrosion will reward us generously!
We beat the Corrosion Fighters this time! We got here before they did!
Inspector! Do something! Those Grubbz are attacking the cables over the bridge and there's a clump of them down below eating at the support beams!
What's more, they're not harmful to the environment. Most paints are non-toxic, non-flammable, and safe to apply...
Don't worry Pig, the builders of this Bridge were very wise in their selection of materials. The metals used are highly resistant to corrosion and I've coated them with paint to protect the Bridge from attack.
Right now, nothing, Pig. We just need to inspect for Grubbz in the Future.
So, what happens next?

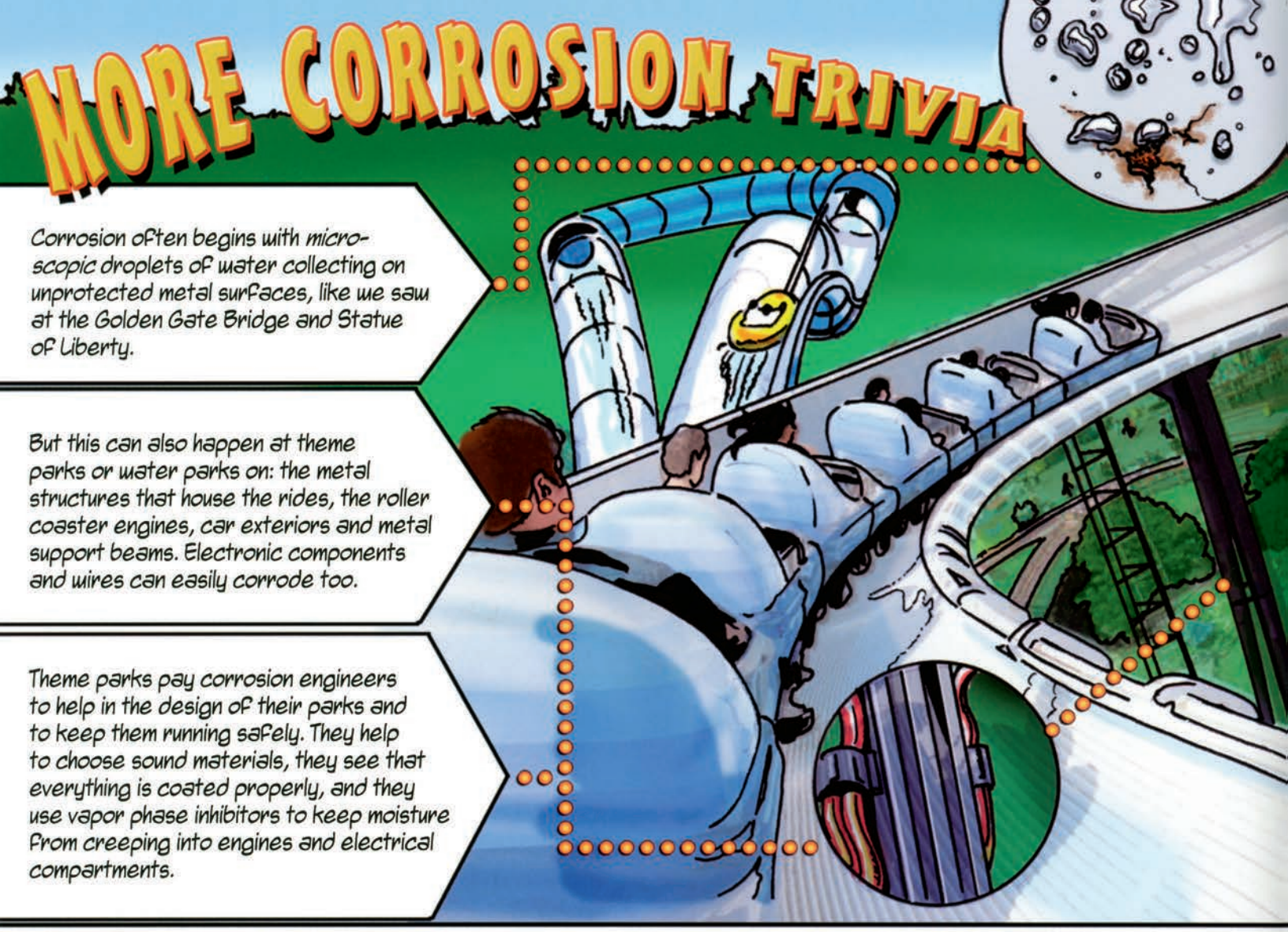

As you can see my friends, although our coatings are kind to the environment, they are VERY unkind to Grubbz!!
You're out of here Grubbz!! You're worthless to me! You're toast!!!! From now on, I'm working alone, and I'm going underground!!
SCHOOL BUS
LOOK'S LIKE THE SMART PIG MAY GET HIS CHANCE!

MORE CORROSION TRIVIA

Corrosion often begins with microscopic droplets of water collecting on unprotected metal surfaces, like we saw at the Golden Gate Bridge and Statue of Liberty.

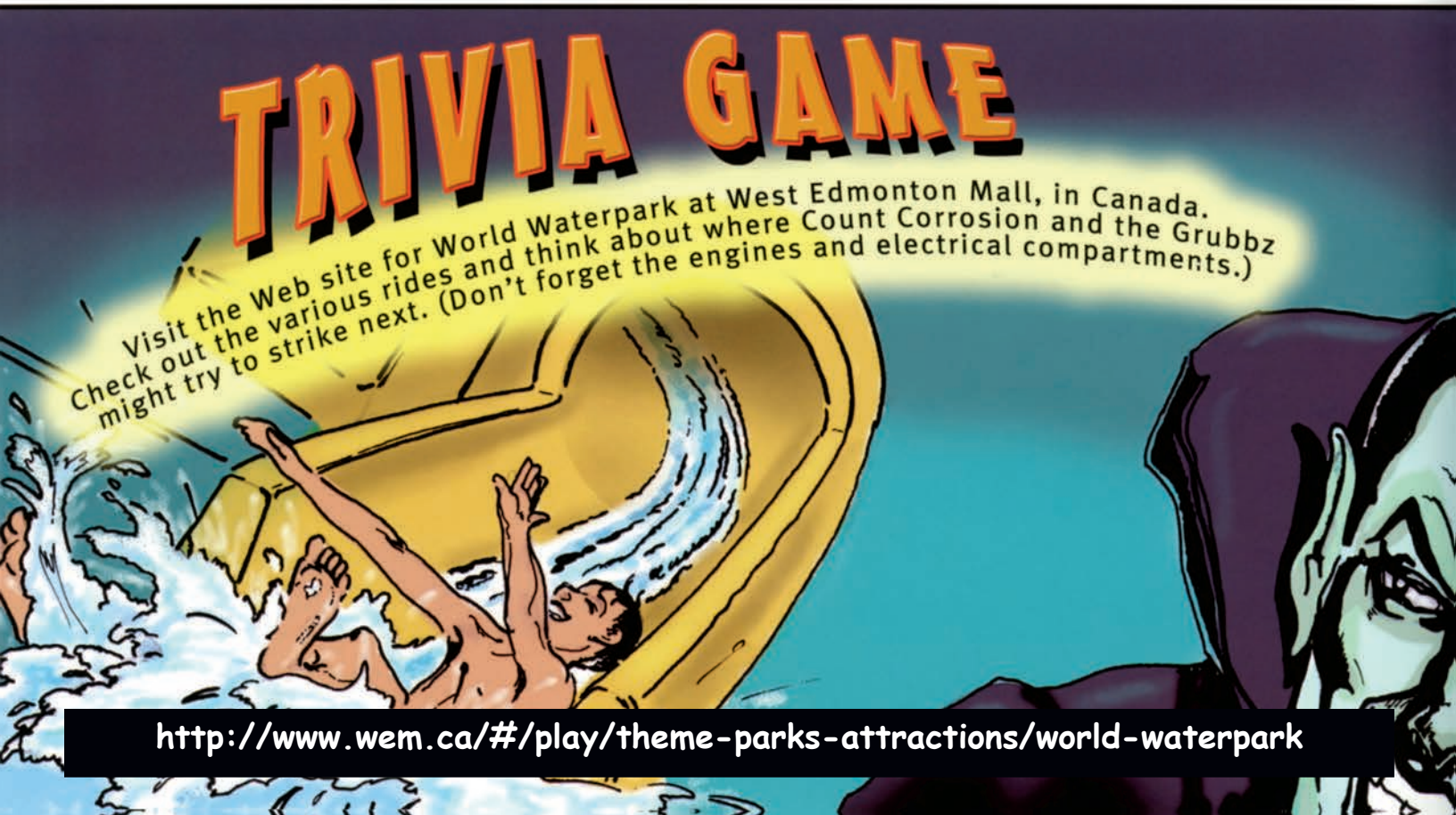
But this can also happen at theme parks or water parks on: the metal structures that house the rides, the roller coaster engines, car exteriors and metal support beams. Electronic components and wires can easily corrode too.

Theme parks pay corrosion engineers to help in the design of their parks and to keep them running safely. They help to choose sound materials, they see that everything is coated properly, and they use vapor phase inhibitors to keep moisture from creeping into engines and electrical compartments.



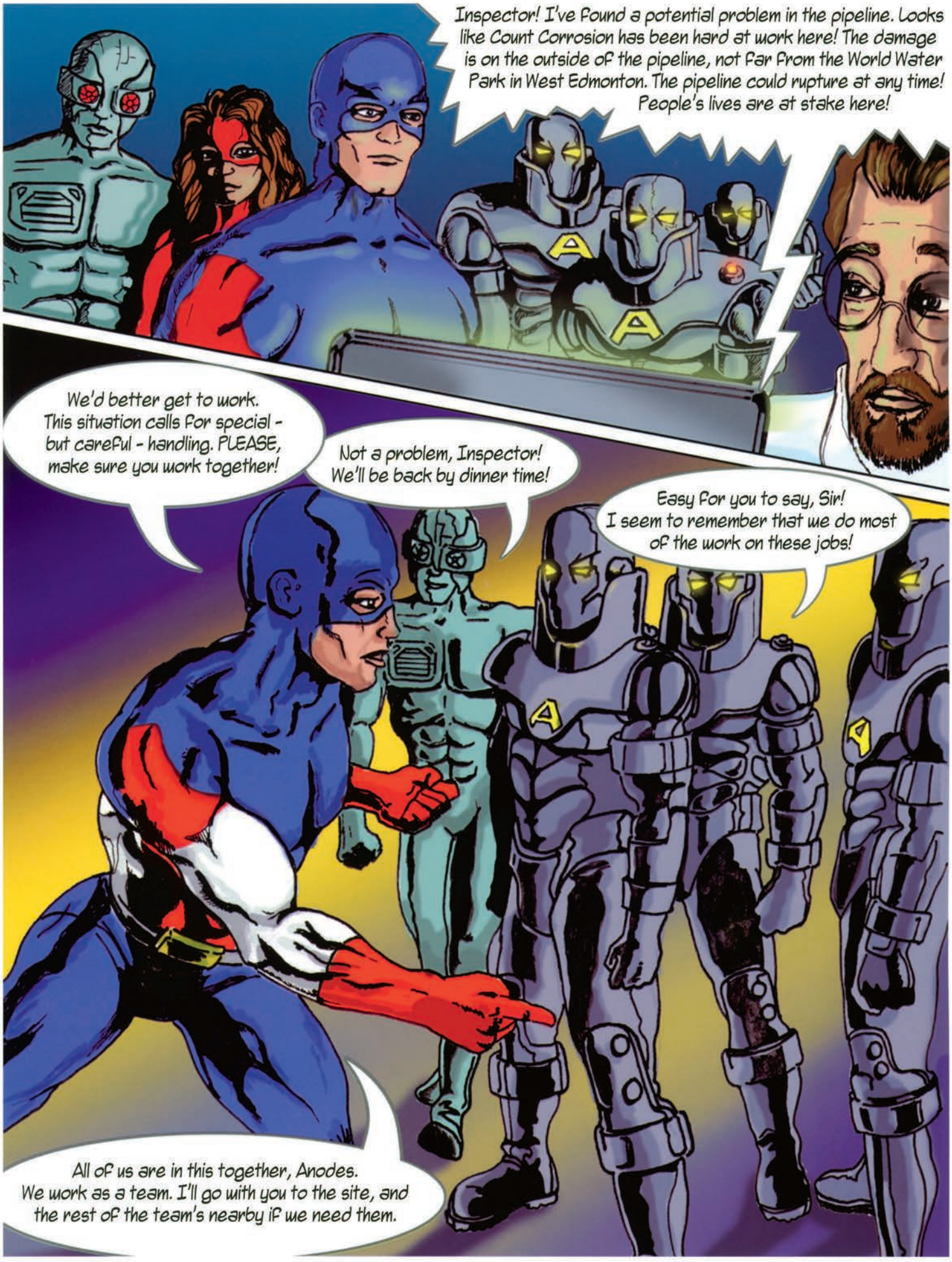
TRIVIA GAME

Visit the Web site for World Waterpark at West Edmonton Mall, in Canada. Check out the various rides and think about where Count Corrosion and the Grubbz might try to strike next. (Don't forget the engines and electrical compartments.)



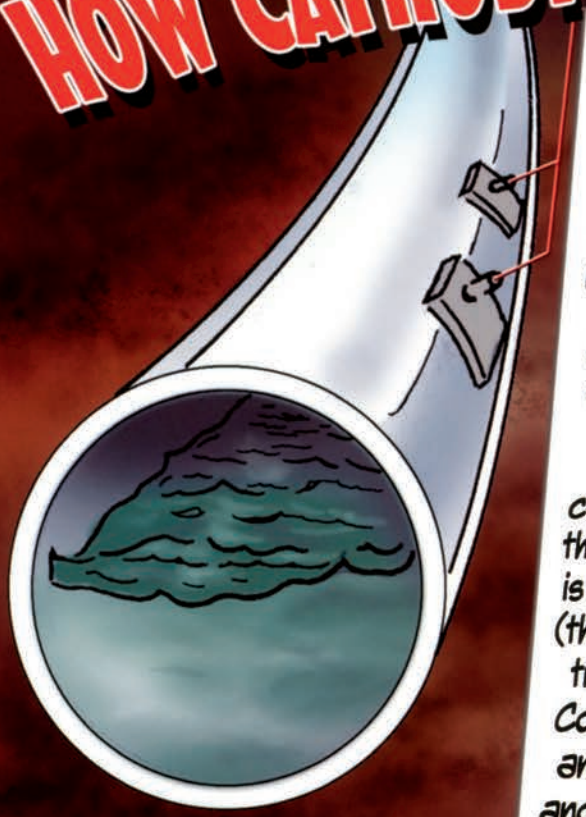
http://www.wem.ca/#/play/theme-parks-attractions/world-waterpark


Has anyone seen Smart Pig? I have a feeling he's gone on ahead of us..
He has headed for Canada to check for a pipeline leak.
EDMONTON, ALBERTA CANADA
Welcome to
Edmonton
Statistics show that 29% of pipeline leaks are caused by corrosion. Many pipelines, like bridges, are 40 to 50-years-old.
Pipeline leaks can be very dangerous to people - especially in the case of natural gas leaks. Leaks can also be very damaging to the environment when pipelines carry oil or other chemicals.
There are hundreds, if not thousands, of pipelines (oil, natural gas, chemicals, and water) buried under the City of Edmonton - not unlike other major cities everywhere in the world.


Inspector! I've found a potential problem in the pipeline. Looks like Count Corrosion has been hard at work here! The damage is on the outside of the pipeline, not far from the World Water Park in West Edmonton. The pipeline could rupture at any time! People's lives are at stake here!
We'd better get to work. This situation calls for special - but careful - handling. PLEASE, make sure you work together!
Not a problem, Inspector! We'll be back by dinner time!
Easy for you to say, Sir! I seem to remember that we do most of the work on these jobs!
All of us are in this together, Anodes. We work as a team. I'll go with you to the site, and the rest of the team's nearby if we need them.

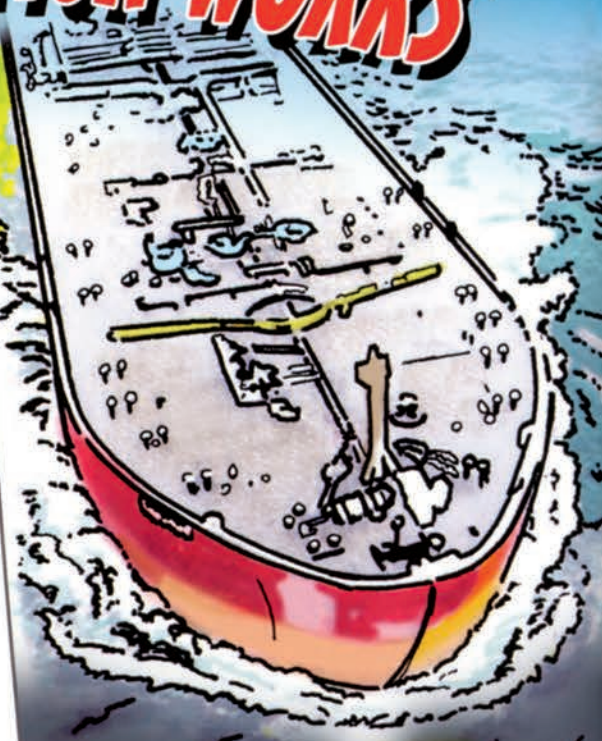

Cathodic protection works by transferring corrosion from the pipe to an Anode.
We need to call in our team of Anodes for this job.
While you and your Anodes are doing that, Captain, I'll send Super Coat to check out the pipeline exterior; and Smart Pig will inspect the inside of the pipe to make sure everything is under control.
Curses!!! Curses!!!! Curses!!!

HOW CATHODIC PROTECTION WORKS



The science of cathodic protection (CP) was born in 1824, when Sir Humphrey Davy discovered that he could protect British war ships from corrosion by the use of iron anodes. The iron transferred corrosion away from the copper parts of the ship.

The basic principle of cathodic protection (CP) is this: corrosion of one metal is reduced if another metal (the anode) is connected to transfer corrosion away. Corrosion deteriorates the anode's metal, which is why anodes are often described as "sacrificial."



Anodes get "used up" and have to be replaced periodically. That's why the anodes in this story have been depicted as clones or duplicates of each other.

TRICKY TRIVIA QUESTION

WHY DOES NATURAL GAS SMELL REALLY BAD?

ANSWER: IT DOESN'T!

Natural gas has no odor. But because it is highly flammable, natural gas producers add an early warning agent called **odorants**, which produce an unpleasant odor. Odorants alert users to leaks before they reach life-threatening levels. This important life-saving precaution is a simple, but effective safeguard and is now used throughout the natural gas industry.


That was a good job for the team, Inspector. We saved the pipeline, and showed the Count not to mess with us. Can we go have some fun now?
Yeah, let's go to that cool water park in Edmonton!
Ah, yes! That's a great place to play and relax - and very well protected from corrosion, too, I might add.
It's not like Count Corrosion to simply disappear without making a scene...
You're absolutely right - Count Corrosion and his team of Grubbz never rest and neither can we!

In 1988, an Aloha Airlines jet lost part of its fuselage at 25,000 feet due to corrosion. One person was killed but the pilots managed to safely land the plane and save the rest of the passengers and crew.

Over 2,500 commercial aircraft are now flying beyond their natural lifespan.

Stay Tuned! Does Inspector Protector and the Colossal Corrosion team make it safely to the ground?

THINGS TO REMEMBER!

Corrosion is the deterioration of a material as it reacts to its environment. From water pipes to automobiles to oilfield equipment, corrosion is everywhere and it can't ever be completely eliminated.

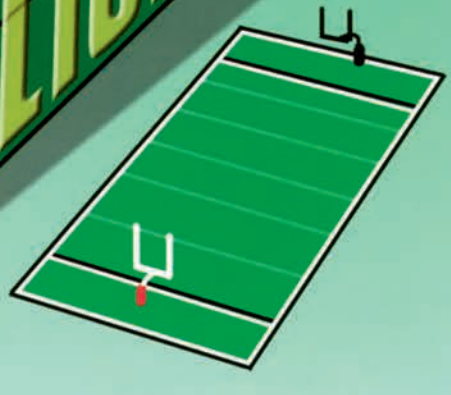
Corrosion can make structures very unstable and unsafe. This can lead to catastrophes we can't even imagine.

What does 276 Billion Dollars Look Like???

It takes 3 years to count to a billion!

Q: How long would it take to count to 276 billion?

A: 828 YEARS!!



Corrosion can happen in a variety of ways to any structure that contains metal.

Common targets include:

Chemical Plants - Pipelines & Storage Tanks - Air and Spacecraft - Nuclear Facilities - Refineries
Automobiles - Highways and Bridges - Dams and Buildings - Historic Structures - Water Treatment Plants
Tank and Rail Cars - Weapons Systems & Military Facilities

Corrosion costs the U.S. over $276 billion a year. This is nearly $1,000 for every man, woman and child in the country. Over one-third of corrosion costs (about $100 billion in the U.S.) could be prevented through existing technologies. Prevention saves lives AND valuable resources that could be better spent on other things.

GLOSSARY

- *ALLOY* - a material made by melting together two or more elements, at least one of which is a metal
- *ANODE* - a metal used to draw oxidation or corrosion away from another metal
- *ATMOSPHERIC CORROSION* - the gradual deterioration of a material by contact with substances present in the atmosphere, such as salts or pollution
- *CATHODE* - the metal being protected from corrosion in a cathodic reaction
- *CATHODIC PROTECTION* - a technology that uses direct electrical current to counteract the normal external corrosion of a structure that contains metal (such as a pipeline)
- *COATINGS AND LININGS* - principal tools for defending against corrosion; substances applied in a variety of ways
- *CONDENSATION* - the act or process of changing from a gas to a liquid or solid state

- ***CORROSION*** - a natural electrochemical process; the tendency of a metal or material to return to its native state

- ***ELECTROLYTE*** - solutions which conduct electrical current and support ionized particles

- ***INHIBITOR*** - substances (or even vapors) which can decrease the rate of attack on a material such as metal

- ***IONIZATION*** - the gain or loss of electrons, affecting the electrical conductivity of a substance

- ***INSPECTION PIG*** - a snug-fitting, remote-powered plug which is able to move through and inspect a pipe or pipeline system from the inside

- ***MATERIALS SELECTION*** - the selection and use of corrosion-resistant materials (such as stainless steel, high alloy, ni-base and plastic) to further preserve a structure

- ***METAL FATIGUE*** - a weakness which develops in metal structures which are used repeatedly

- ***MITIGATION*** - the process of combatting or counter-acting a process, to make the effects less harmful

- ***OXIDATION*** - a corrosion reaction in which the corroded metal forms an oxide; usually applied to reaction with a gas containing elemental oxygen, such as air

CORROSION WORD SEARCH

Q I O L A T E M M Z I V Z F I P C Q Y T F Y L J W
F Q U I X M D I Z B L U P D B R W T Q H Y V B P G
A B A V A B O B I P S L U N T V K X V N B U Z Y P
X L T U B S N C G E V E K E Q H R H I L H Q N B F
Y U E B P H A W W B O L A M G G I N H I B I T O R
S U A I N S I N S P E C T I O N B H L E C L W D U
D K R U A Z Z L R T E A U H P R S M H O R A H V D
V E H H I V F L F V G G T S D D N I R Q F D G C R
N L I K K G Y V C U C D S M B V U R K Y P D F J Z
I O Q O S O F D R P F Q O T O E O T U E M H U E T
W O I R P M E B Q Y S T A K Y S P T B X G M C T R
F G N T J I I D M F M M V F I N P R M S Y T V S G
L Y F I A H G T O R Q J T O O O W H M P R M A X E
G Q O E Z S C I I H A E N H Q T R S E L W G R R S
C K D G O A N P C G T G M E L J H H J R H L S P G
V H V J G D T E G Y A A Q T F X N Q K Z I L Z A N
E S S H T C Q I D R K T C Y B K O C V L D C F N I
Z L B V X O N X O N C T I L W N O I T A D I X O T
K J V J P F H V J N O W K O Z C V D T E V W O O A
B A Z D Y S F I L R B C K R N Q H O F N R T O C O
Z F V W Q F K T Q E U G I T A F L H G E T V Q Q C
S J O G L I Q D Z M Z B A C X I R T E Z V H P I C
D P C S B H W D O F B E V E V N B A B P Z L R E U
W G H P E P B L L B Z H U L F U U C U R W Q A W X
J J U J W X K I Y E N I X E E H E V G Z A L L O Y

Search the puzzle above for the corrosion terms listed below. Words may appear forwards or backwards, up or down, or diagonally. Go to www.nace-foundation.org/ckit for the solution!

ALLOY
ANODE
ATMOSPHERIC
CATHODE
CATHODIC
COATINGS
CONDENSATION
CORROSION
ELECTROLYTE
INHIBITOR
IONIZATION
INSPECTION
FATIGUE
METAL
MITIGATION
OXIDATION
PIG

15835 Park Ten Place
Houston, Texas 77084

800 Trumbull Drive
Pittsburgh, PA 15205

Phone: 281-228-6205
www.ampp.org/emerg
emerg@ampp.org

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