



INDUSTRIAL HOSE

HYDRAULIC HOSE

CONVEYOR BELTS

LIGHTWEIGHT
CONVEYOR BELTS

REPLACEMENT PRODUCTS

POWER TRANSMISSION

TRANSPORTATION DE

Conveyor Belts for Underground Coal Mining

The Goodyear Tire & Rubber Company

March 28, 2007



We're Here For Safety

- Goodyear has been one of the leading global suppliers of conveyor belting to coal industry for 90 years.
- We manufacture belts to exceed all required standards in all regions of the world.
- We continue to invest in R&D to improve all aspects of belt safety.
- We welcome this opportunity to participate in improving belt safety for underground mining.



Overview

- How belts are made
- Trends in belt design
- Goodyear's continuous quality improvements
 - Improving belt safety
- What we mean by belt safety
 - The attributes of belt fire safety
 - New technologies that will improve belt safety
- Summary

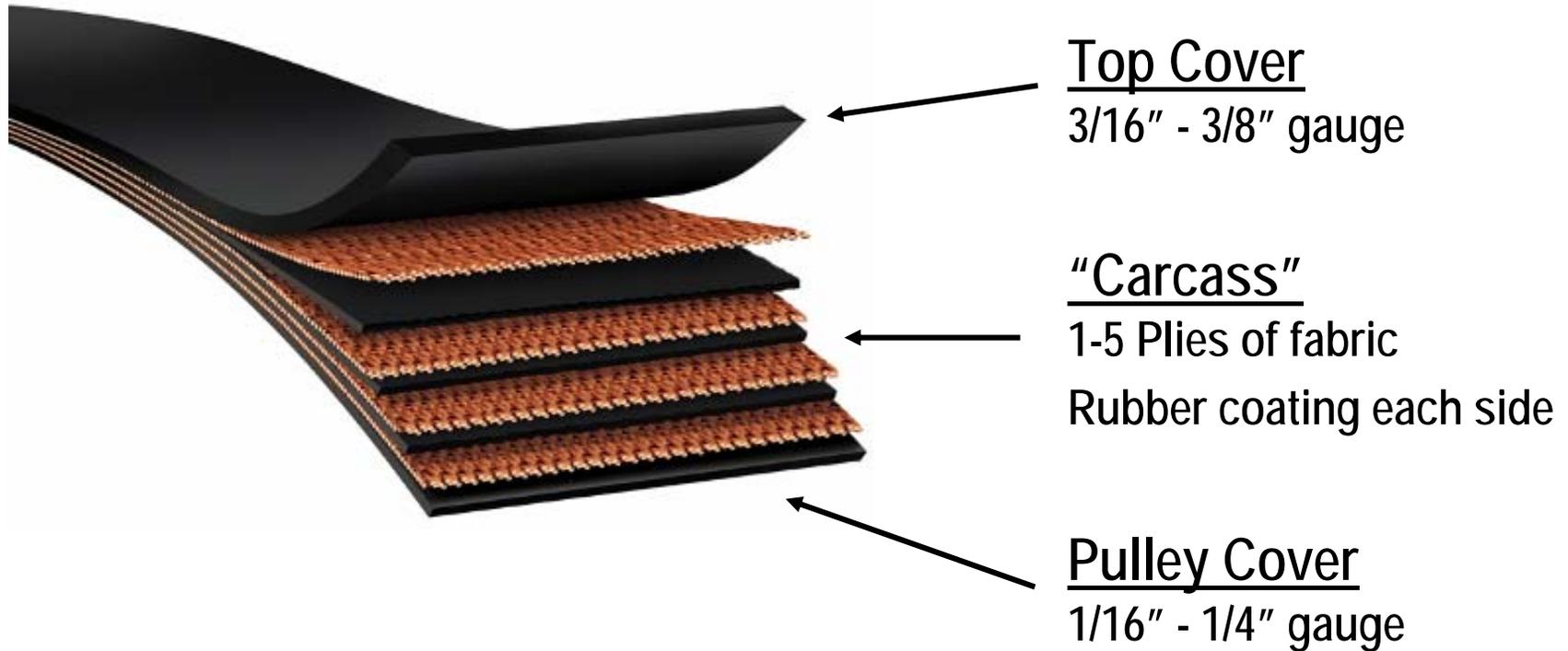


How Belts are Made



How Rubber Belts Are Made

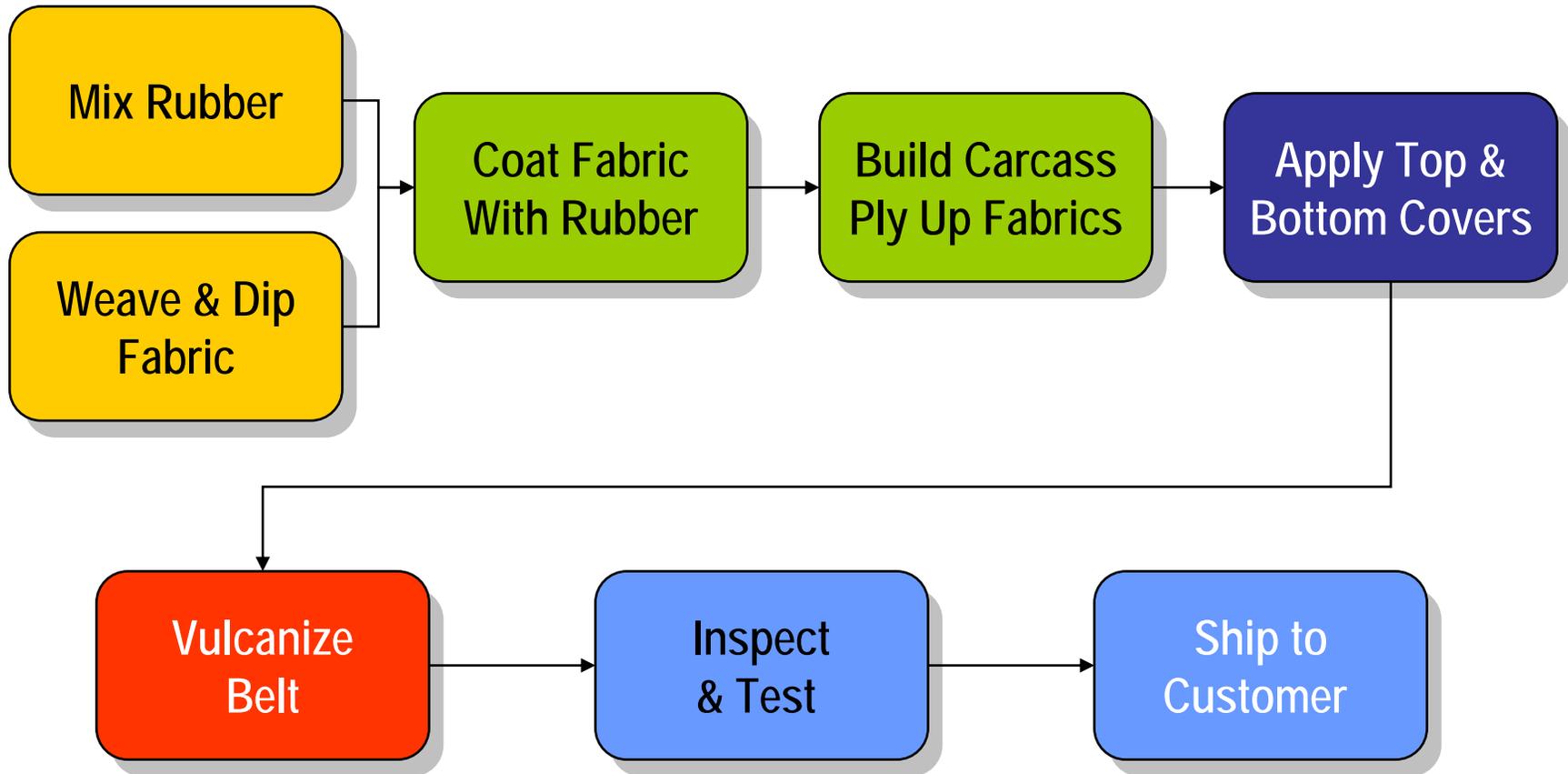
Typical USA Construction



Note: USA does not use "Rubber Covered Belt Edges",
uses thicker coats and unique fabric constructions



How Rubber Belts Are Made



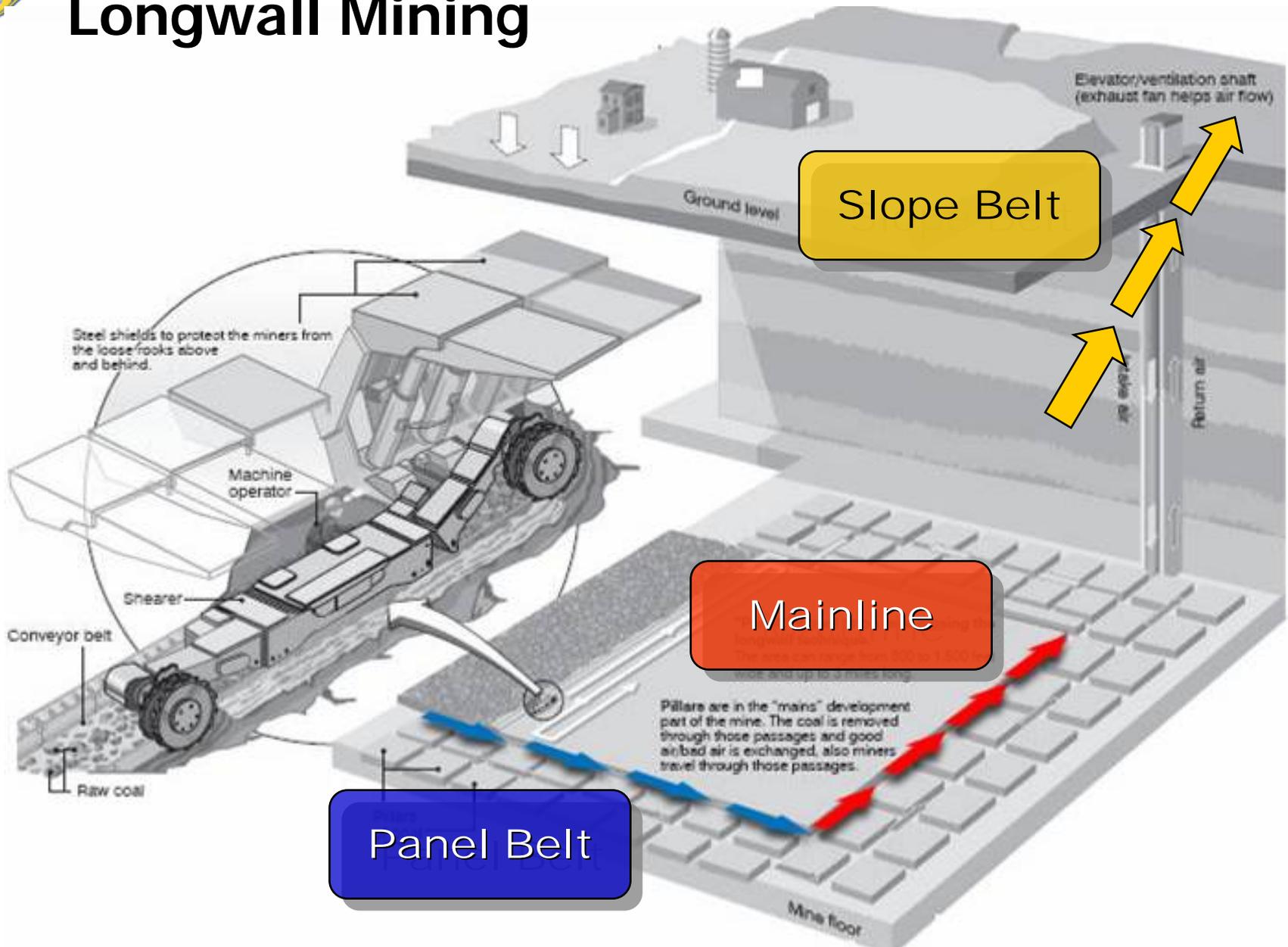
Standard runs are 1,000' to 3,000' rolls



Trends in Belt Design & Application

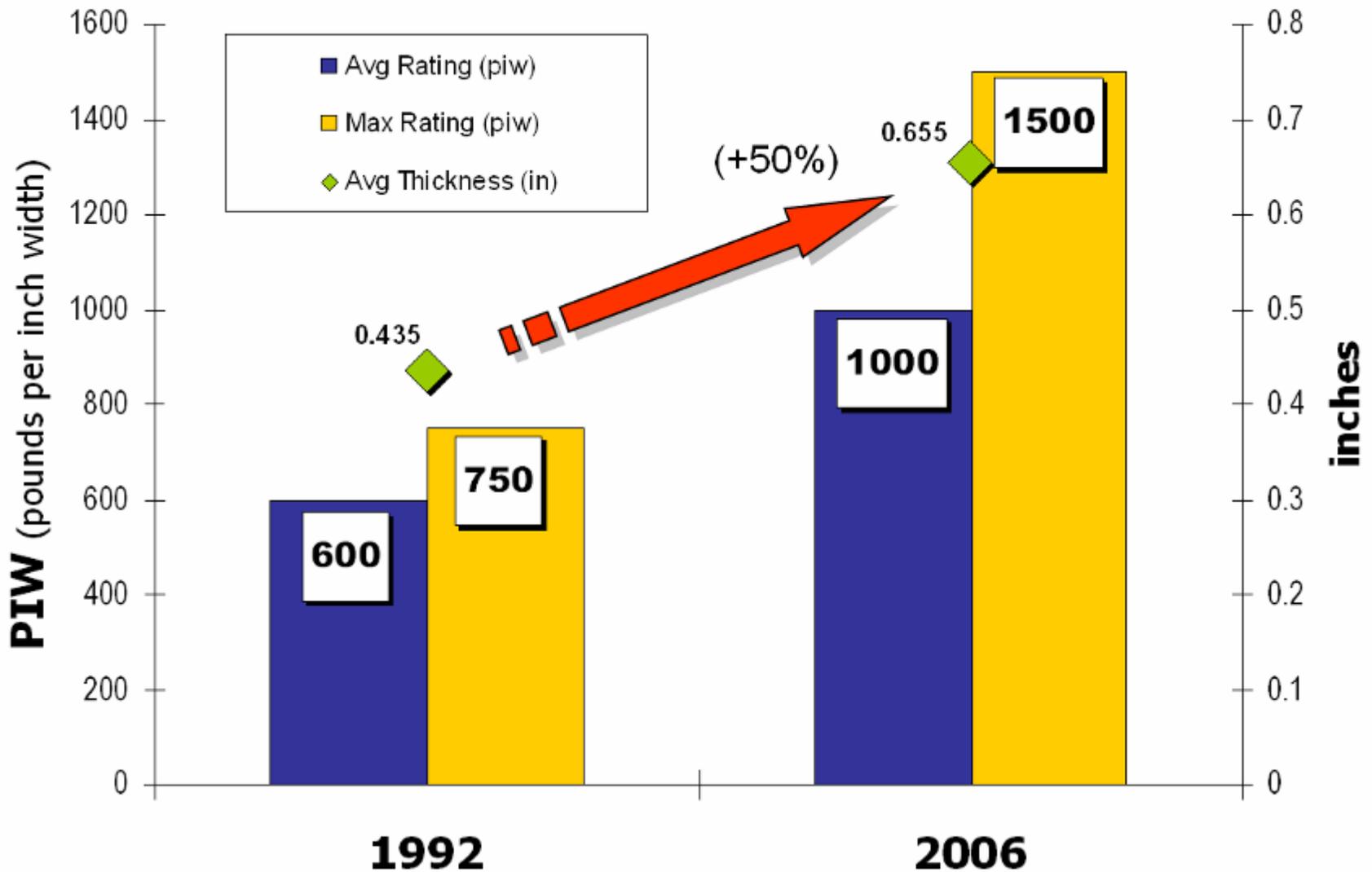


Longwall Mining



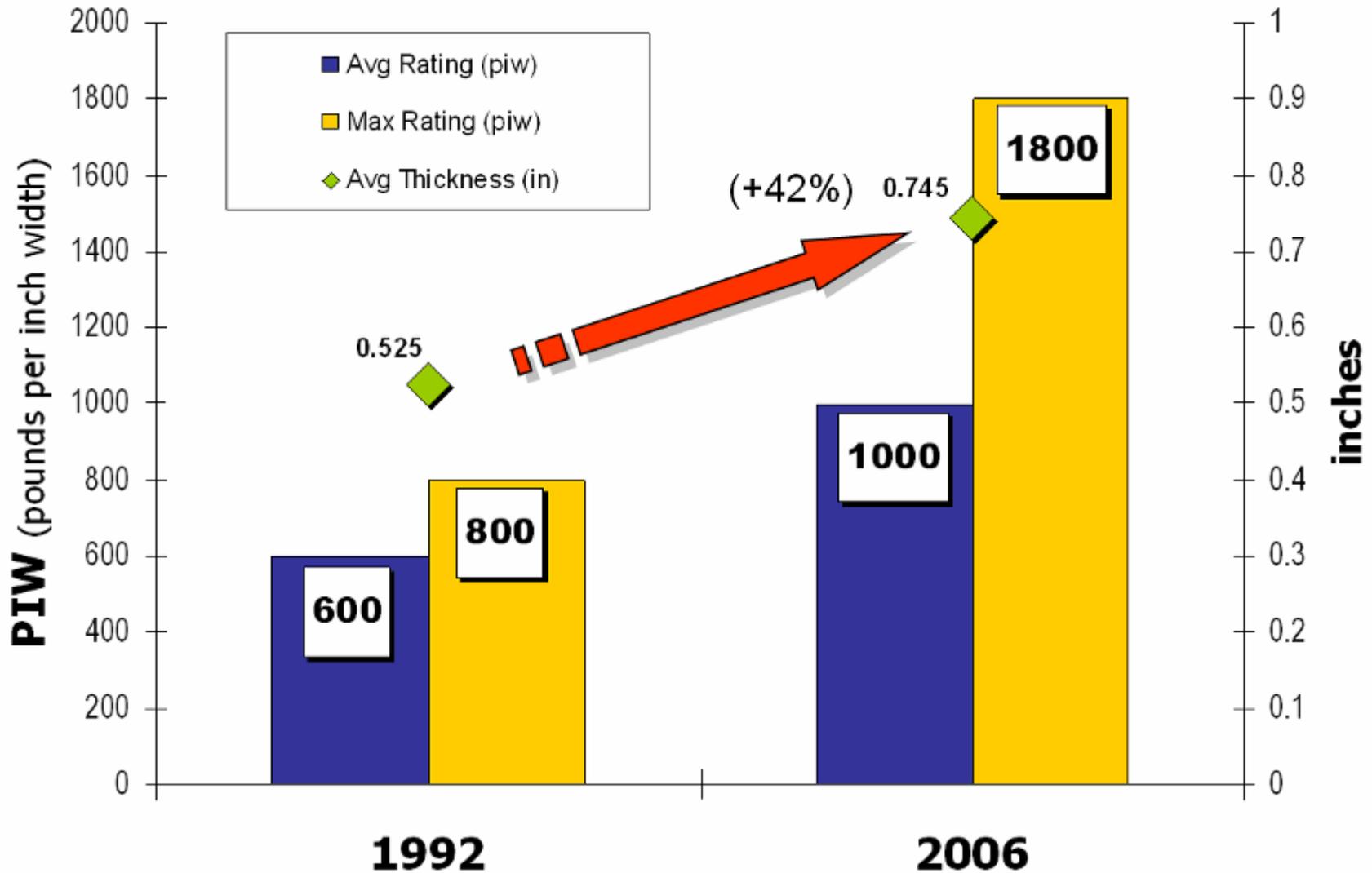


Trends in Belt Design - Panel Conveyors



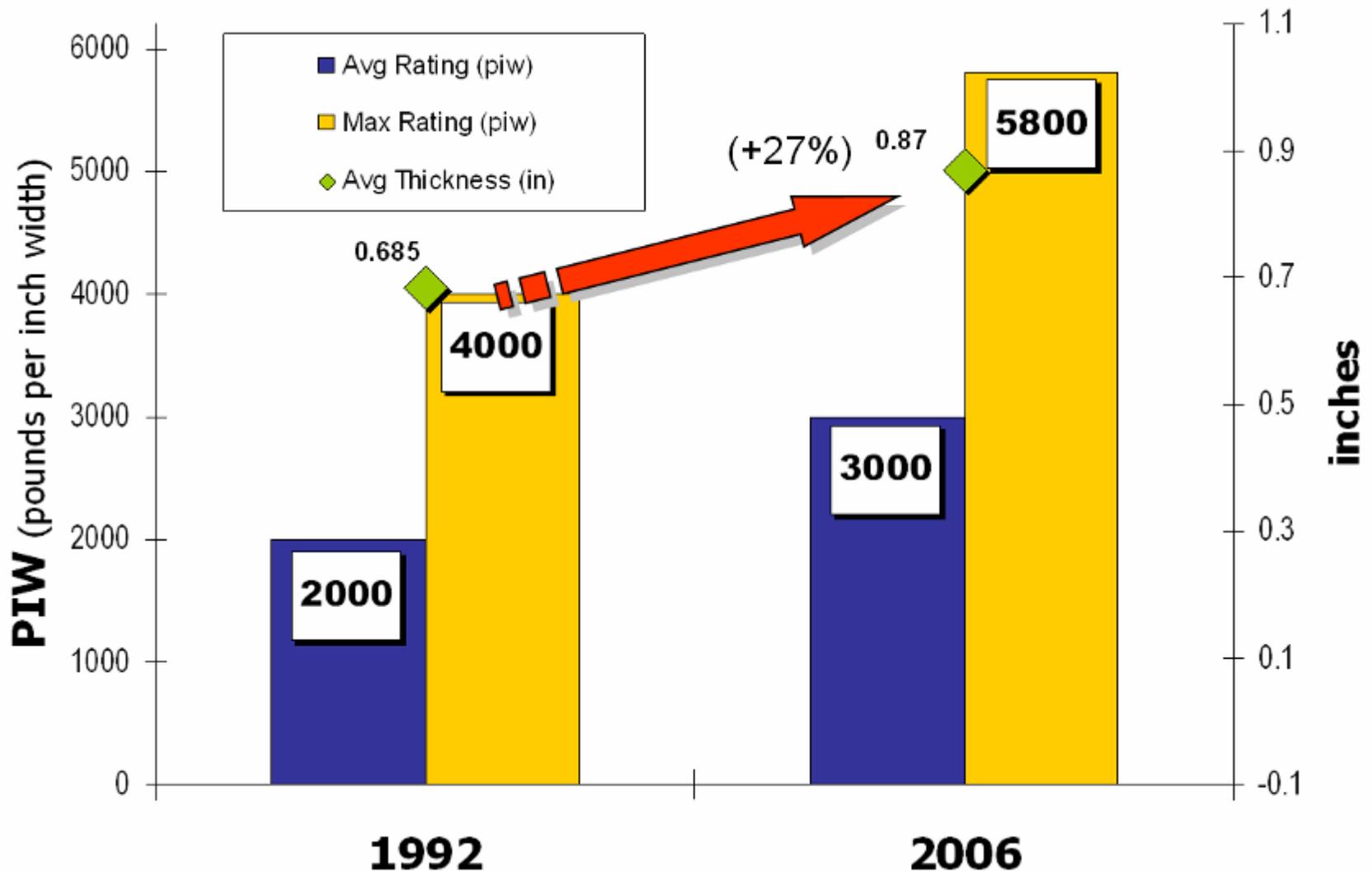


Trends in Belt Design - Mainline Conveyors





Trends in Belt Design - Slope Conveyors





Improvements to Belting



Continuous Quality Improvement

- Durability
- Adhesion
- Flammability resistance
- More permanent flame retardants

All Contribute to Improved Safety



Durability

Three Key Areas:

- Abrasion resistance of covers
- Rip/tear strength of carcasses
- Fatigue resistance of belts

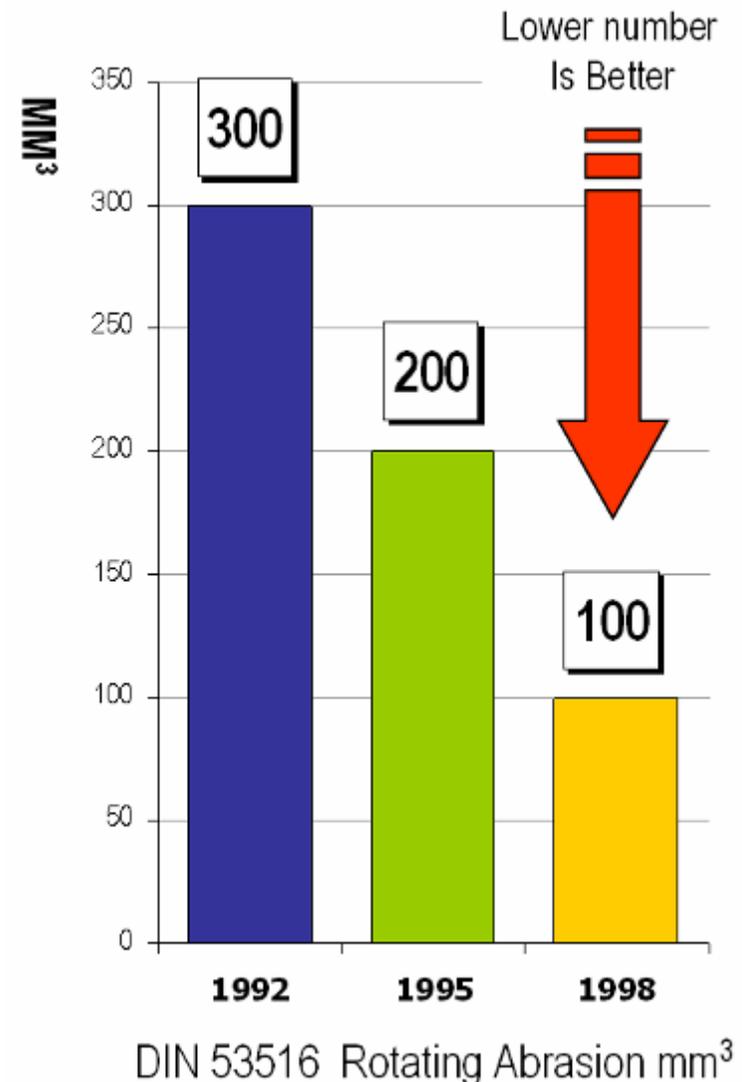
Durability Improves Safety

Rip/tear/rubber loss could cause fire hazards and other safety issues such as belt breakage



Durability - Abrasion Resistance

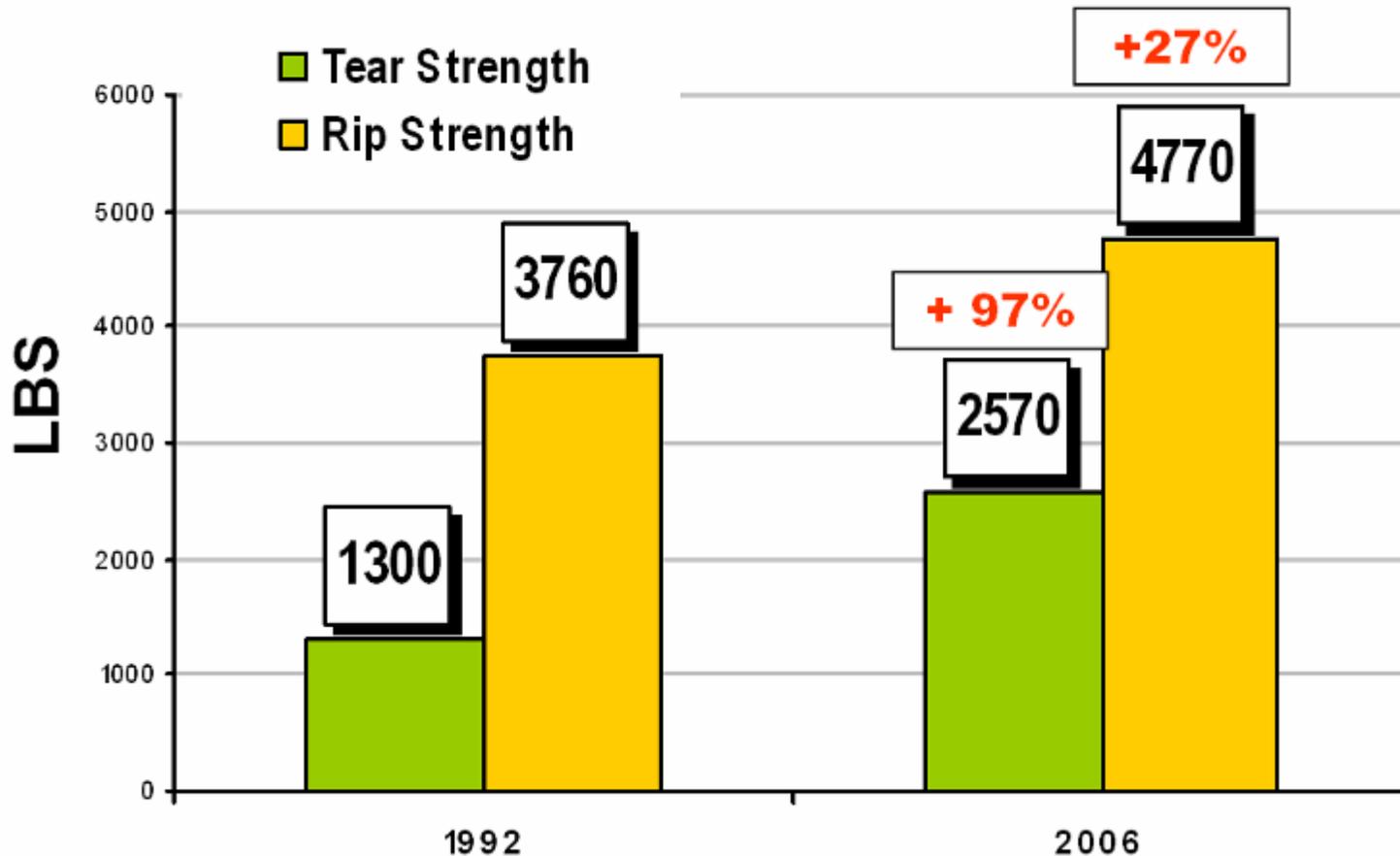
- Field studies in coal mining show good correlation to durability.
- Mainlines durability up to 10 years versus 3-5 years.
- More rubber on belts reduces fire hazard





Durability – Panel 1000 piw Construction

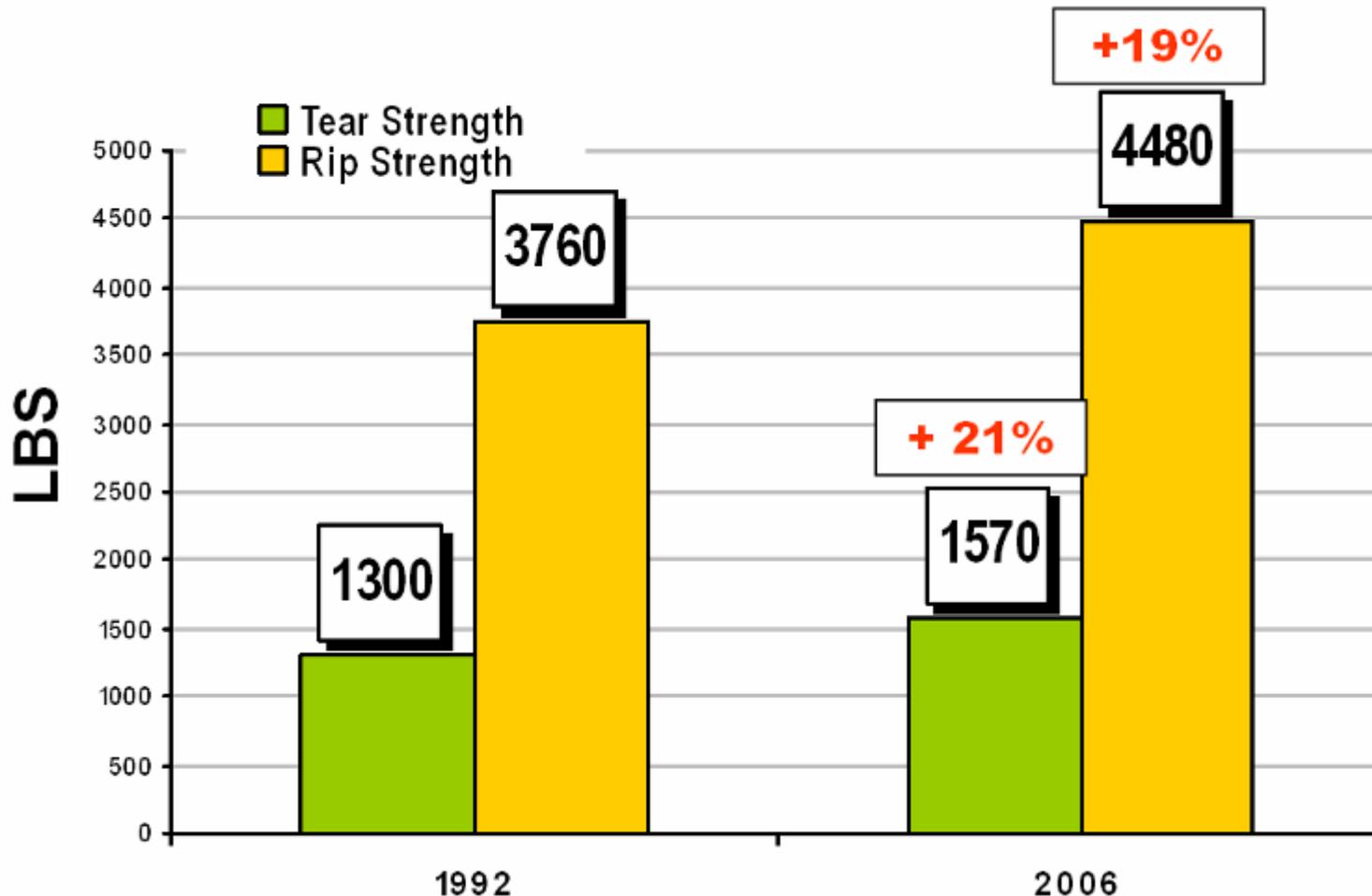
- Rip/Tear/Tensile Strength of Carcasses has increased
- Typically lasted only 1-2 moves – now up to 6 moves
- Reduced Stringing





Durability – Mainline 1000 piw Construction

- Rip/Tear/Tensile Strength of Carcasses has increased
- Reduced Stringing



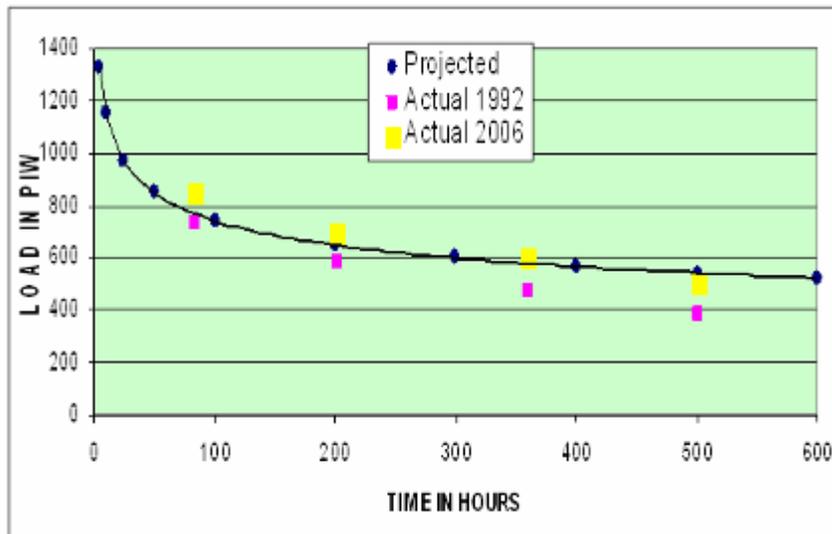


Durability - Fatigue Resistance



Glide 600 Vulcanized Splice Fatigue Life Six Pulley Bend Tester

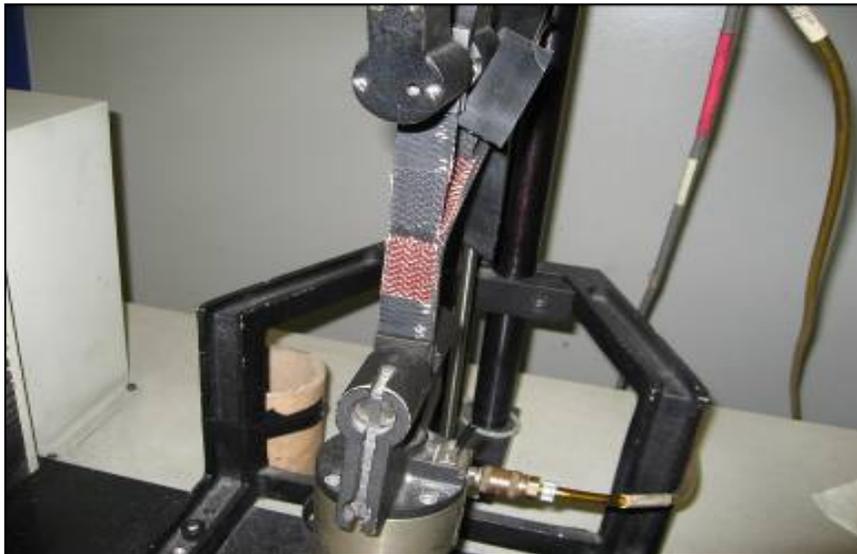
- Goodyear has invested heavily in dynamic test equipment to improve durability.
- Fatigue curves/actual performance has shown improved durability.



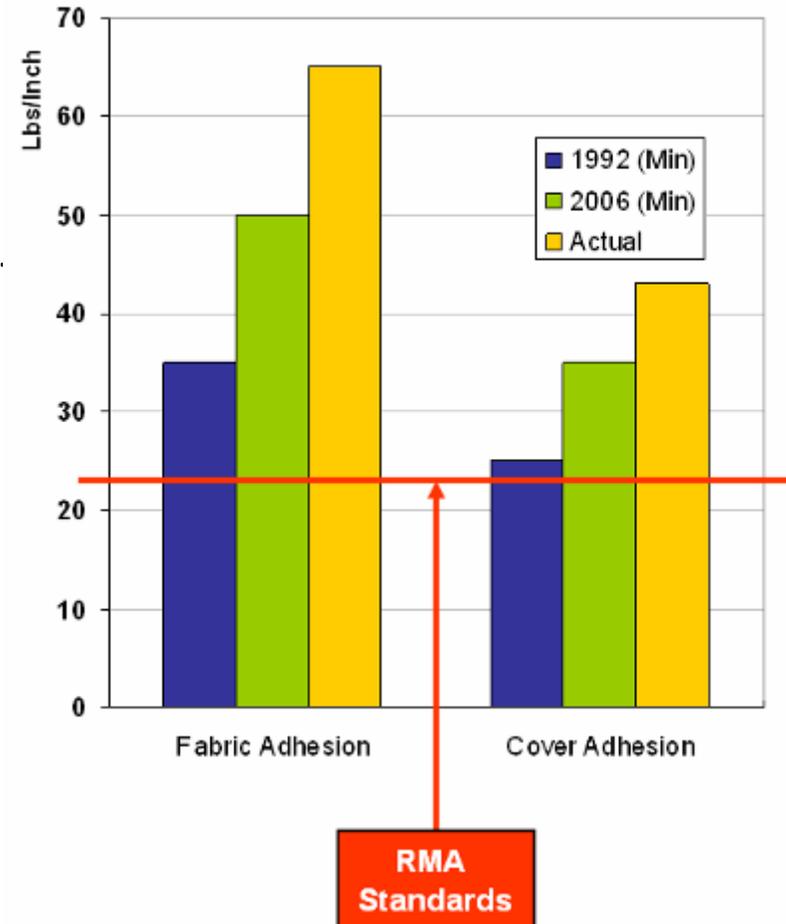


Adhesion

- Low adhesion in belt can cause potential safety issues
 - Belts separate, potentially easier to ignite.
 - Fabric separates/strings on edges, again potentially easier to ignite.
 - Improvements in adhesion in last 10 years have significantly improved minimum and average adhesions.
 - Fabric constructions developed to eliminate edge stringing (common in panel belts).

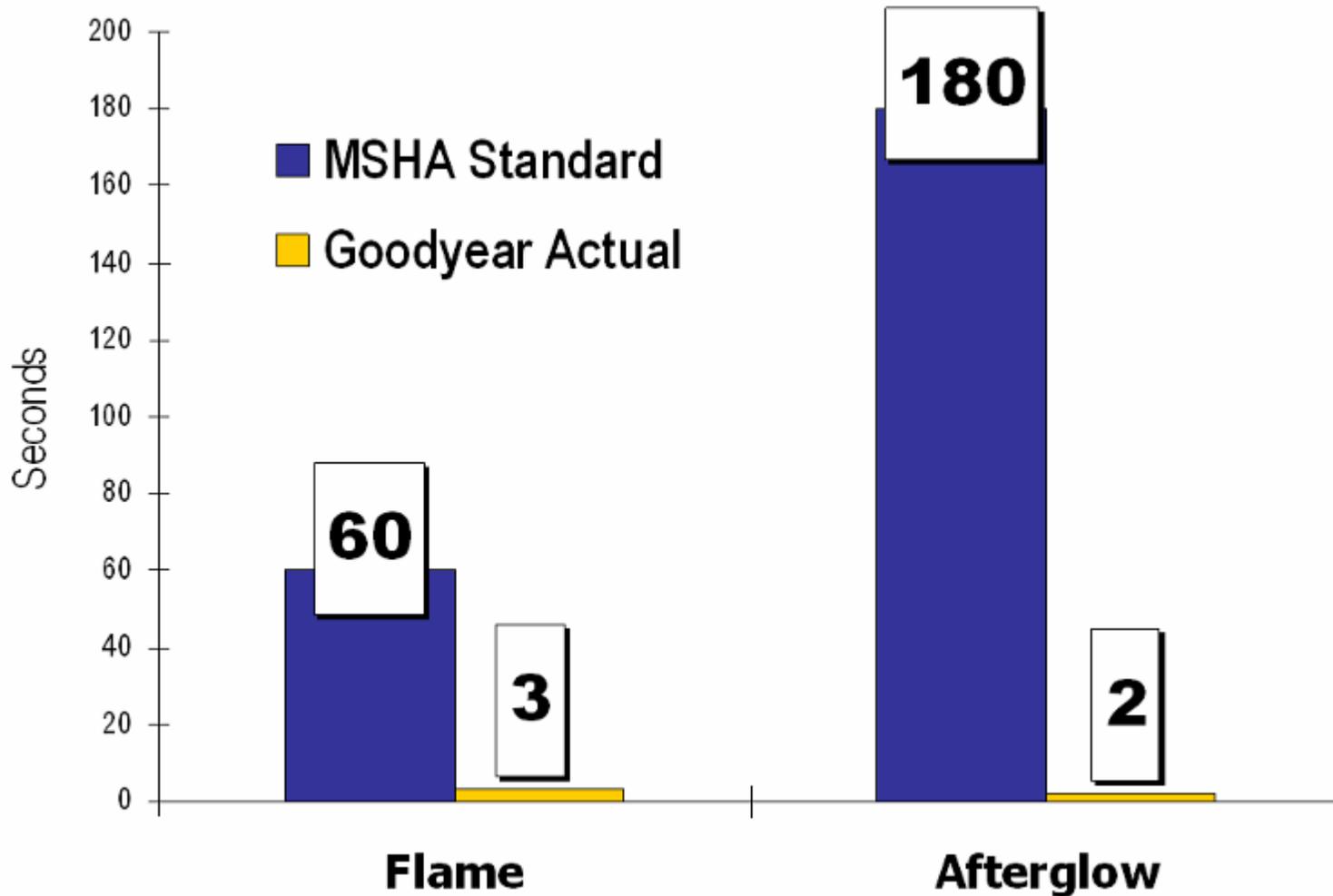


Goodyear Belt Adhesion (lbs/inch)





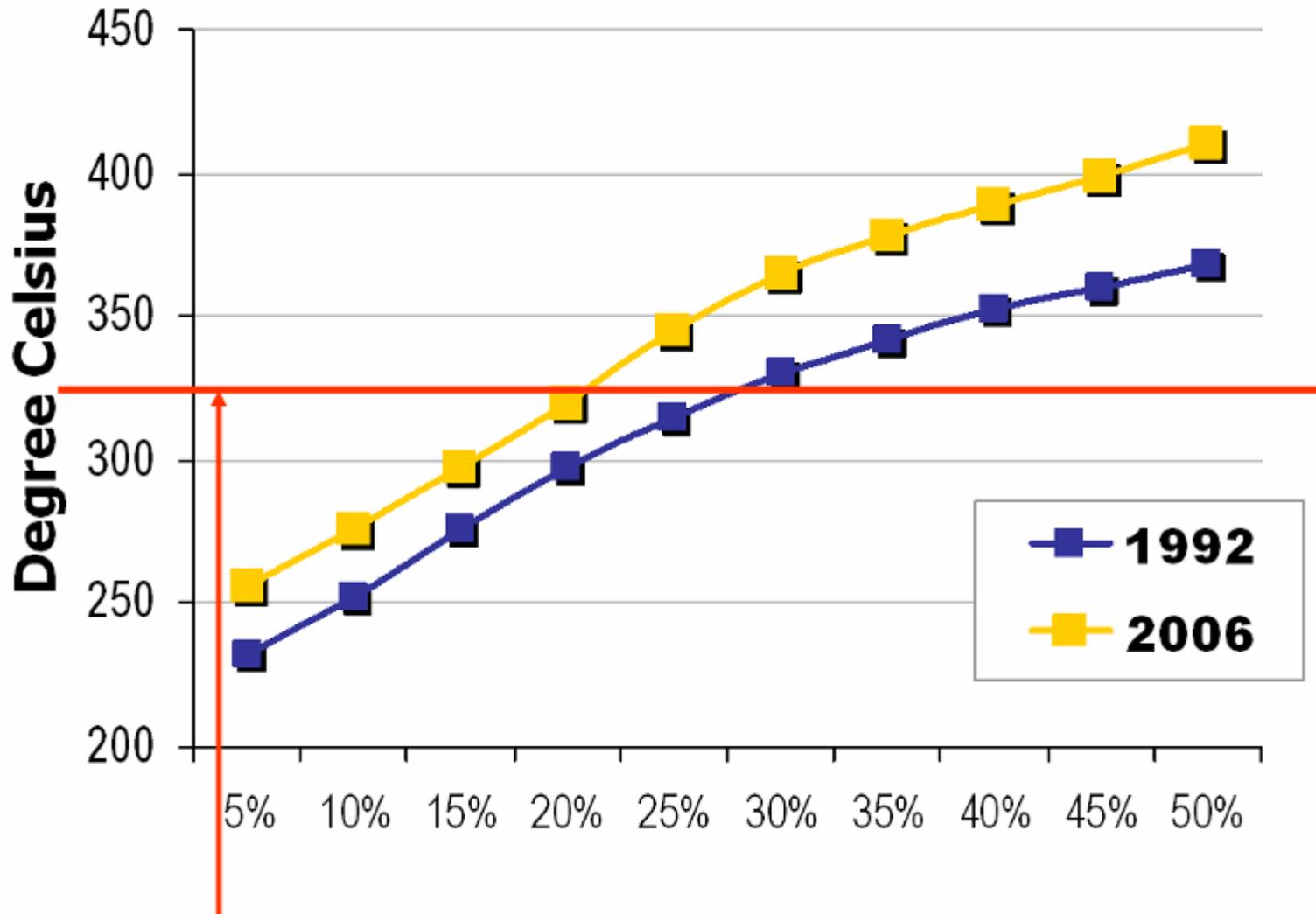
Flammability Resistance



Goodyear belts exceed the MSHA 2G standards
Goodyear tests every roll of belting for release



More Permanent Flame Retardants



New flame retardants remain in rubber at elevated temperatures



Summary - Changes since 1992

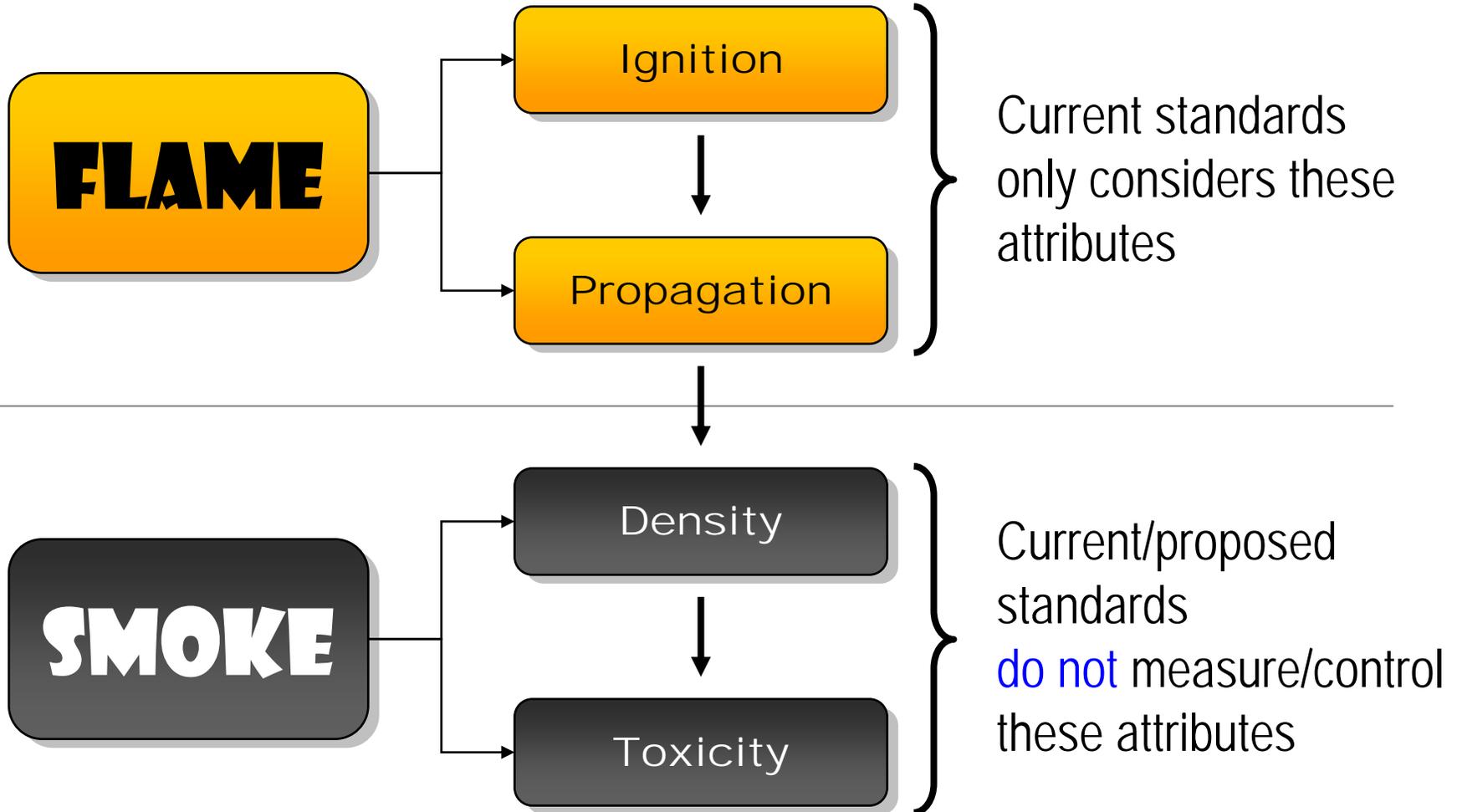
- Belts are thicker/stronger
- Belts are more durable
- Far exceed the current MSHA 2G standard
- Have more permanent flame retardants



Attributes of Safety

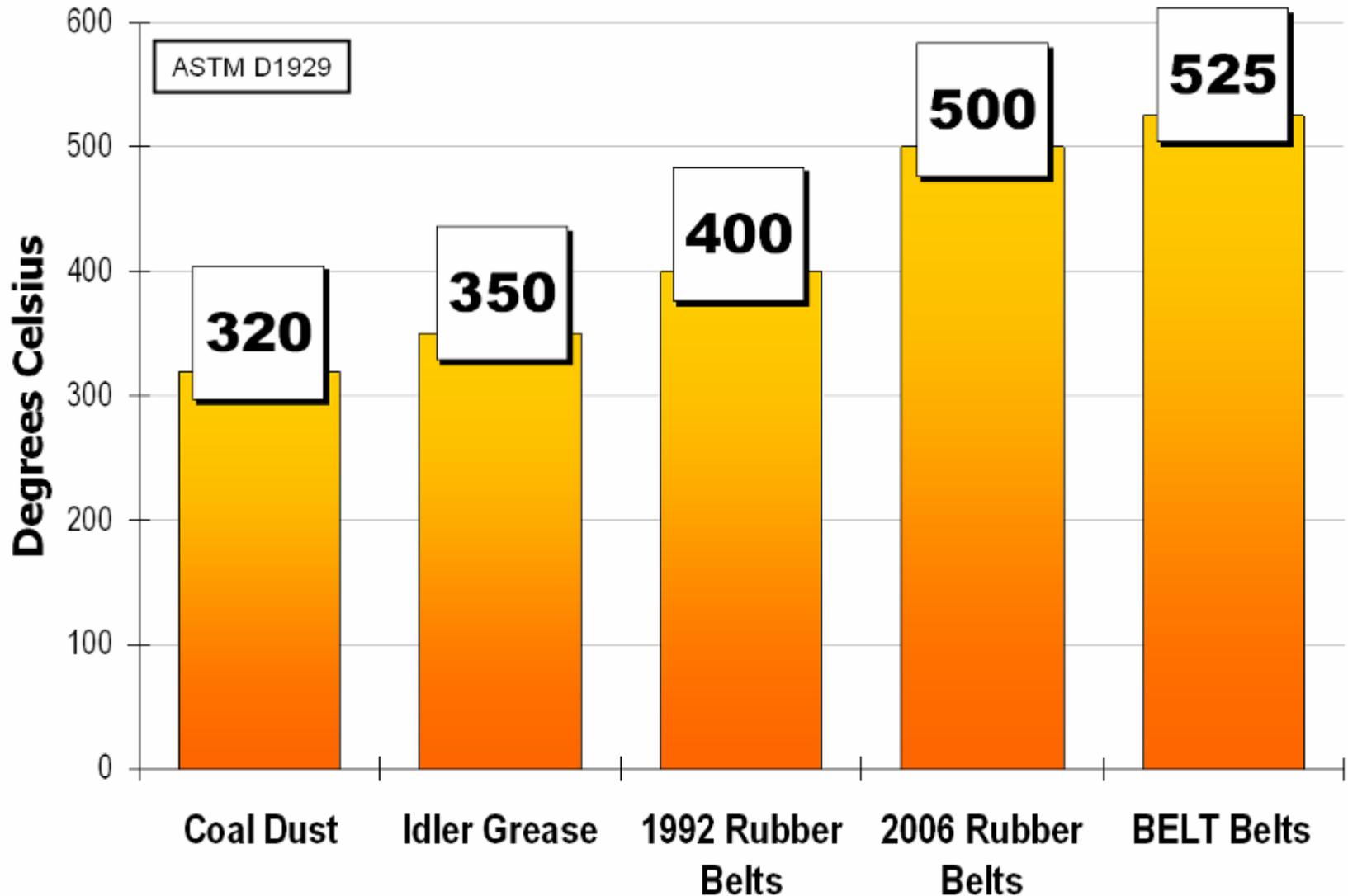


Attributes of Belt Flame Resistance Safety





Belt Safety: What Ignites First?



Belt Safety: Ignition/Propagation Tests

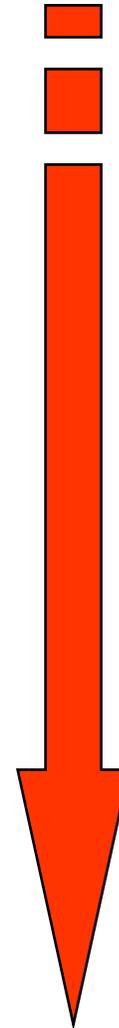
MSHA 2G



ISO 340



B.E.L.T.



Higher level of flame retardants needed



Belt Safety: Smoke

- Smoke is a danger to miners
- Smoke needs to be considered for improved belt safety
- Smoke from a belt can occur without ignition
 - frictional heat

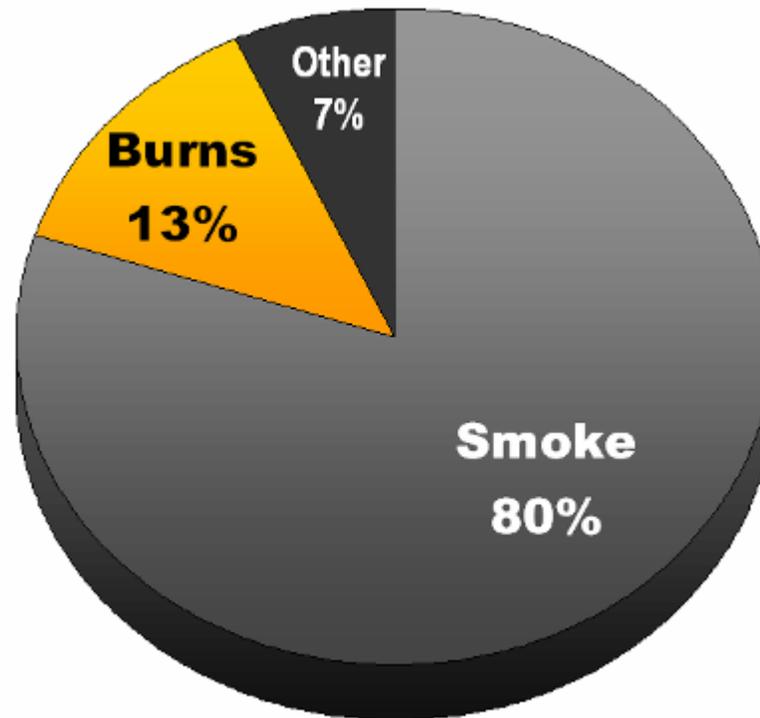


Smoke

- Other industries have studied and addressed this issue
 - PetroChemical
 - Non-Residential Construction
 - Aerospace
 - Military
 - *Wire & Cable*



Wire Cable Industry Discovered



Causes of Death from Fire*

* Lew, C.F., "Flammability testing: fighting fire with fire", ME, August 1989, 31-34.



Belt Safety: Smoke & Halogens

There are two groups of flame retardants that can be added to hydrocarbon materials (rubber/plastic etc)

Halogenated Materials

Contain Bromine or Chlorine
Very effective for propagation resistance
Lower cost than alternate materials

Halogen Free Materials

Use non halogenated materials.
Higher levels needed to be effective for propagation
Higher cost than Halogenated materials - depends on type/level of flammability resistance



Wire/Cable Industry

Benefits of Halogen Free materials

- Low Smoke
 - Improved visibility, less irritating.
 - More time to escape, Increases time to exit the fire area.
- Low Corrosivity
 - Acid gases from halogens corrode and damage equipment during and after fire.
- Low Toxicity
 - Less harmful emissions.
 - Increases time to exit the fire area.



Wire/Cable Industry

- Typical Test Methods

- Smoke Density:
 - ASTM E662
 - NES 711
 - JCS 397
- Toxicity:
 - NES 713
 - Pittsburgh Protocol
 - BSS 7239

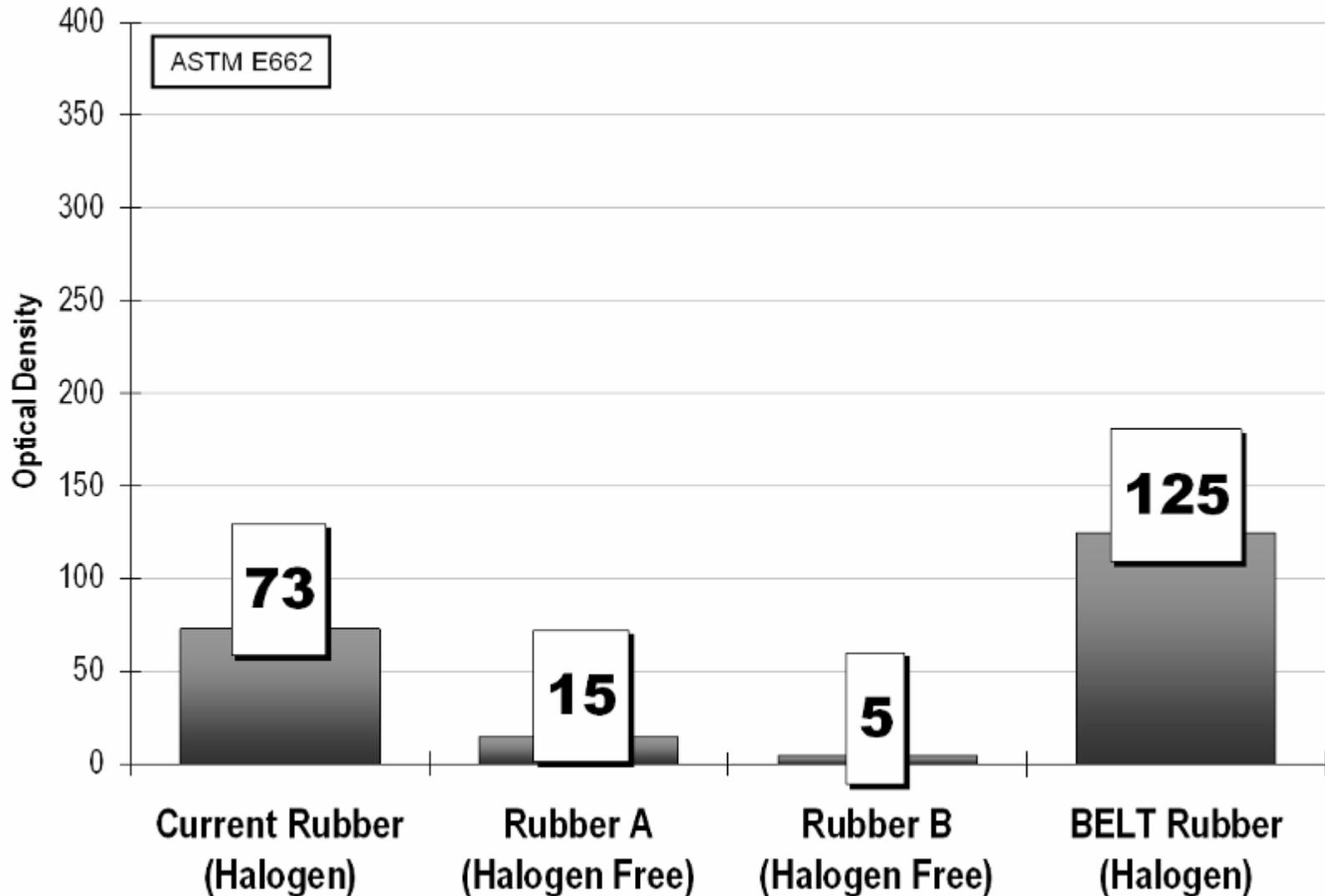


Actual Belt Tests



Smoke Density from Belts

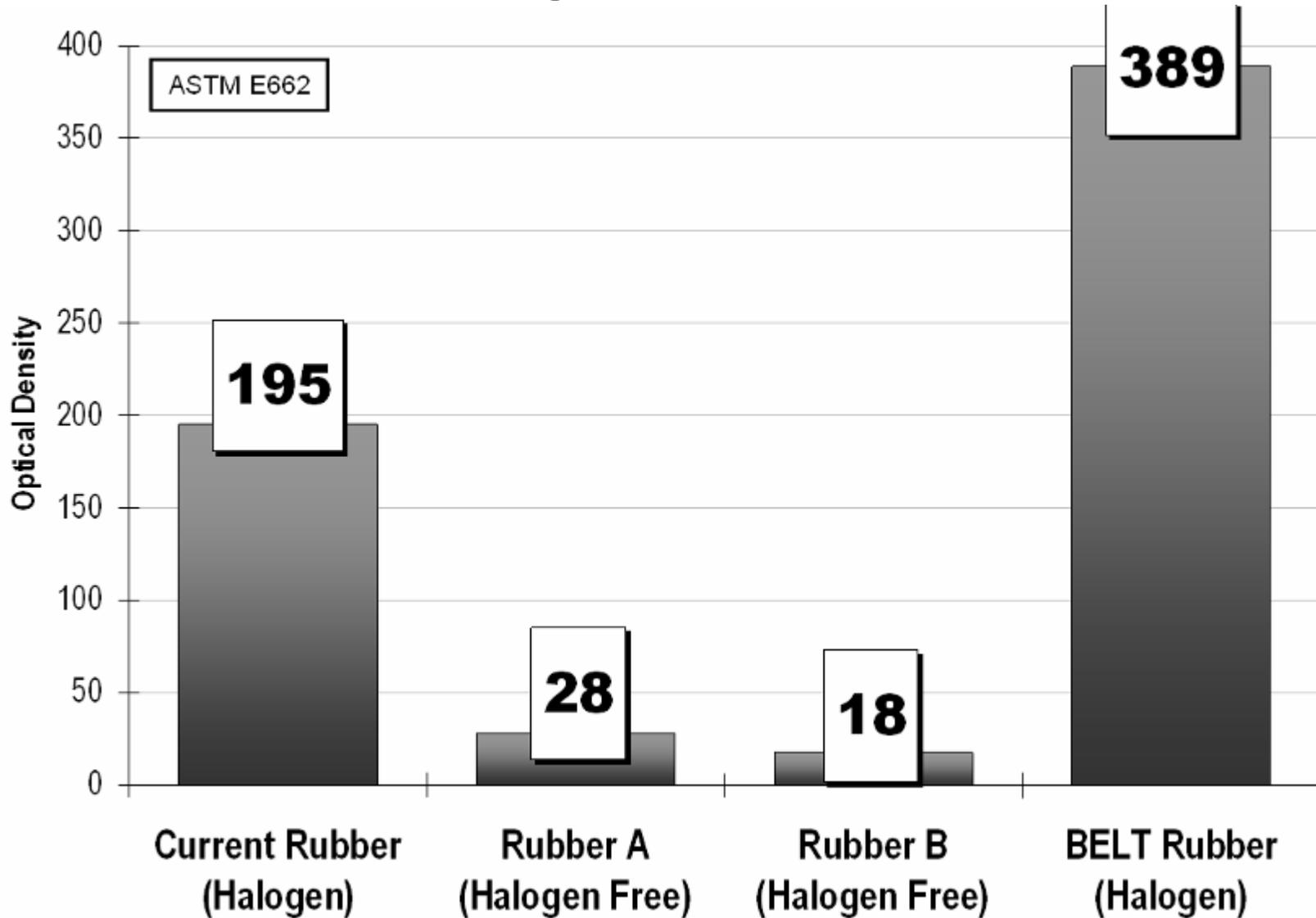
After 4 Minutes – Smoldering before Ignition





Smoke Density from Belts

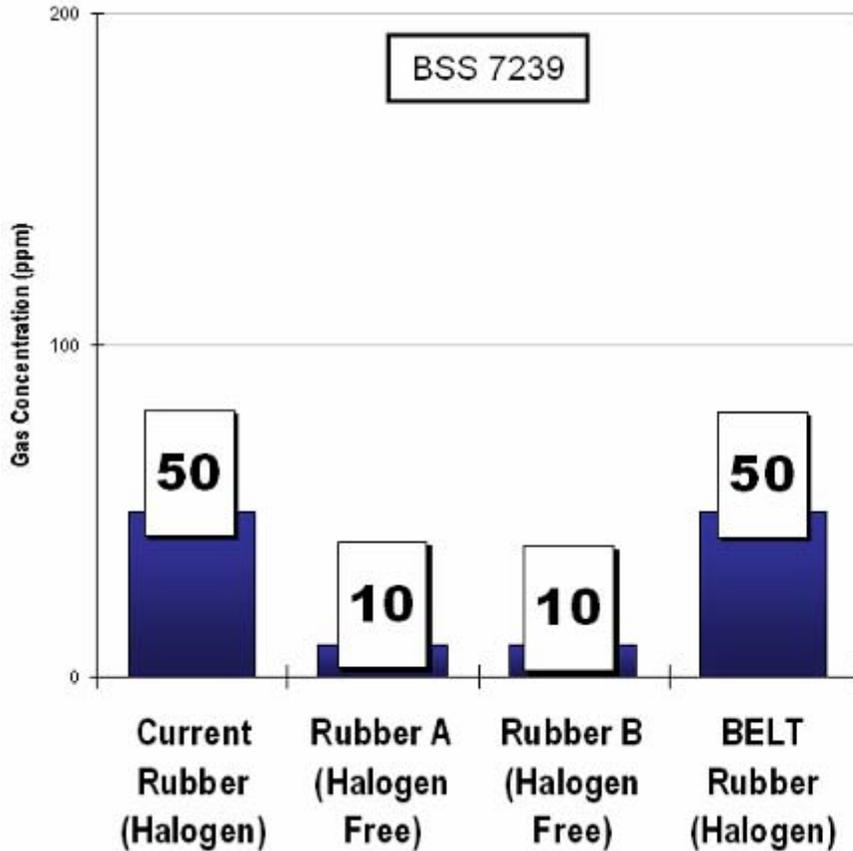
After 4 Minutes – Flaming



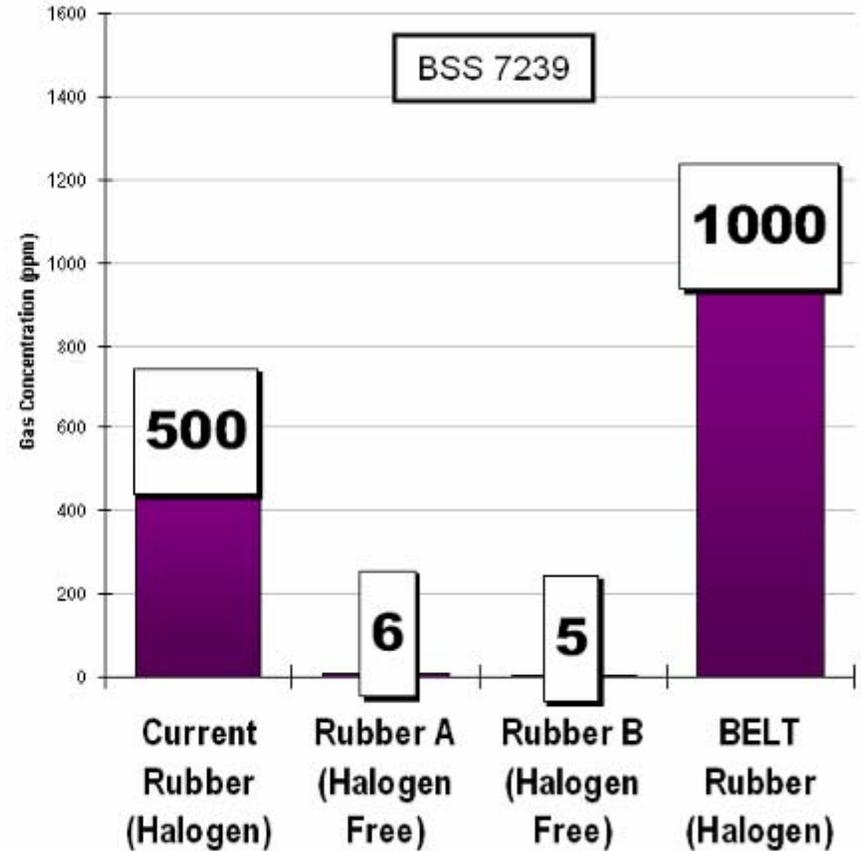


Toxic Gases from Belts

After 4 Minutes – Smoldering before Ignition



Carbon Monoxide
(CO)

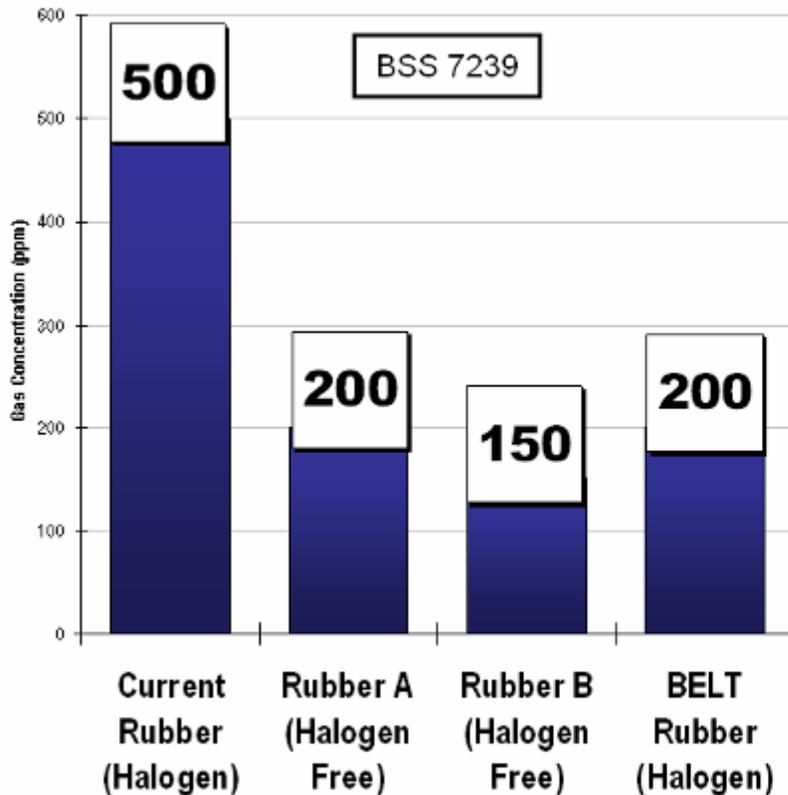


Hydrogen Chloride
(HCl)

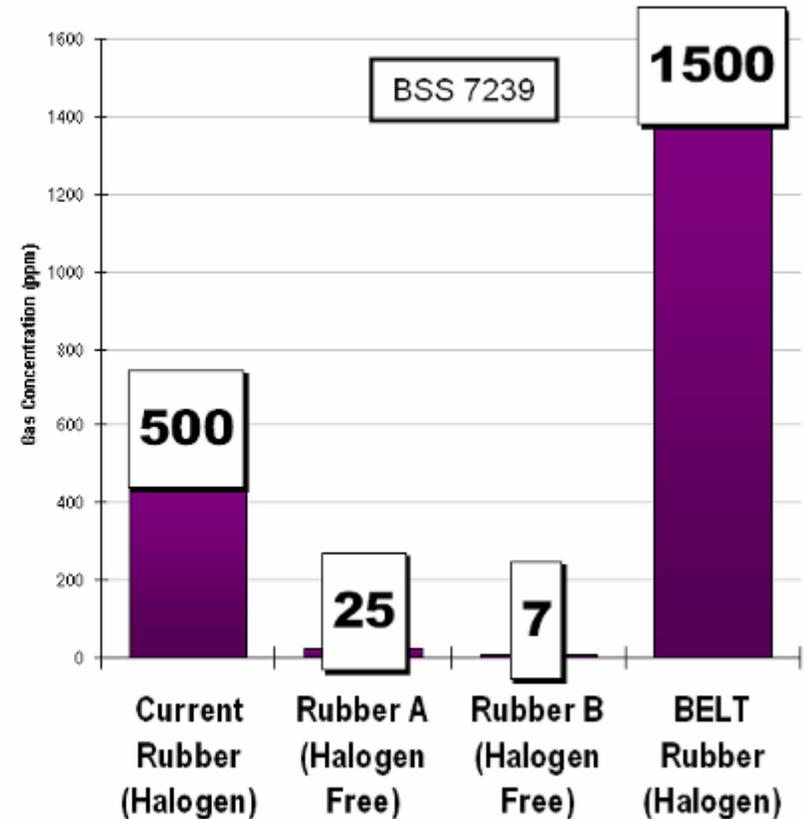


Toxic Gases from Belts

After 4 Minutes – Flaming



Carbon Monoxide
(CO)



Hydrogen Chloride
(HCl)

MSHA Flame Test

Current Belt



Halogen Free A



MSHA Flame Test

B.E.L.T.

Halogen Free A





Smoke from Frictional Heat

- Drum Friction Test used in other regions of the world
 - Run for 1 -2 hours
 - Belt must stay below 325C
 - PVC belts melt and break
 - Rubber belts glaze over and stay intact

Drum Friction Test

Belt 1

Belt 2

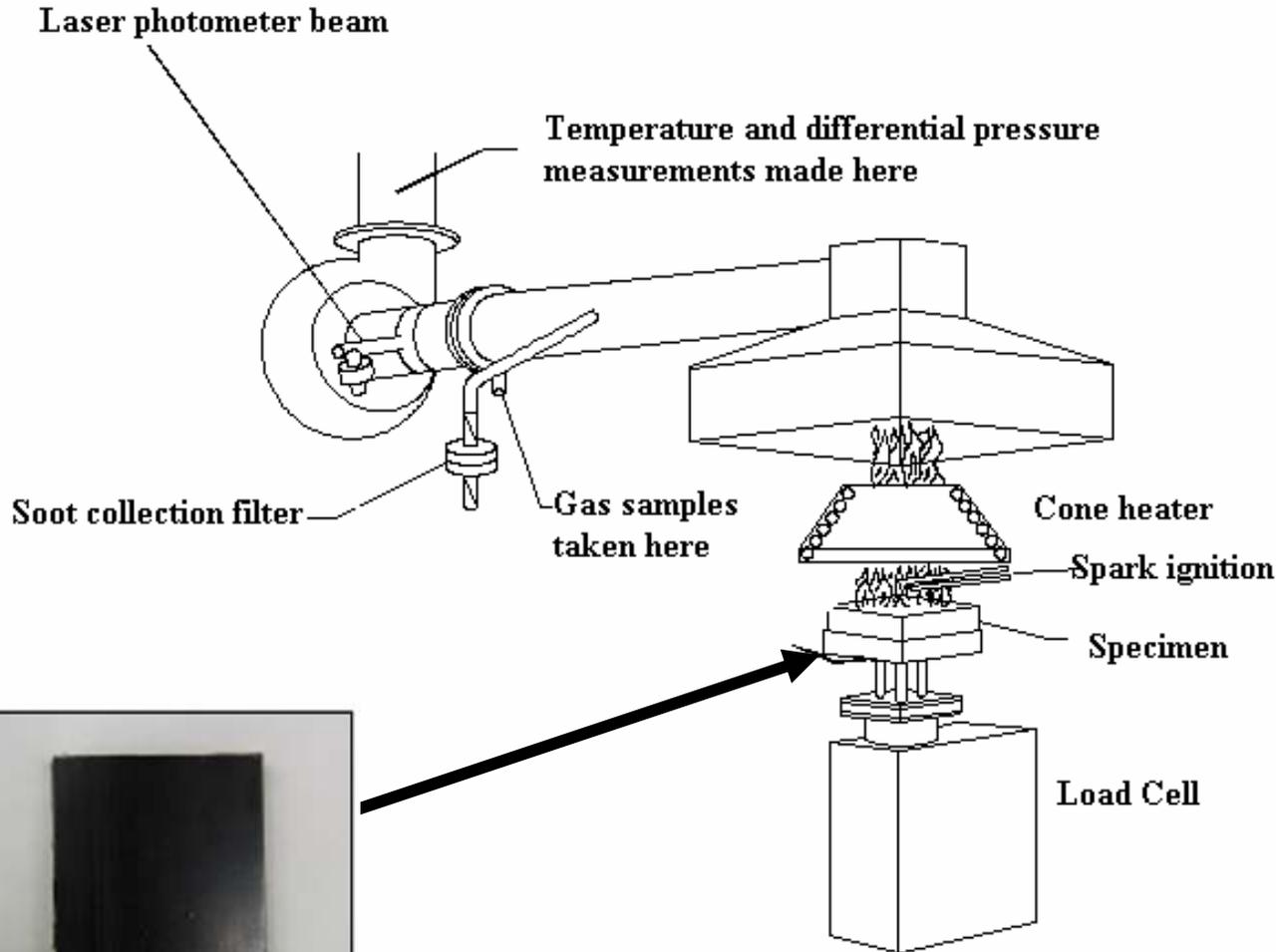




Another Test Method For Smoke Analyses



Cone Calorimeter



- Heat Release Rate
- Effective Heat of Combustion
- Specimen Mass Change
- Smoke Density
- Gas Analyses



Factory Mutual and CSIRO, Australia have used cone calorimeters to study conveyor belts



Cone Calorimeter Demonstration





Cone Calorimeter Benefits

- Measures key properties in controlled conditions.
- Measurement of both flammability AND smoke.
- Small sample size.
- Used extensively by other industries.



A Systems Approach



Belt Safety: A Systems-Based Approach

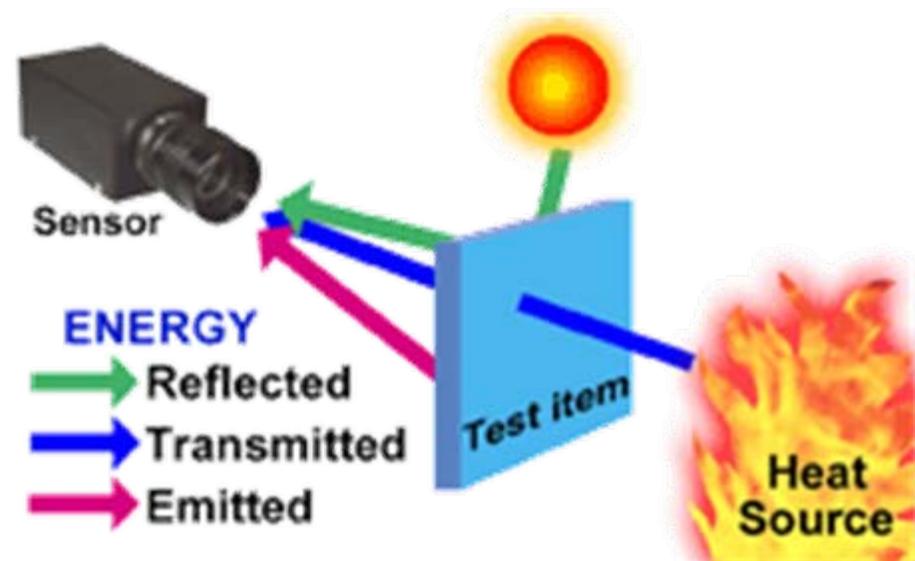
- Belt fire safety is **MORE** than just the flame resistance of the belt.
- Smoke density/toxicity needs to be evaluated.
- Temperature detection and suppression can be integral to belt safety.



Infrared (IR) Sensors

Detection of IR Radiation

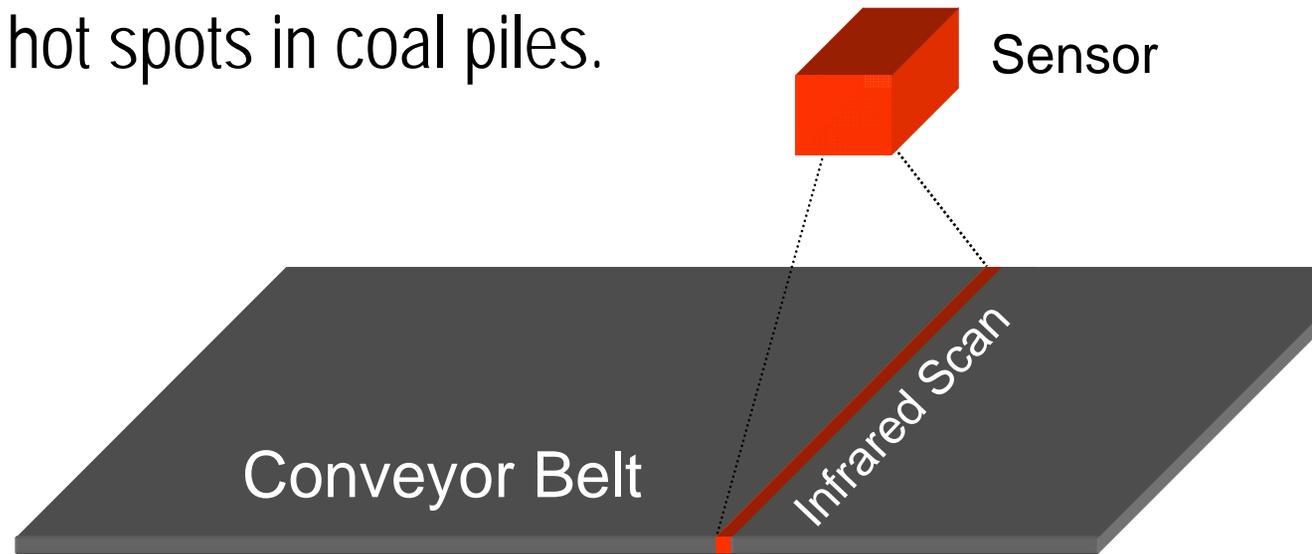
- IR sensors detect:
 - Emitted IR radiation
 - Reflected IR radiation
 - Transmitted IR radiation



- IR radiation can be used to directly measure the temperature of a material, conveyor belt and coal – not air temperature

Infrared Temperature Detection system

- High resolution IR line scan and quick hot spot detection
- Alarm can be relayed to suppression systems and/or belt controls.
- Currently in use in other conveyor belt applications (power plants/grain handling).
- Used to detect hot spots in coal piles.



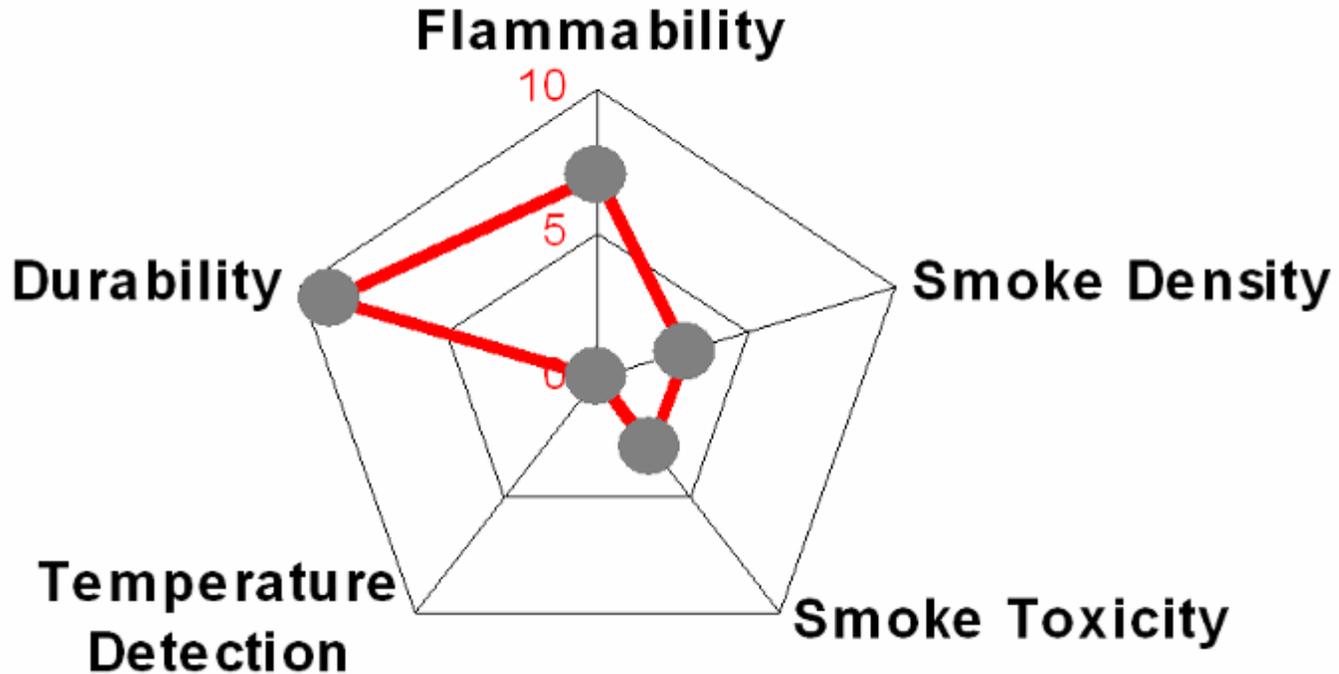


Temperature Detection Demonstration





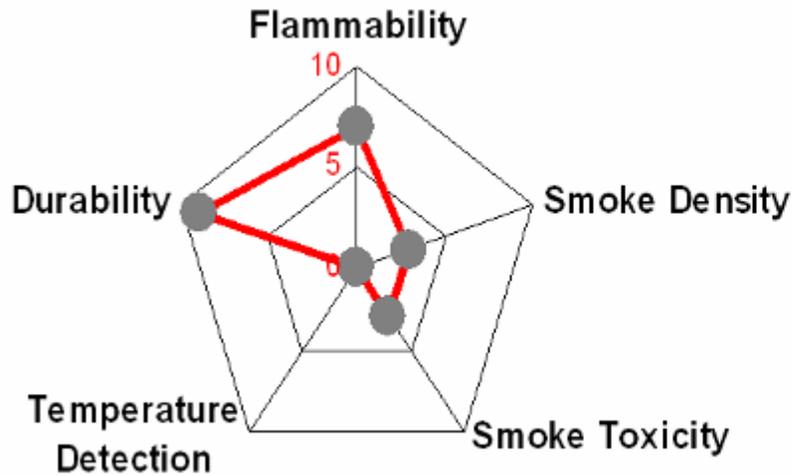
Systems Based Approach



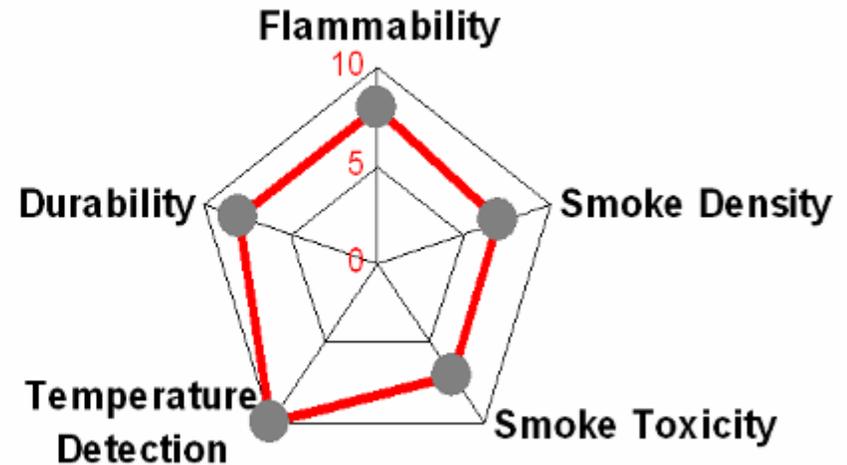
Rubber Halogen
Current Belts



Systems Based Approach



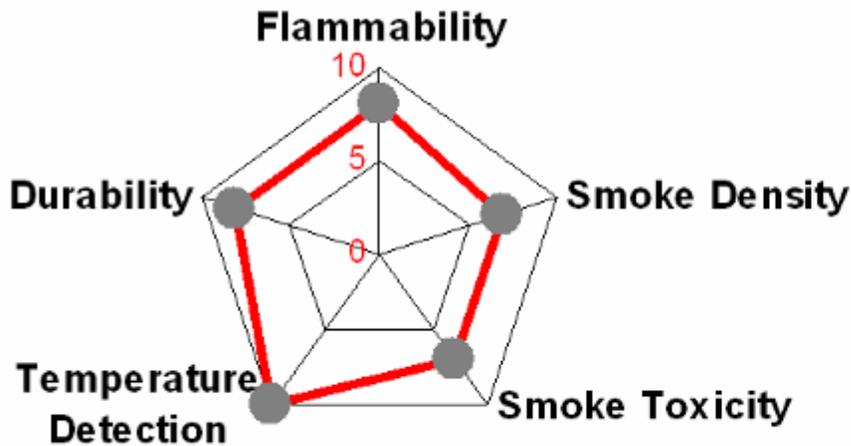
Rubber Halogen
Current Belts



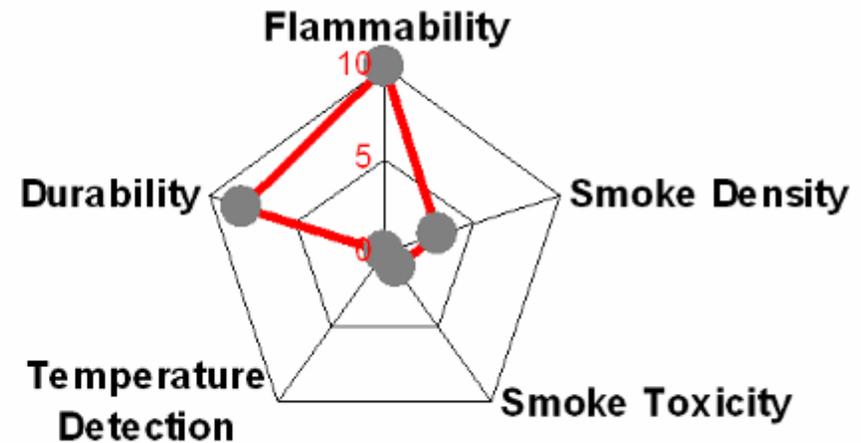
Halogen Free Belts with
Temperature Detection



Systems Based Approach



Halogen Free Belts with
Temperature Detection



BELT Rubber
Halogen



Process for Improving Conveyor Belt Safety

- Include all elements of belt safety
- Inclusive, open, transparent process for developing new test standards

All stakeholders represented in development standards and tests procedures

- Government agencies
- Unions
- Mines
- Belt manufacturers

- RMA may be an option to pull together all stakeholders





Examples of Consensus Standards Process

How RMA Has Helped Safety



Welding hoses

- Standard developed with RMA (hose manufacturers) and CGA (Compressed Gas Association)
- 3 separate hose specifications issued in 1987 - oxygen/acetylene/propane/MAPS

Anhydrous ammonia hose assemblies

- Anhydrous ammonia very aggressive material.
- Hose specifications/test procedures issued to ensure hose and hose assemblies are resistant to anhydrous ammonia and that care/maintenance guidelines are communicated.

Industry has seen dramatic improvement in hose/hose assembly performance since 1989



Summary

- **Goodyear supports improved safety for miners**
 - Yesterday, today and tomorrow ...
- **Conveying Belting is safer today**
 - More permanent flame resistance
 - Higher ignition points
 - Better adhesions/durability
 - Thicker constructions
- **Smoke density/toxicity should be considered**
 - Smoke is a significant danger to miners – reaches working areas faster and can't always be detected
 - MSHA recognizes this by requiring CO monitoring systems in mines today
 - Other industries have successfully addressed - Halogen free
- **Temperature detection has greatly improved in recent years**
 - Measures the actual temperature of surfaces not the surrounding air temperature
 - Redundant systems raises the level safety in mines
- **Rubber Manufacturers Association involvement has proved helpful in other industries**
 - Standardization
 - Accelerated industry consensus



Thank You.