CAST URETHANE
THE DURABLE NOISE SOLUTION

Mining Hearing Loss Prevention Workshop

Salt Lake City, Utah

Presented By:

- Kary Valentine
- Product Development Manager
- C.U.E. Incorporated
- September 26, 2006
- NIOSH Hearing Loss Prevention Workshop
- Salt Lake City, Utah

What is C.U.E.?

- We are a privately-held company with two facilities, dedicated entirely to molding cast polyurethanes.

C.U.E.'s History

- We trace our polyurethane molding roots back to 1957, when we were part of the Armstrong Cork Company.
- In the mid 1970's, we were purchased by a California-based conglomerate called Fluorocarbon.
- In 1986, the division was bought by its managers and we became C.U.E., Inc.
- Since 1986, generous reinvestment into the company has fueled our growth and built our loyal and growing customer base.

C.U.E. Today

- C.U.E. is now one of the United States' largest molders of cast urethanes.
- We have over 100 loyal employees in two locations: Cranberry Township, PA and Mount Hope, WV.
- We have over 120,000 square feet of manufacturing space, processing about 3 million pounds of urethane annually.
- The quality of our urethane products generates a global demand, and we ship our products to more than 50 countries every year.

Our Polyurethane Materials

C.U.E. Materials

- Over the past 45 years, we've worked with thousands of customers and produced tens of thousands of different parts.
- Through this history, we've developed dozens of proprietary urethane compounds to meet virtually any elastomeric requirement. These compounds have been enhanced over time and the best remain on our active compound list.
- We currently offer over 35 "standard" C.U.E. compounds to meet your needs.

C.U.E. Materials

- We offer a variety of polyurethane types including MDIs, TDIs, PPDIs, polyethers, polyesters, aliphatics, and polycaprolactones.
- On Staff, Ph.D. Polymer Chemists, helps to match the correct chemistry with any unique requirements.
- Our time-proven formulas regularly out-perform “off-the-shelf” urethanes from smaller shops, and offer an outstanding value to the user.
- We offer durometers from 40 shore “A” to 80 shore “D”.

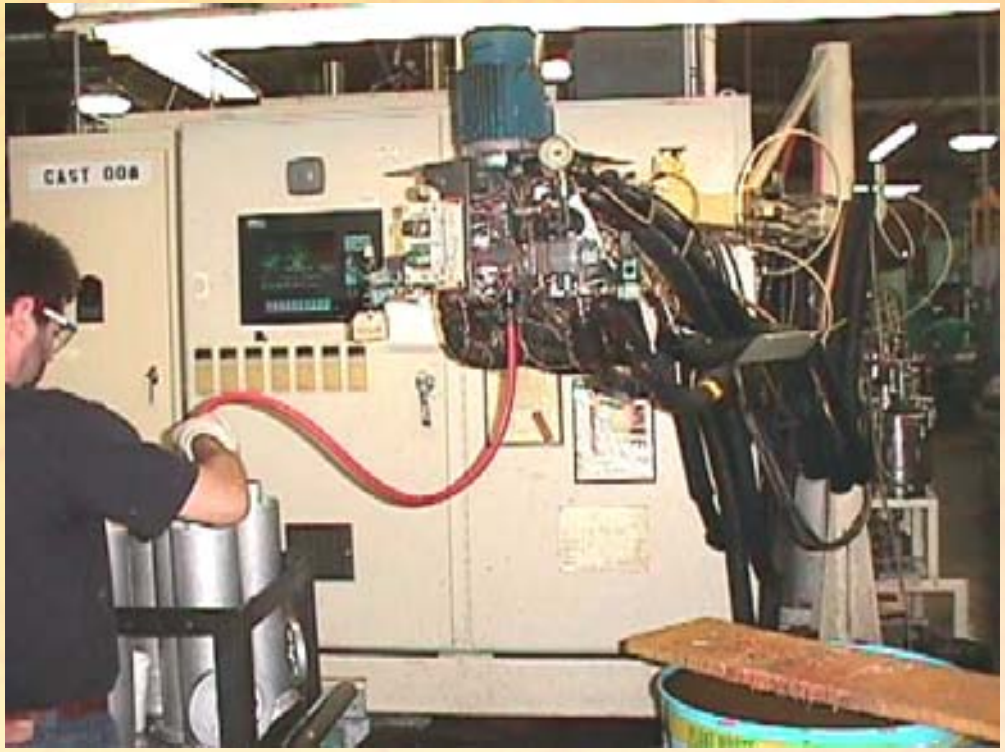
C.U.E. Materials

- Producing highest-quality urethane compounds relies on receiving the highest-quality raw materials that make up our compounds.
- Our size and history give us purchasing power with the major chemical vendors supplying the urethane industry, giving us high-end chemicals at great prices.
- The volume we process allows us to order our own, unique formulations from our vendors, as we receive entire reactor-batches in a single shipment.
- We receive our prepolymers in 43,000 pound shipments via tanker truck.

Manufacturing Capabilities

C.U.E. Manufacturing

- Our materials are processed via state-of-the-art casting machines. We have over 12 machines in operation.

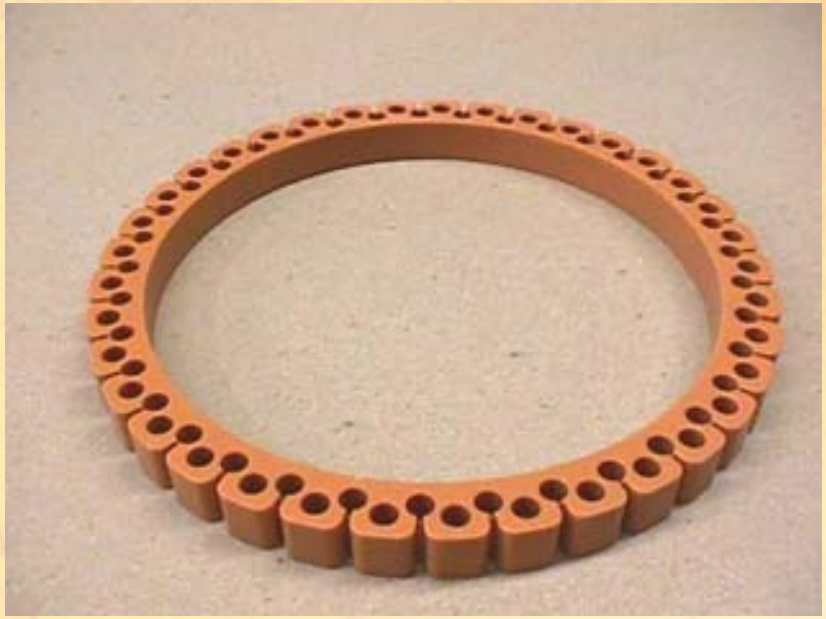


C.U.E. Manufacturing

- Our casting machines allow us to maintain strict control over the process that converts raw materials into polyurethane.
- We do not “hand batch” our urethanes.
- This process control allows for the most consistent results, especially with the harder-to-produce MDI urethanes.
- Our fleet of casting machines allows us to run dozens of different urethane compounds and color combinations everyday.

C.U.E. Manufacturing

- We manufacture parts that weigh any where from only a few grams, all the way up to and over 1000 + pounds per part.



C.U.E. Manufacturing

- Our in-house engineering team designs all of our molds to be simple, cost-effective, and efficient to run.

C.U.E. Manufacturing

- These molds are then run on one of our standard production lines, or, if volume permits, on a dedicated production line with dedicated, skilled operators.

C.U.E. Manufacturing

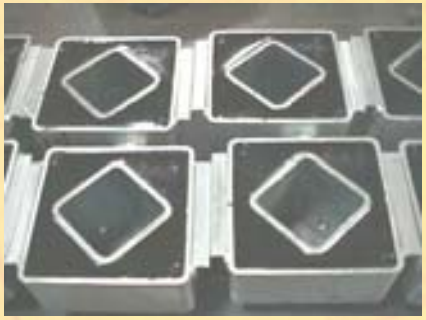
- Once the parts are molded, they are post-cured in ovens for 12 to 48 hours, depending on the material and part application.

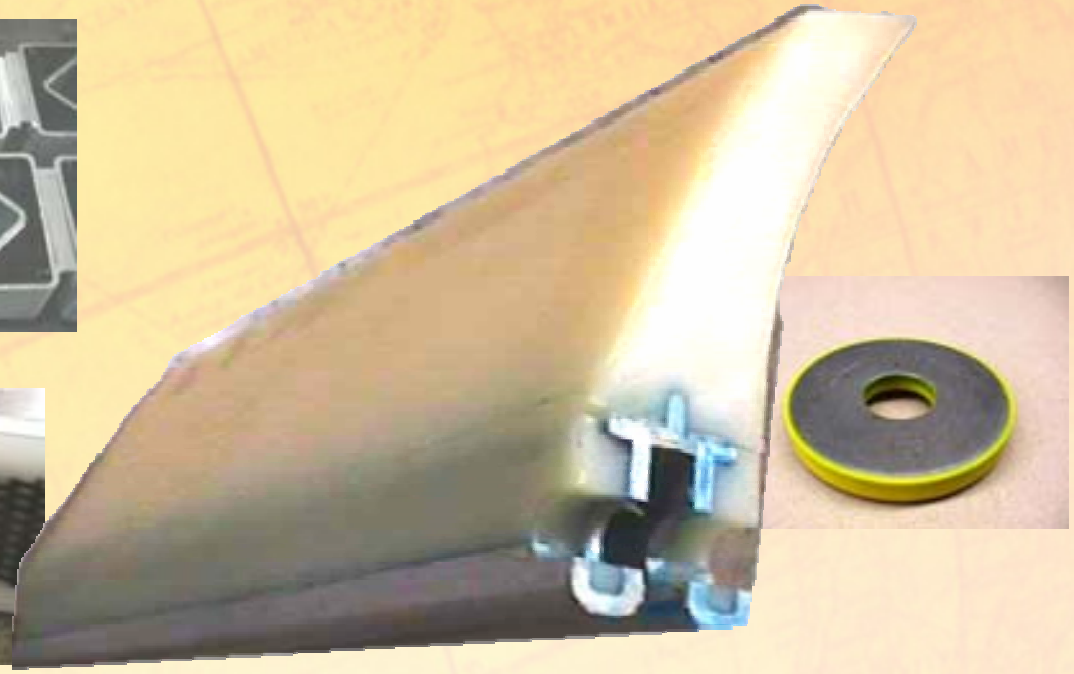
C.U.E. Manufacturing

- After the post-cure, the parts are ready for any needed finishing work.
- We have a large finishing department to handle virtually any customer requirement.

C.U.E. Manufacturing

- We specialize in custom molded urethanes bonded to metal and dual-durometer parts.
- We make dozens of varieties of these specialized parts each production shift.





C.U.E. Manufacturing

- We have become an industry leader in bonding urethane to metal thanks to our proprietary systems for preparing metal to allow a *permanent* urethane bond.

The Road to Durable Noise Control

The Road to Durable Noise Control

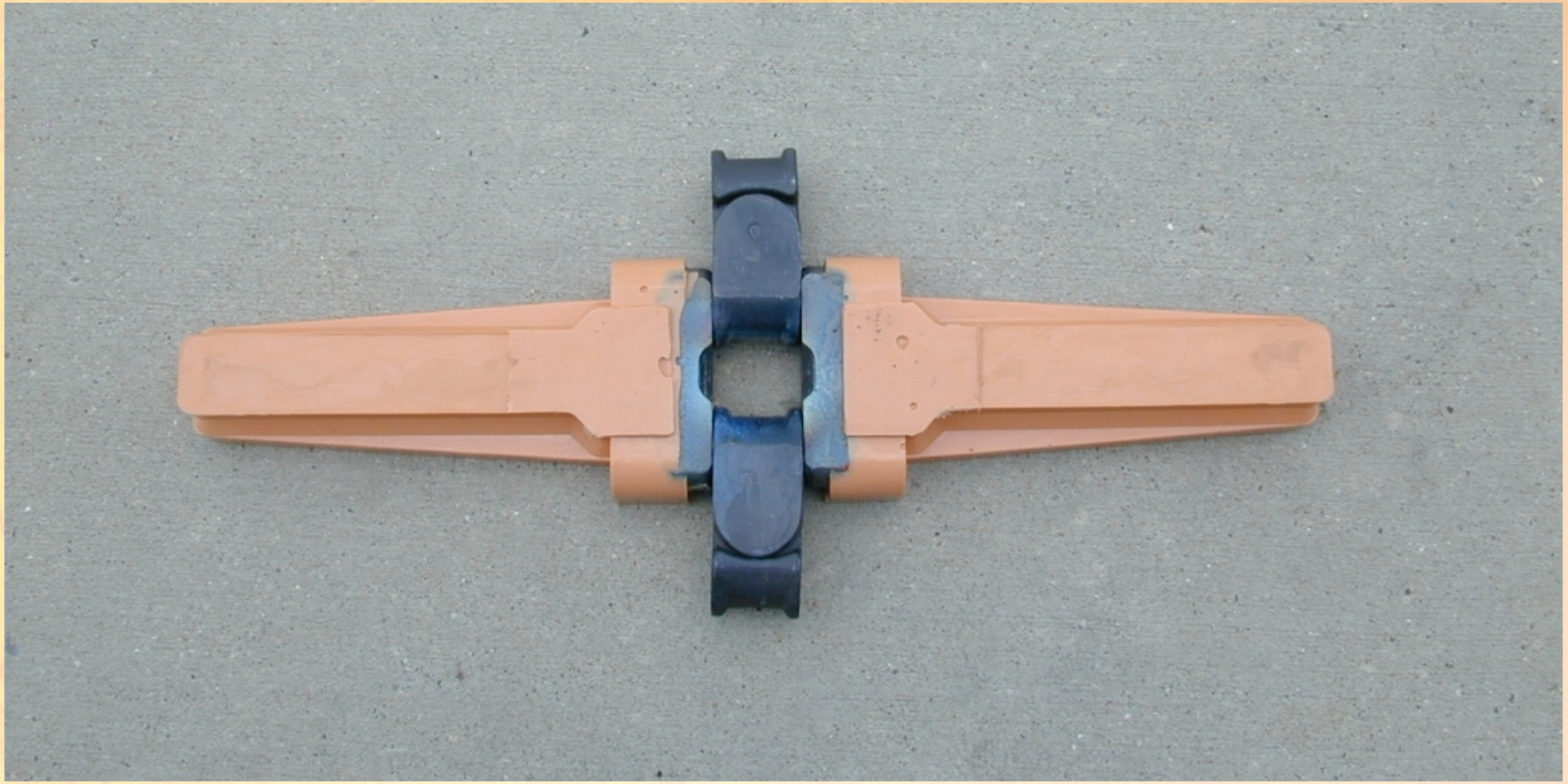
- Around July, 2000 C.U.E. Inc., Joy Mfg. and NIOSH began a relationship which took us down a path -- “The Road to Durable Noise Control”
- The project started at the request of NIOSH to have C.U.E. develop a durable urethane material that would reduce the noise generated by a Continuous Miner Conveyor section.
- In January of 2001 the very first primitive urethane coated flight bar prototypes were delivered to NIOSH for testing and evaluation.

The Road to Durable Noise Control

- At first, Version (1) prototypes were very crude and the urethane covering was only on the bottom surface of the flights so NIOSH could quickly and cheaply test parts in the lab.
- Very soon after the lab tests, new and improved versions of the coated flight bars were designed in conjunction with NIOSH and Joy Manufacturing.
- One of the earliest, Version (2) was a form-fitting, thin urethane coating that enveloped the unmodified forged steel flights.
- The lab tests were impressive, a full 7 dB(A) reduction.
- However, durability and a continued noise abatement in the real world was still thought to be a concern.

COATED FLIGHT BARS

VERSION (2)



COATED FLIGHT BARS

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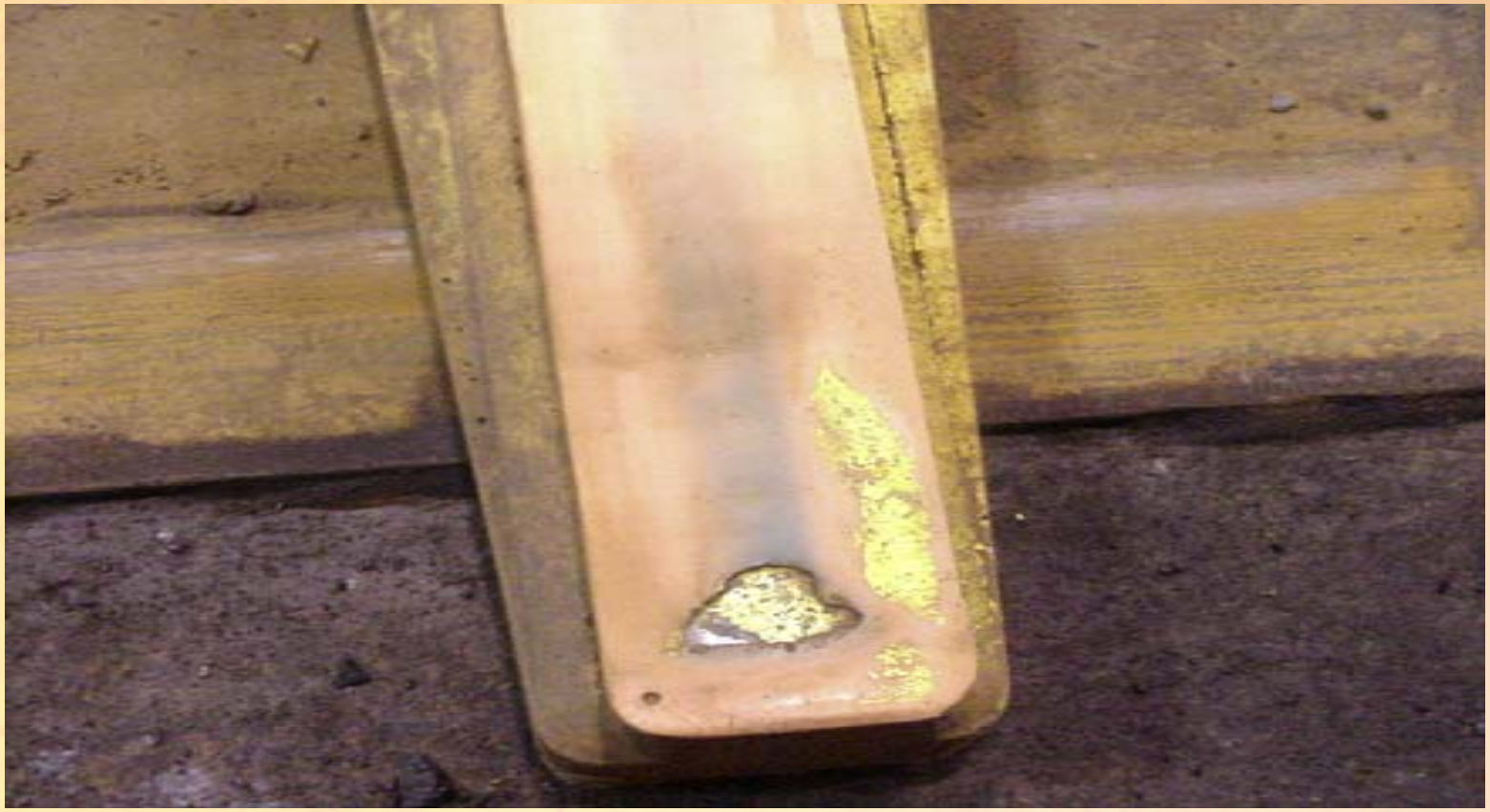


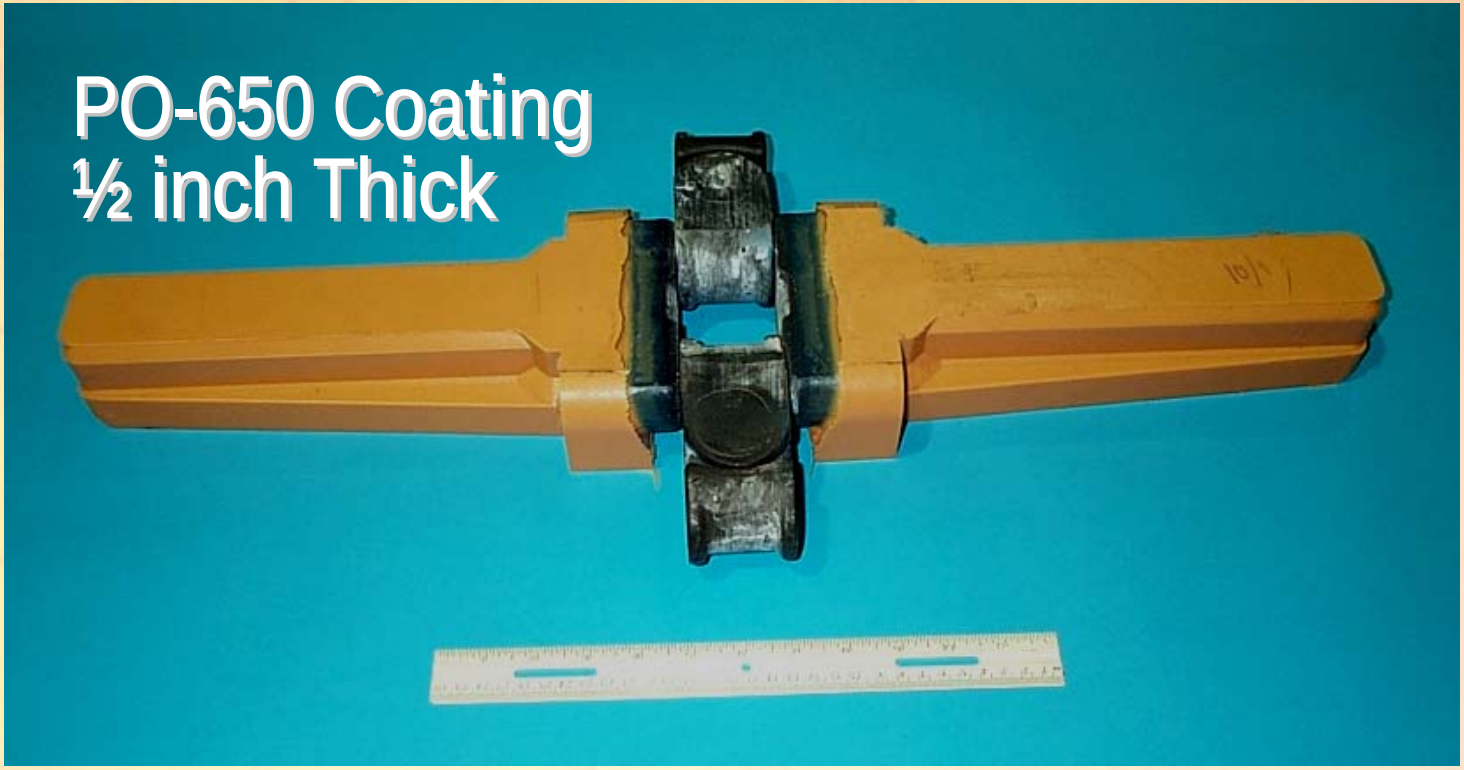
Preliminary Wear from Lab Tests

The Road to Durable Noise Control

- Soon after testing Version (2) in the lab it became apparent that the urethane coating was not robust enough to ensure success in the field.
- It was obvious that the urethane thickness needed to be increased at the expense of the thickness of the forged steel flights.
- Version (3) soon followed with new urethane molds and machined down forged flights to accommodate the extra urethane thickness.
- It was decided at this time to trial two candidate materials:
  - CUE Compounds, PO-650 (Tan) and PO-652 (Red).
- This new test comprised of one chain, assembled with several flights each, manufactured from the two urethane material selections.
- Different colors were used to quickly identify the material selections.

COATED FLIGHT BARS

VERSION (3)



The Road to Durable Noise Control

- Chain flight bars were coated with a durable polyurethane damping material.

- Objectives:
  - Increase bar's damping
  - Minimize impact noise
  - Minimize scrapping noise

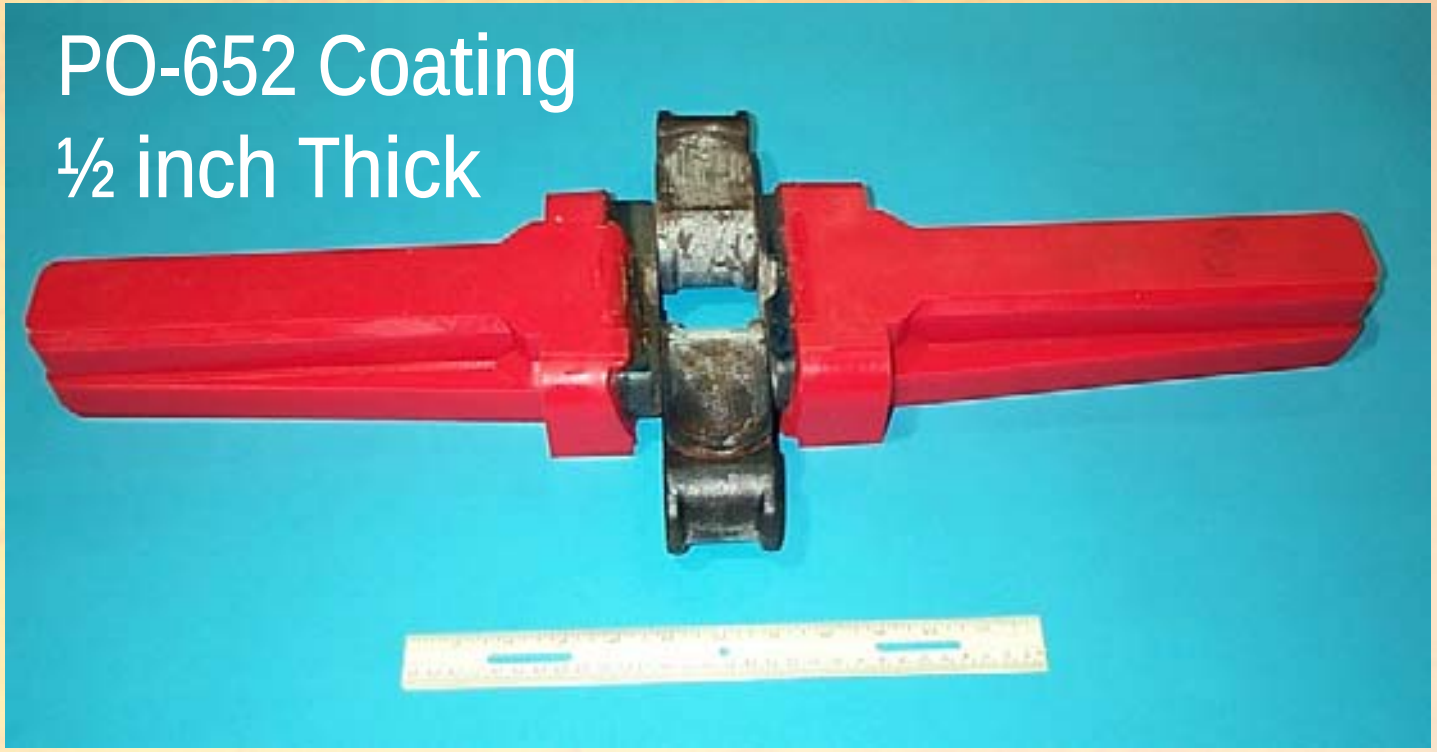
PROPERTIES

- **Polyurethane Material (PO-650)**
- **Durometer 84A**
- **Max. Elongation 550%**
- **Compression Set 45% max.**
- **Ultimate Tensile Strength 6000 psi**

C.UE. Inc.
11 Leonberg Road
Cranberry Township, Pa. 16066-3601 U.S.A.
Phone 724-772-5225
Fax 724-772-5280
Web: www.cue-inc.com

COATED FLIGHT BARS

VERSION (3)



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- **Durometer 93A**
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RESULTS AFTER 128 SHIFTS

52,331 tons mined

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52,331 tons mined

The Road to Durable Noise Control

- Soon after testing Version (3) under ground it was apparent that the urethane formulation which performed best was PO-650 Tan.
- After thorough study of the tested parts it was determined that a slight geometry change of the forged flights as well as the urethane coating would further improve the design.
- Version (4) soon followed, again with new urethane molds and newly machined flights to accommodate the desired geometry changes.
- It was decided at this time that a new, full chain test would be performed under ground with the PO-650 material and the new flight geometry.

COATED FLIGHT BARS

VERSION (4)

UNDER GROUND CONDITIONS

Overcast Rock

UNDER GROUND RESULTS

VERSION (4)

The Road to Durable Noise Control

- Soon after testing Version (4) under ground it became apparent that the urethane coating was quite durable and may even have extended the life of the chain.
- The chain lasted about six months in the relatively severe conditions.
- An un-coated chain typically would last about six months but would have on average (3) failed links in that time frame.
- The urethane coated chain lasted the entire six month time frame without a broken link and proved useful for considerable noise reduction throughout the entire test.
- Noise measurements and testing proved a consistent 7 dB(A) reduction throughout the test period even towards the end of the test when the chain coating appeared very rough in condition.

The Road to Durable Noise Control

- When the chain finally failed it was due to a problem with the Ripper Chain on the Continuous Miner and the entire conveyor chain was destroyed.
- The results however, were quite impressive up to that time, so a new Version (4) chain was manufactured and a new “confirmation” test is currently under way.
- The new test is being conducted in a production coal mine and all involved expect the new chain to last up to 1.5 to 2 times that of a normal chain in these conditions.
- It appears that not only does the urethane coating greatly reduce the noise level of the machine it may also improve the life of the chain as well by way of dampening the shock loading on the chain links.

The Road to Durable Noise Control

- Along with the urethane coated flights CUE, Joy and NIOSH continue with other feasible solutions to help reduce noise exposure to Miners.
- The Coated Tail roller is an example of this continuing work.
- The following slides show progressive versions of urethane and steel tail rollers which come in contact with the coated flights on the Continuous Miner conveyor section.
- These Tail Rollers have been tested in conduction with coated and non-coated flight chains and results from the tests show that an additional reduction of approximately 3 dB(A) can be expected.
- The final design iterations of the Tail Roller will continue and a durable urethane and steel combination is on the horizon.

COATED TAIL ROLLER

VERSION (1)

Machined Core Urethane Casting

COATED TAIL ROLLER

VERSION (2)

Thick Wall Over-molded Urethane Casting

COATED TAIL ROLLER

VERSION (3)

STEEL URETHANE STEEL CONSTRAINED LAYER DAMPNING APPROACH

Conclusion:

- The engineering and subsequent evaluation of durable urethane coated flights has been a great experience.
- The timing of the project has seemed very long and involved but so far, the results of the testing seem to show promise for the future.
- It's been a long sought solution to identify and reduce the excessive noise sources generated by Continuous Mining machines.
- It is fair to say that a full 35% of Miner exposures that exceed the MSHA approved PEL for Noise Exposure are associated with Continuous Mining equipment.
- It is surely our desire that C.U.E. Inc., Joy Mfg., and NIOSH continue to work together and forge ahead to engineer and design feasible controls for this real world problem.

Thank you for your time!

Questions ?