NPE2024 | MADE FOR YOU
The Plastics Show

# How Science-based Training Develops a Skilled Workforce and Contributes to a Greener Future

Richard (Rick) Barnes

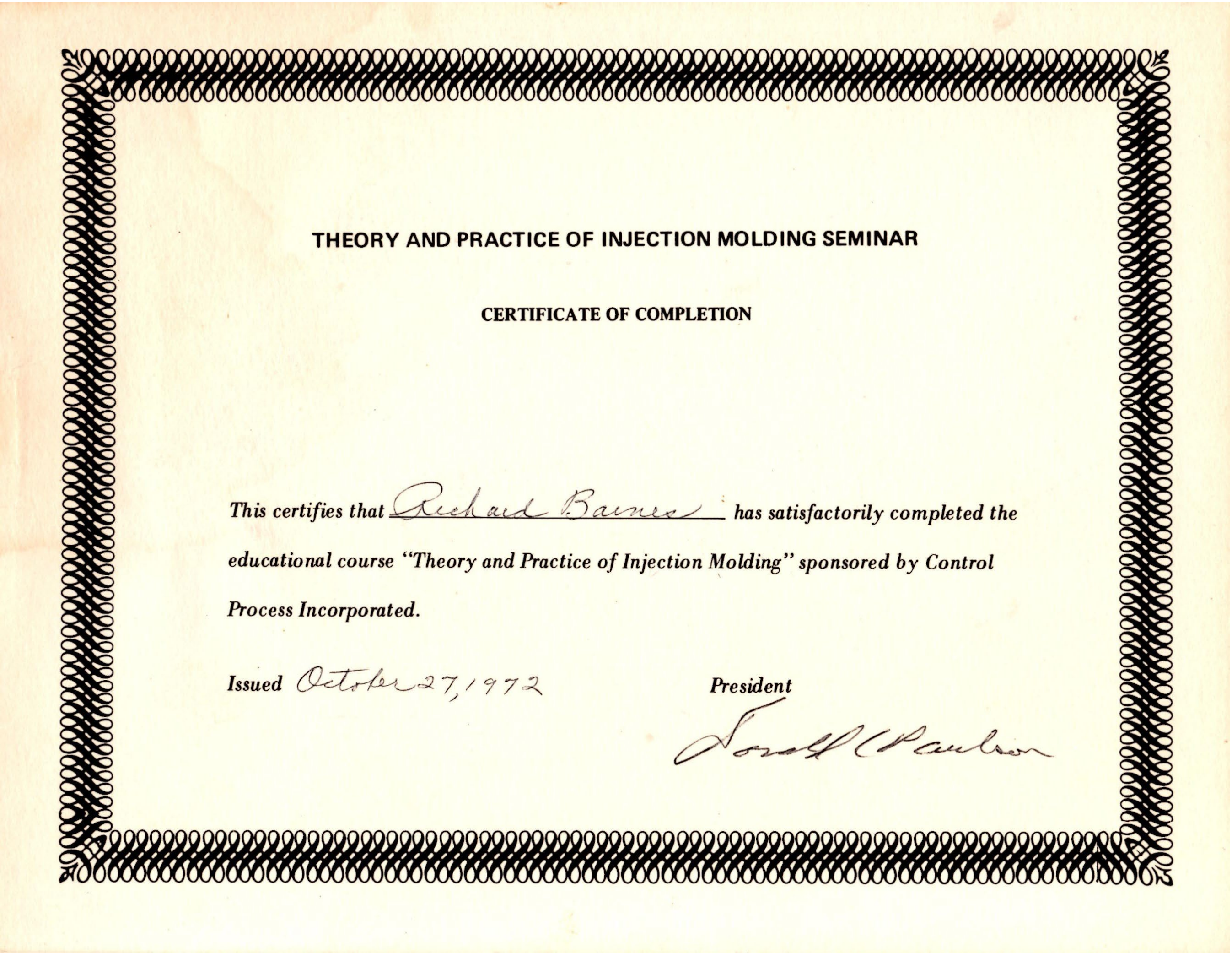
Senior Instructor/Consultant
Paulson Training Programs

## Rick Barnes, Paulson Training Instructor

Canadian trained chemical engineer,
polymer chemistry major,
University of Waterloo.

Quickly learned that my degree taught me how to think, but not how to do.

Had the pleasure of taking formal injection molding training from Control Process Inc.  Donald Paulson himself was the instructor.


THEORY AND PRACTICE OF INJECTION MOLDING SEMINAR

CERTIFICATE OF COMPLETION

*This certifies that* Richard Barnes *has satisfactorily completed the educational course "Theory and Practice of Injection Molding" sponsored by Control Process Incorporated.*

*Issued* October 27, 1972

*President*

Donald Paulson

# 52 Years In The Plastics Industry

Have worked in and taught injection molding, blow molding, extrusion, foam molding, preform manufacture, and advanced composites.

Solid history in developing and running technical training programs for machine operators, where productivity increased dramatically.

A perfect match for Paulson Training. Became an instructor in 2016.

**Paulson**
**Plastics Academy**

# Instructor Certification

In recognition of your leadership in instructor training,

Paulson Training Programs, Inc. is pleased to award this certificate to:

## Rick Barnes

***Who is hereby qualified as a Paulson Plastics Academy Instructor***

This certification number 2016.04.16.008 is valid in accordance with the terms and conditions of the Training Contract for Paulson Training Programs, Inc.

Karen M. Paulson
President, Paulson Training Programs, Inc.

Companies in the plastics industry grapple with the dual challenges of workforce development and environmental impact reduction.

But how do we address those problems without compromising production or quality?

These are not dual challenges.

They are the same challenge looked at from two different perspectives.

# Tribal Method
# vs
# Scientific Method

OR

We’ve always done it that way

Vs

The Better Mouse Trap

# Tribal Method

Tribal knowledge in manufacturing is information regarding a process that is not properly documented and is only available via word of mouth.

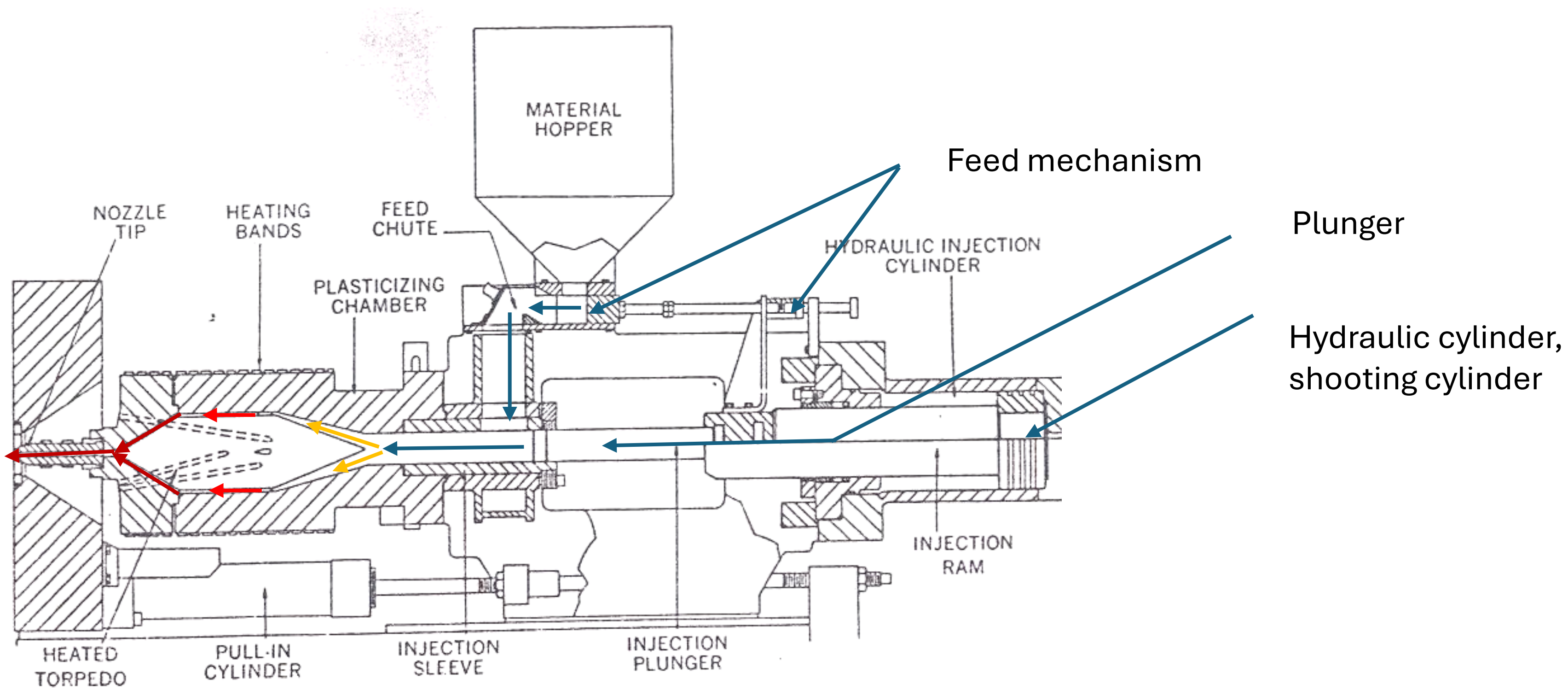
# Tribal Method vs Scientific Method

Starting with simple aspects of plastics processing, we will compare how it was done with how it could be done.

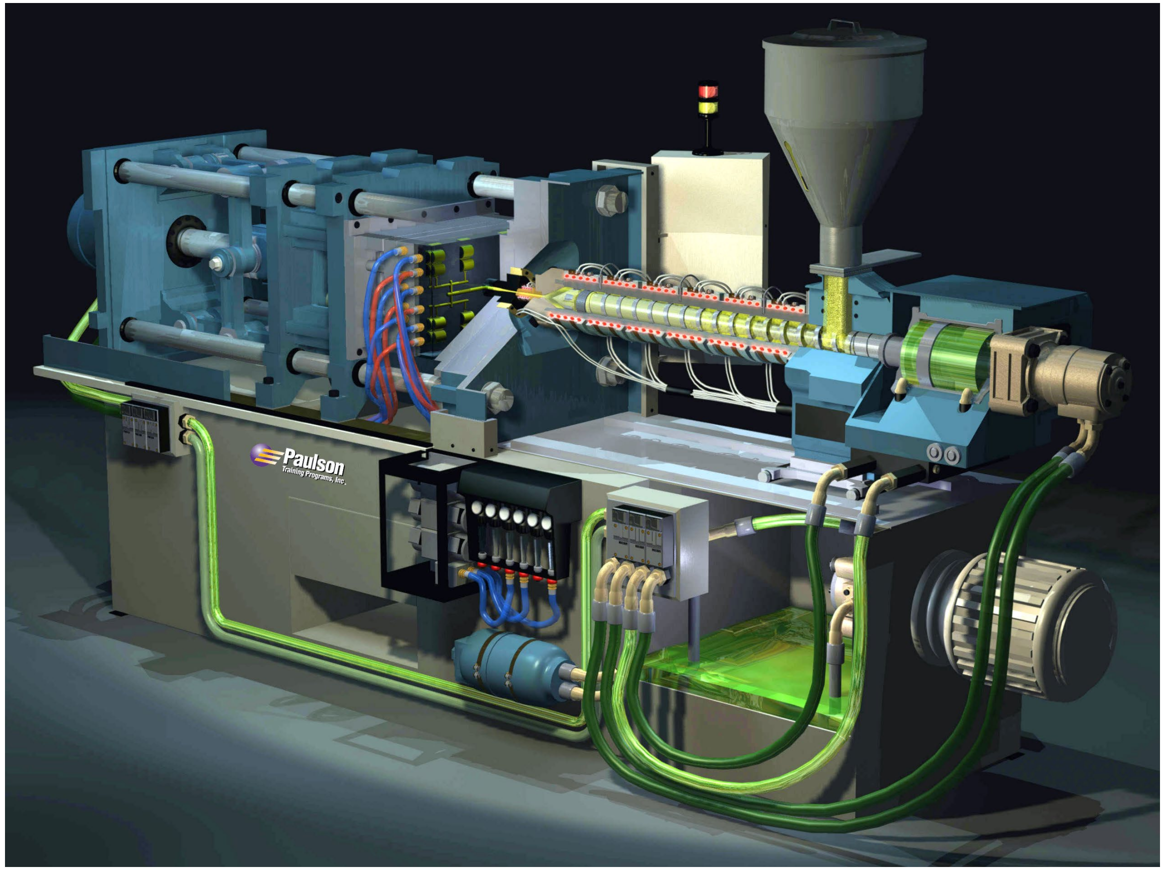
# Tribal Method
# Injection Molding: No Cushion

Cushion is defined as the material remaining ahead of the screw or the screw position when the pack/hold sequence times out.

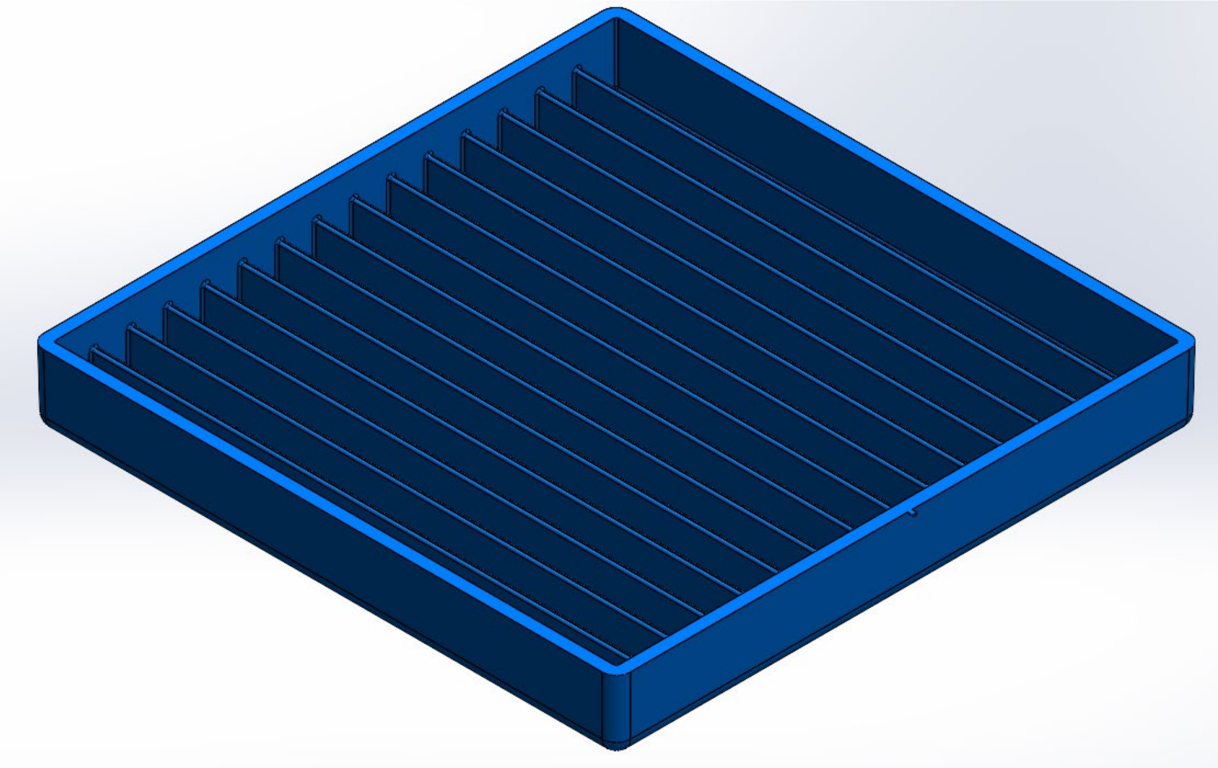
# Tribal Method
# Injection Molding: No Cushion



# Scientific Method
# Injection Molding: Cushion



# Scientific Method
# Injection Molding: Cushion

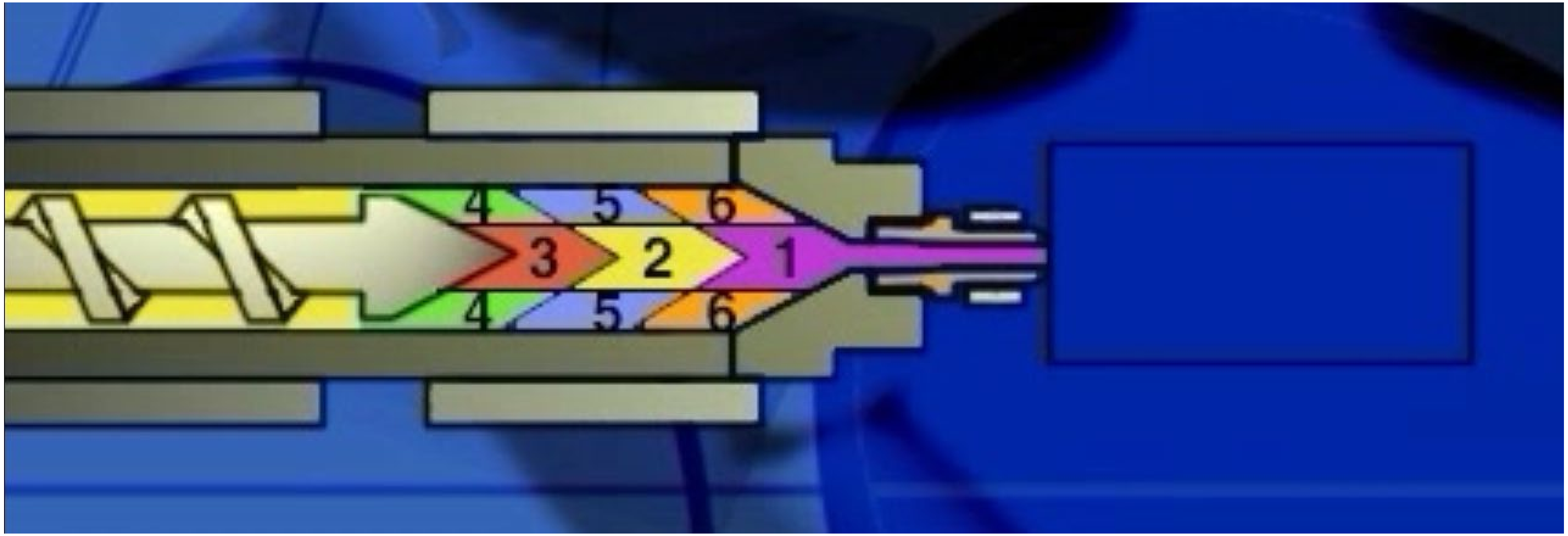


How much cushion?

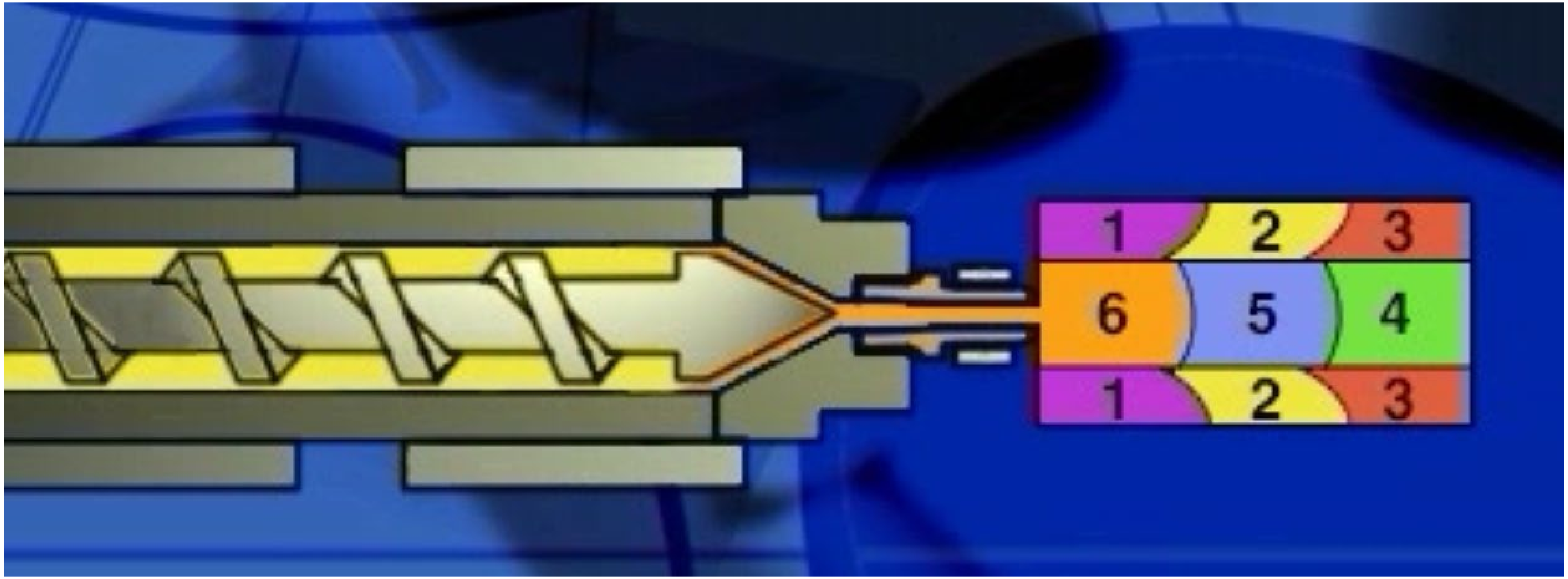
Cushion: ¼” or 10% of screw diameter or 5% to 10% of the shot size.

# Scientific Method
# Injection Molding: Cushion

## How much is too much?

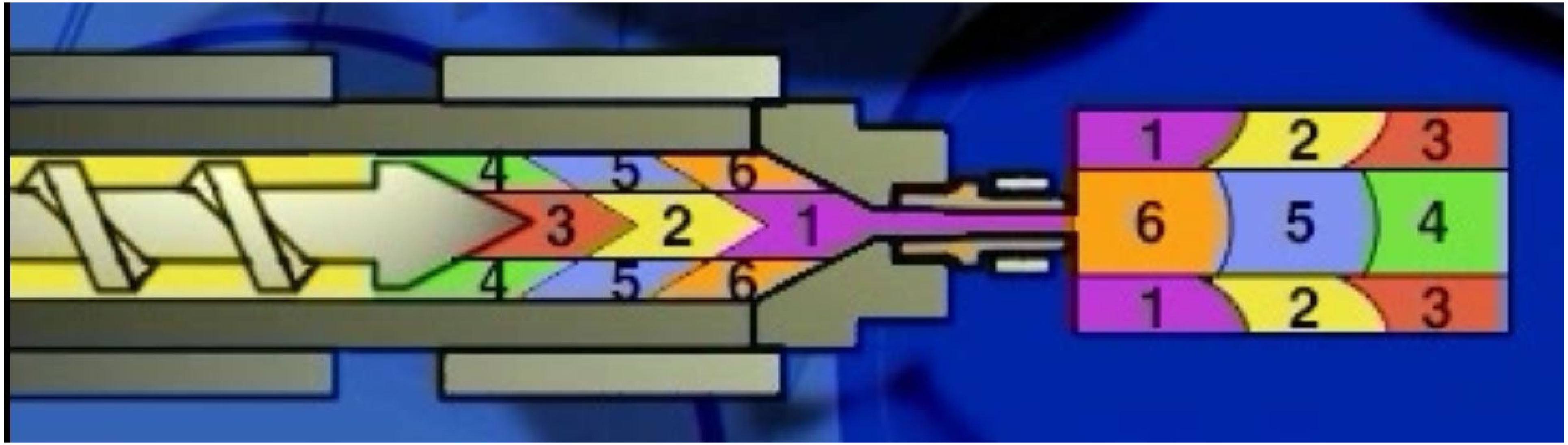


# Scientific Method
# Injection Molding: Cushion




How much is too much?

# Scientific Method
# Injection Molding: Cushion



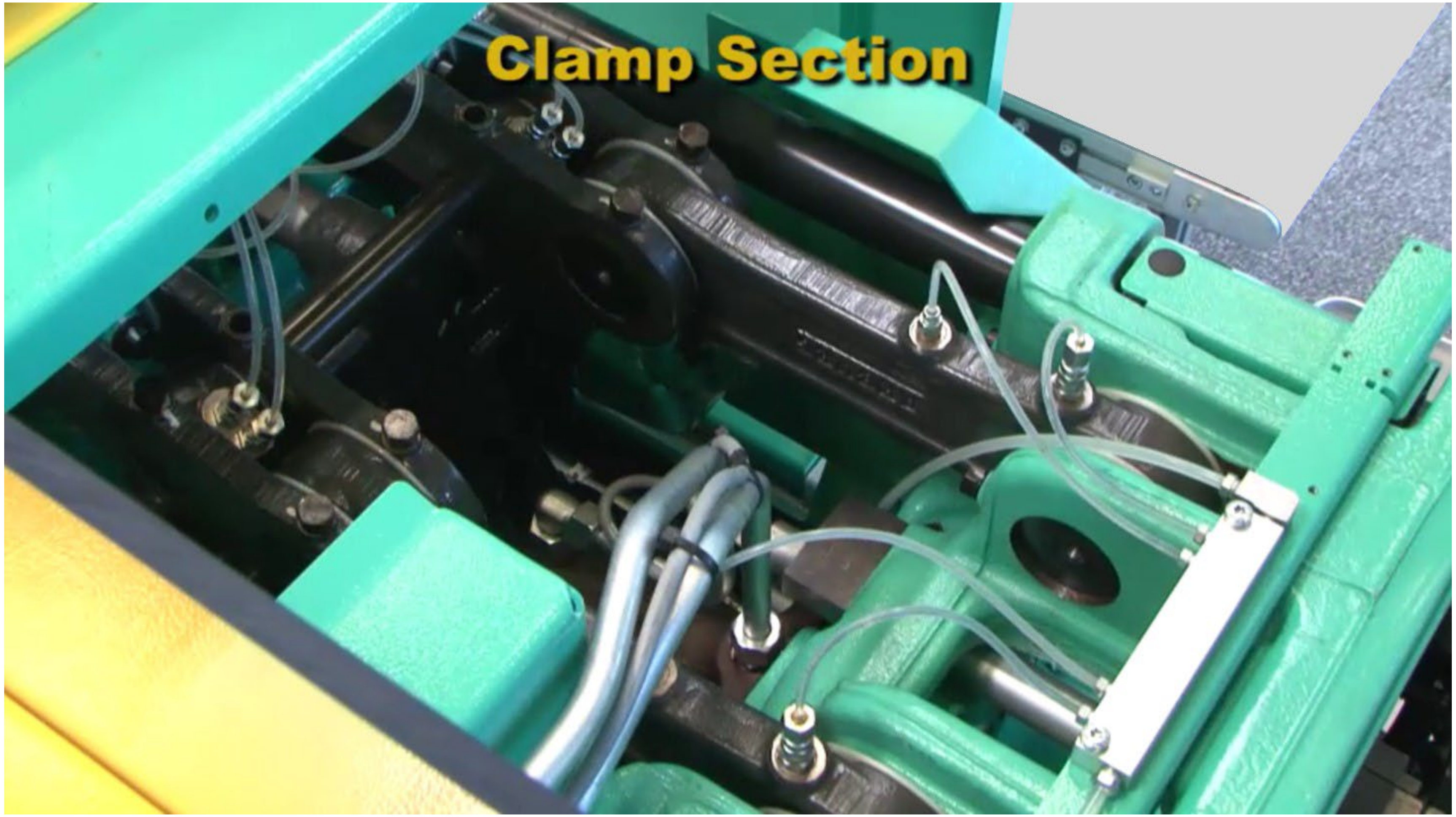

How much is too much?

# Scientific Method
# Injection Molding: Cushion

A well-trained employee/technician will understand the importance of cushion size and its effects on the decrease in scrap, and, by that,  the effective use of energy and machine time.

# Tribal Method
# Injection Molding: Clamp Requirements

# Scientific Method
# Injection Molding: Clamp Requirements



# Scientific Method
# Injection Molding: Clamp Requirements

This change to scientific molding technique approach not only decreased cycle time and therefore required machine time, it also dramatically decreased energy usage as the machine run time was decreased and the need of a thermolater on the tool was eliminated.

# Scientific Method
# Injection Molding: Clamp Requirements

**Thin Wall Molding Clamp Requirements**
**Original definition of thin-wall was anything under .040” or 1 mm.**

Now defined as thin wall if ratio of flow length to part thickness is greater than 150:1

Part is .1” thick and distance from gate to rim is 28” (8” from gate to base edge + 20” from base edge to rim).

Ratio is 280:1

For every 50:1 above the 150:1 ratio, add 1 ton/sq. in.

Adjusted Tonnage = (280 – 150)/50 +3
= 130/50+3
= 2.6+3
= 5.6 tons per square inch of projected part area.

# Tribal Method

## Injection Molding: Front Zone Temperature Determines Melt Temperature

Tribal Method

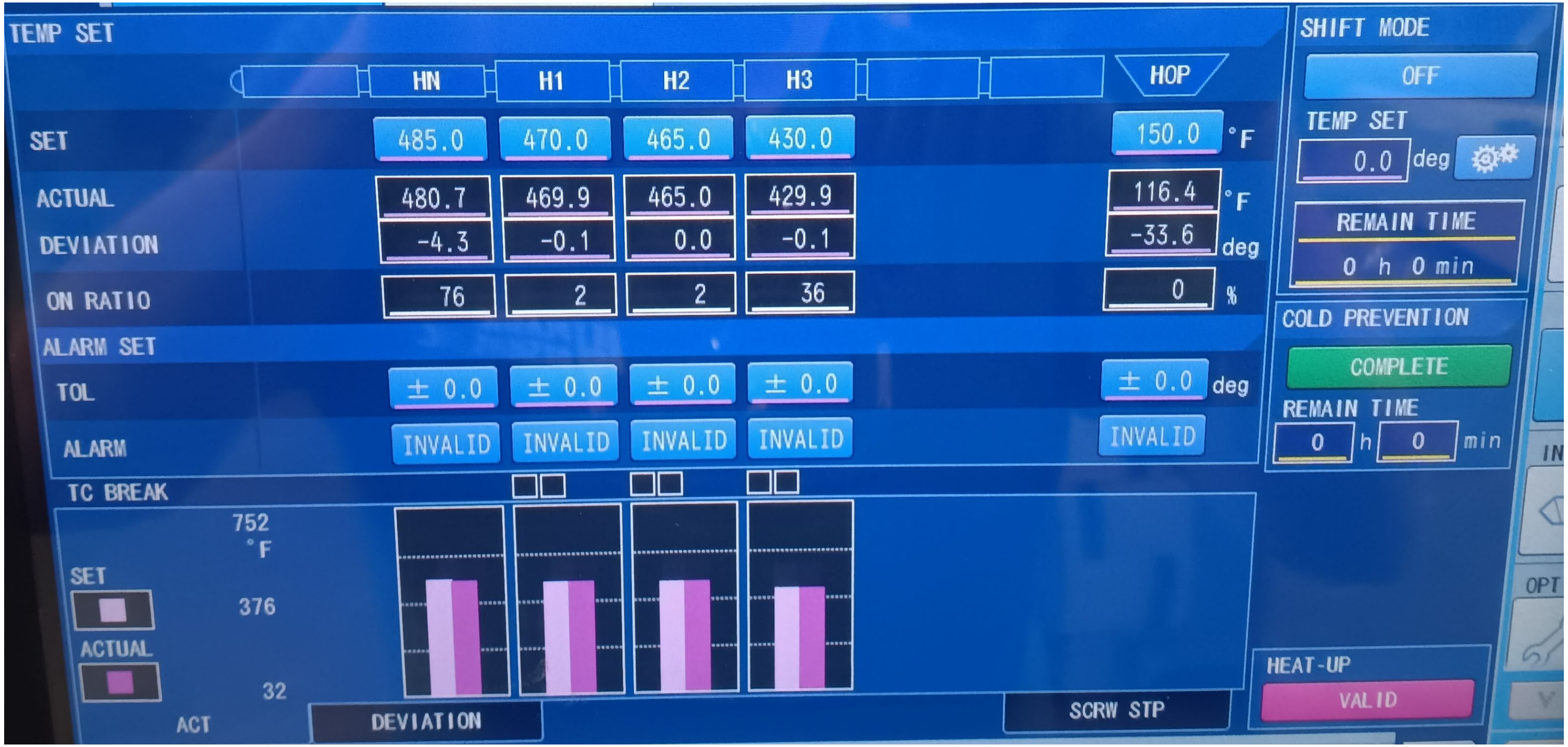
Injection Molding
Front Zone Temperature Determines Melt Temperature

Scientific Method

# Injection Molding

## Melt Temperature Must Be Measured and Adjusted

# Tribal Method
# Injection Molding: Front Zone Temperature Determines Melt Temperature

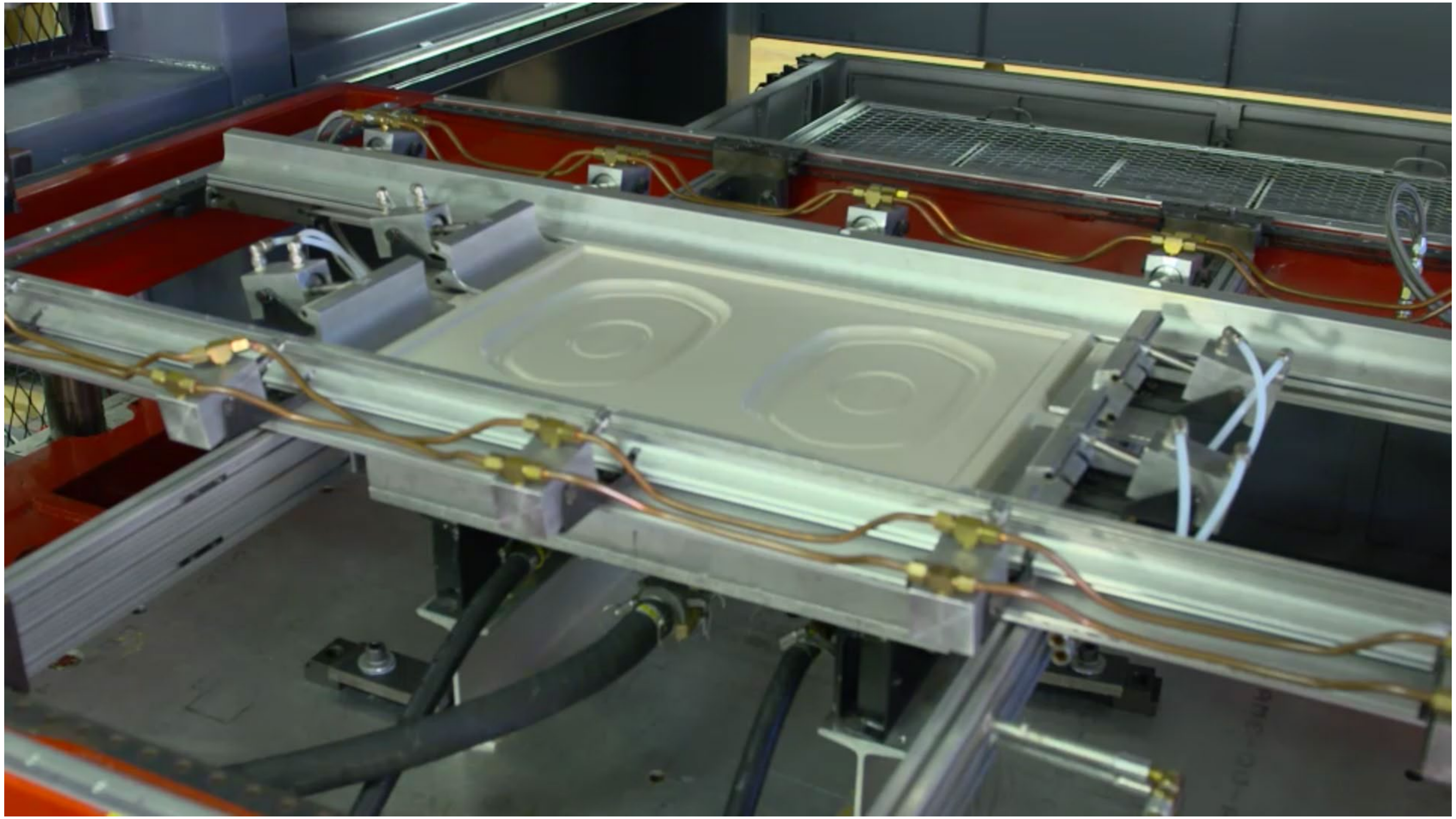


# Scientific Method

# Injection Molding: Melt Temperature Must Be Measured and Adjusted

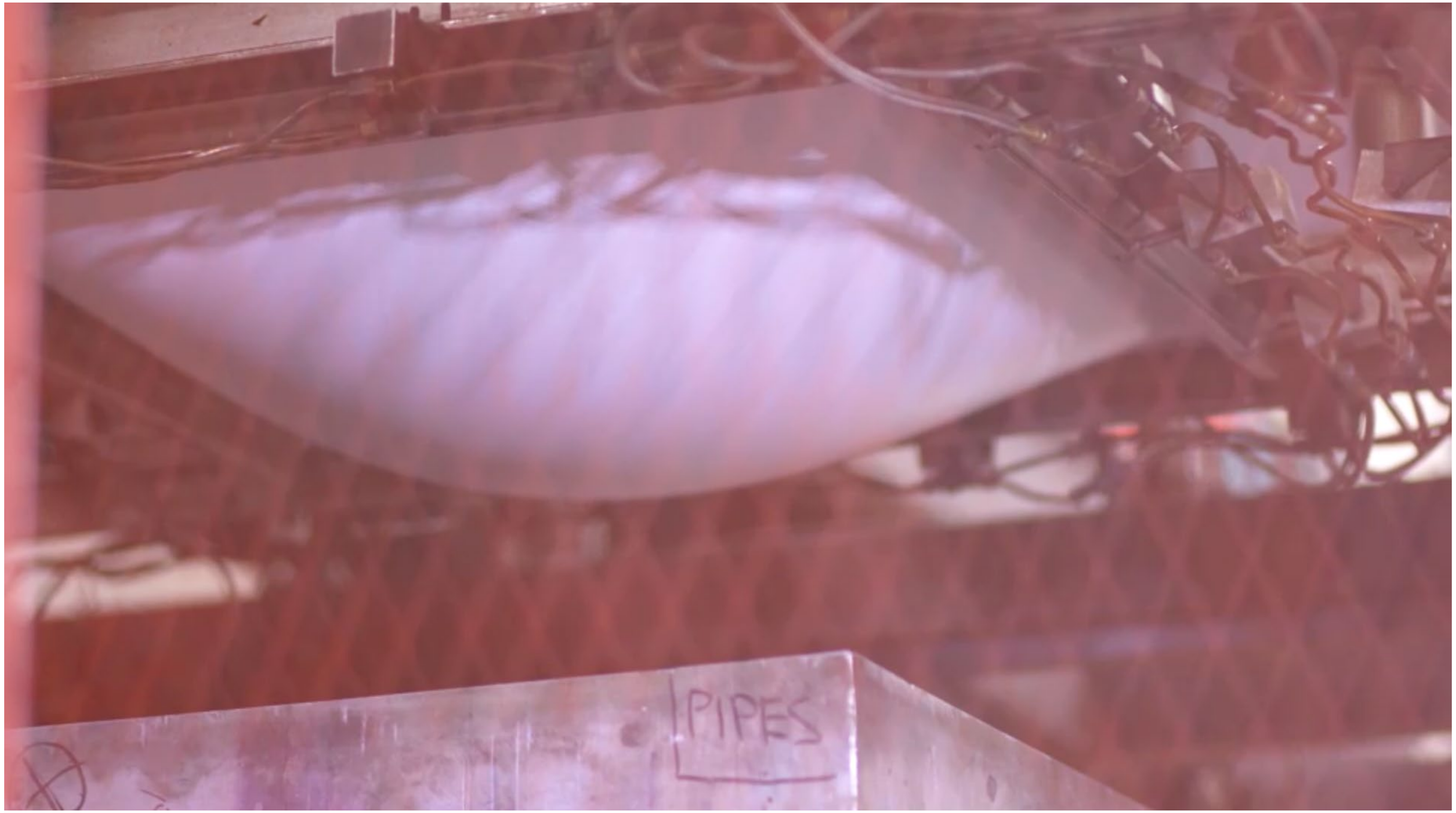
# Tribal Method
# Thermoforming: Heating Rate

# Tribal Method
# Thermoforming: Heating Rate

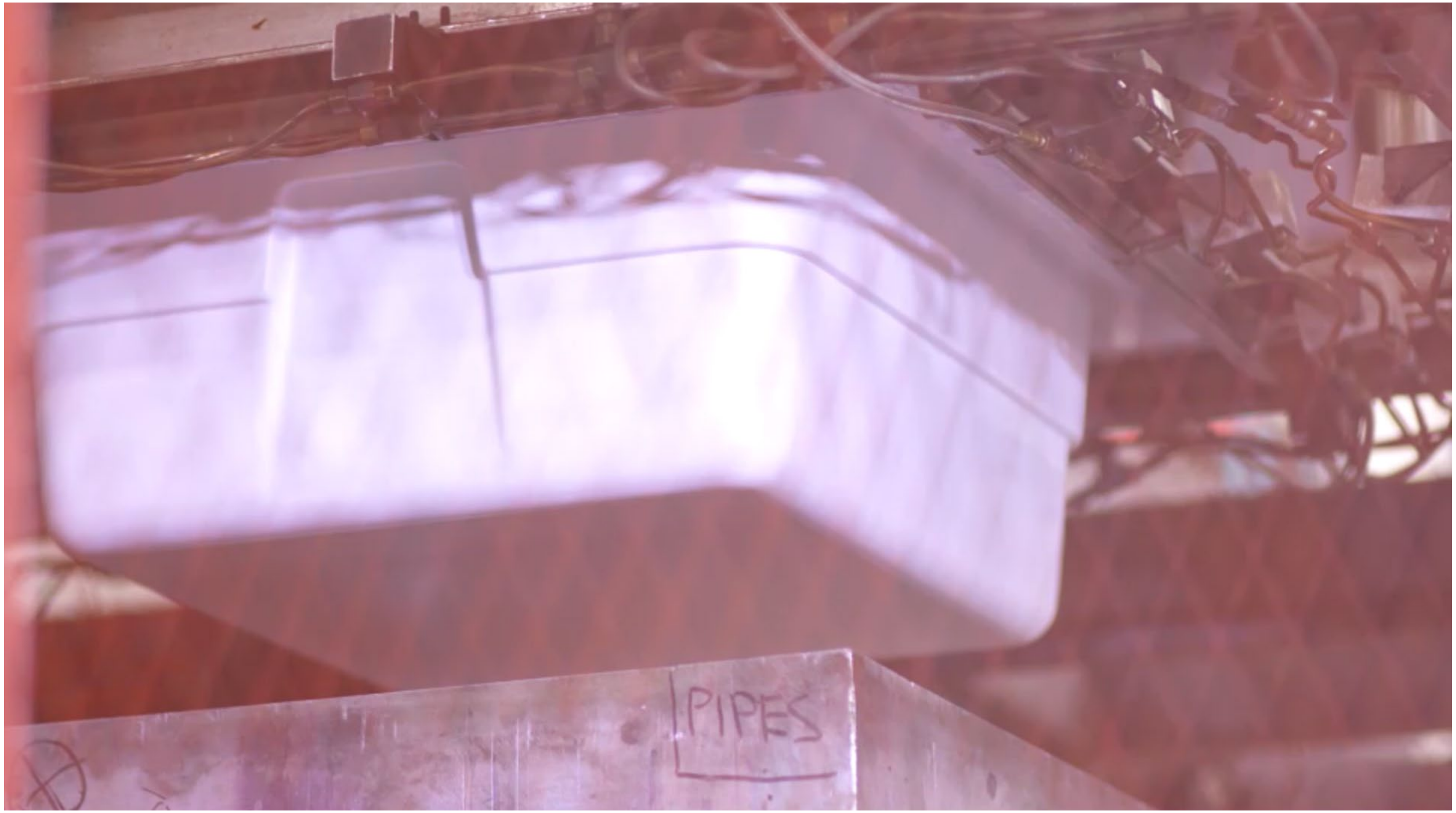


Scientific Method

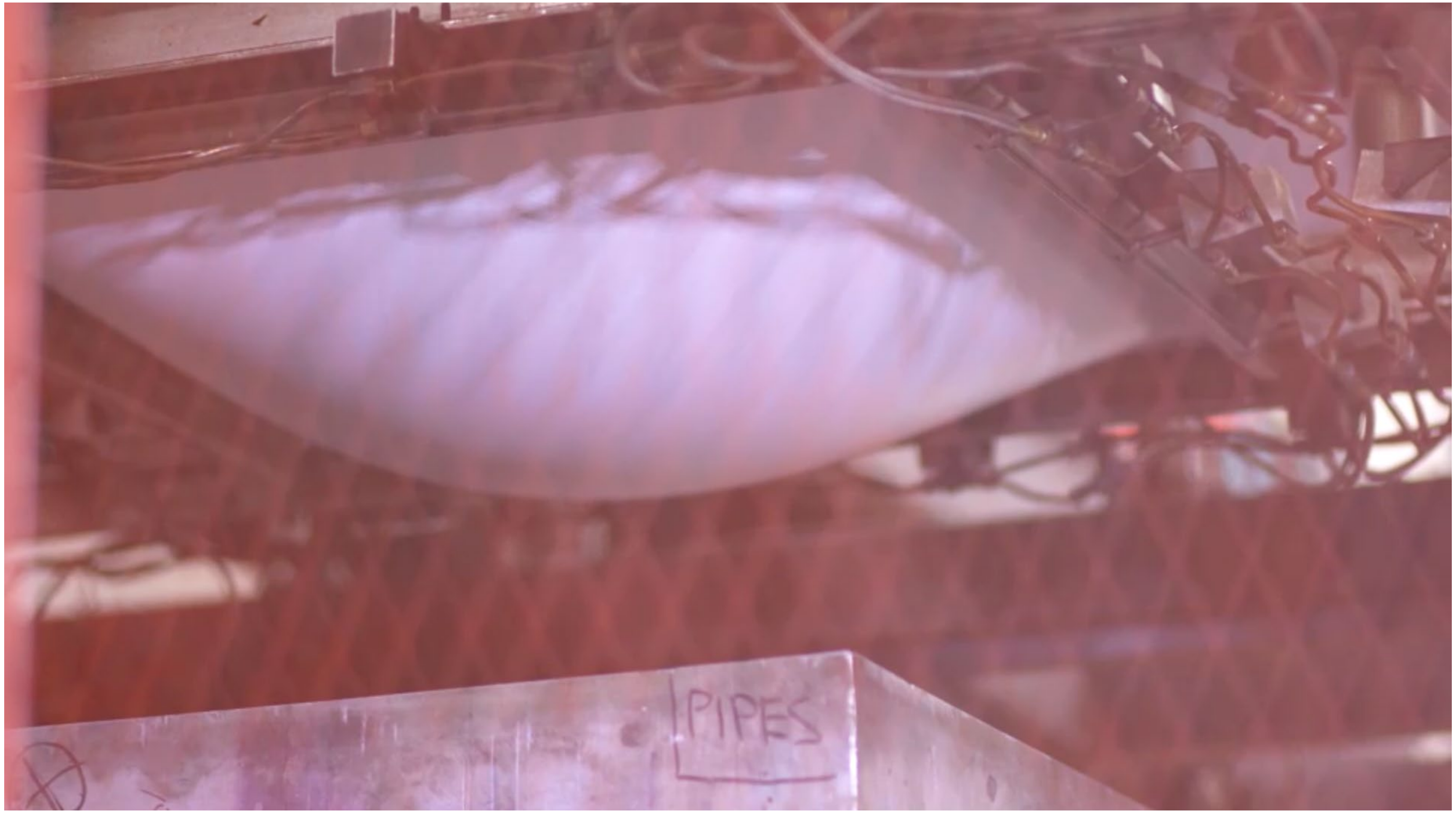
# Thermoforming: Heating Rate



# Scientific Method
# Thermoforming: Heating Rate



# Tribal Method
# Thermoforming: Forming Temperature

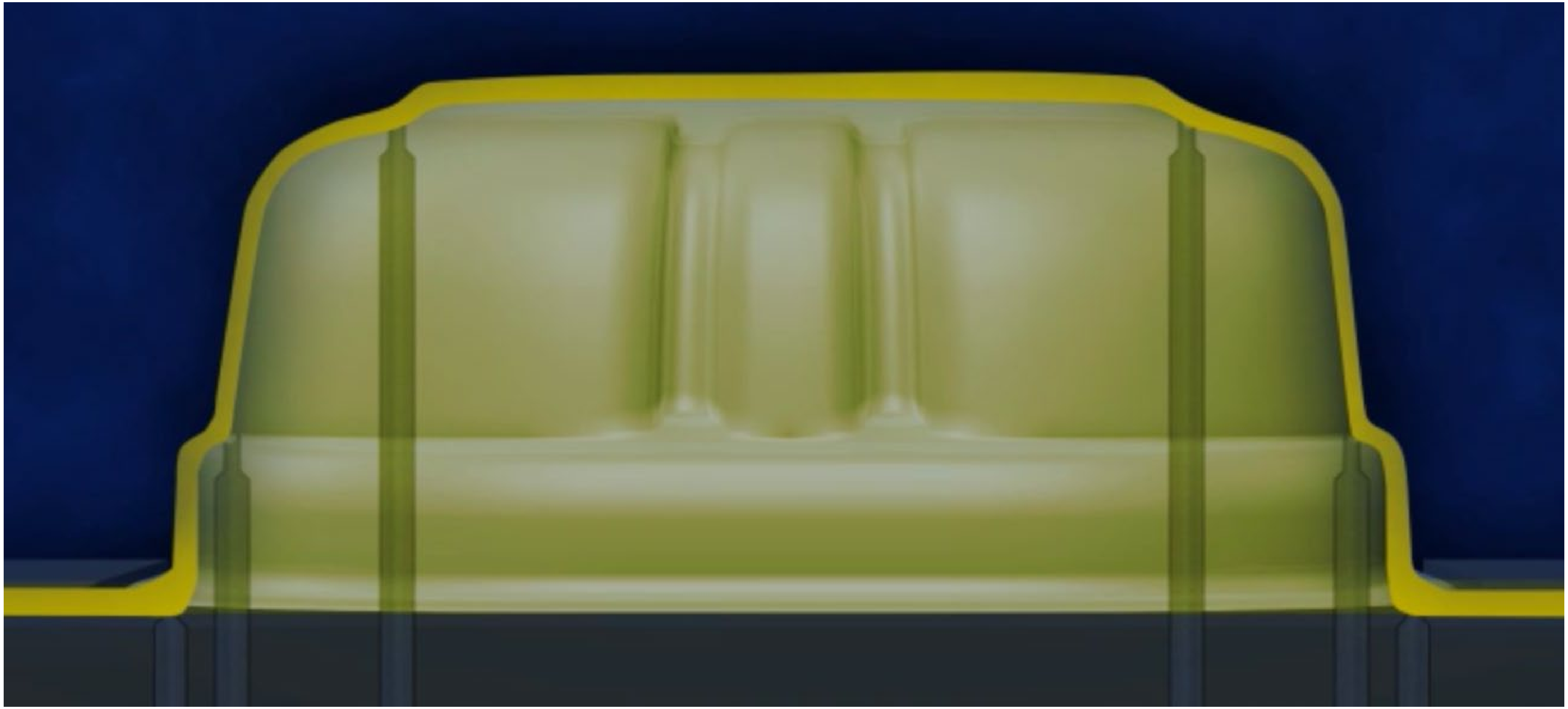


# Scientific Method

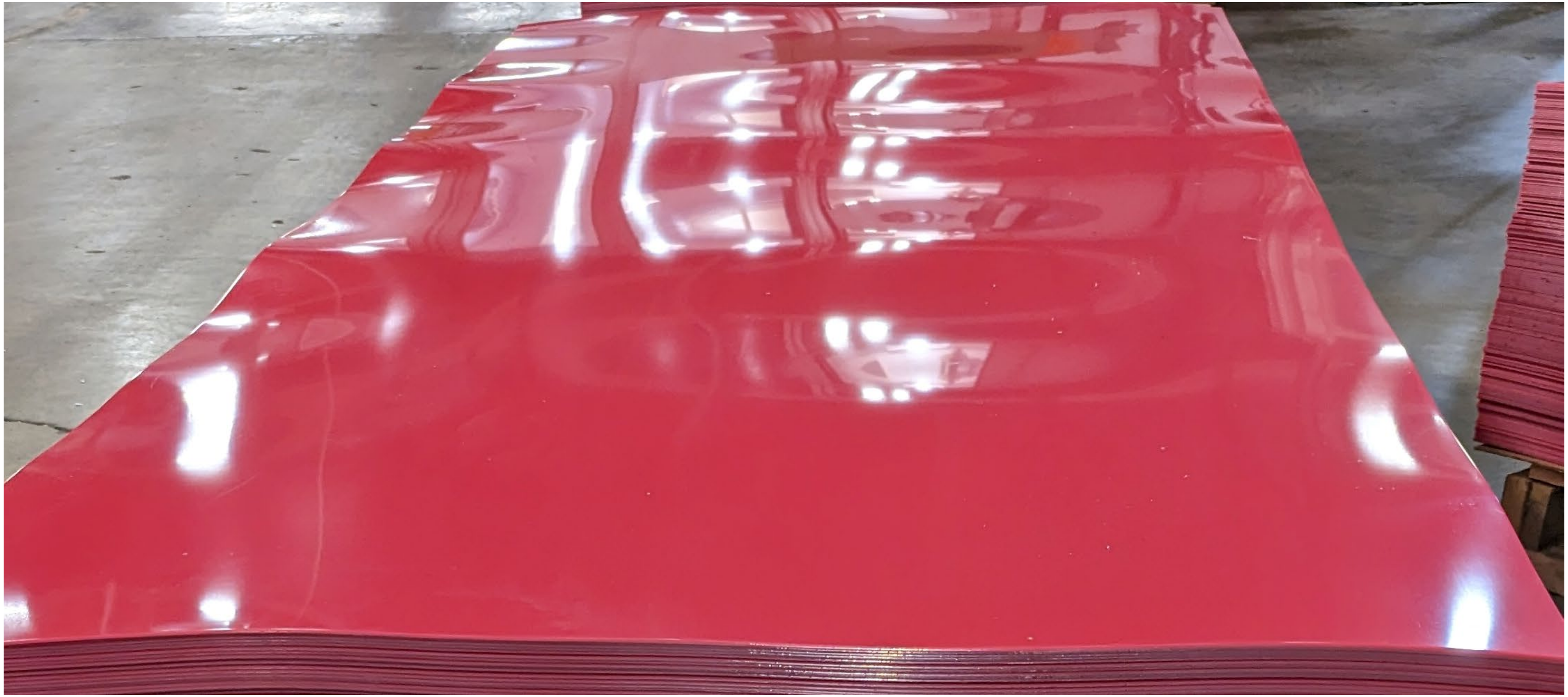
## Thermoforming: Forming Temperature

| | Normal Forming (core) Temp. °F | Normal Forming (core) Temp. °C |
|---|---|---|
| Acrylonitrile Butadiene Styrene (ABS) | 300-310 | 149-154 |
| Polycarbonate (PC) | 375 | 191 |
| Polyester, amorphous (APET) | 305 | 152 |
| Polyethylene, high density (HDPE) | 295 | 146 |
| Polypropylene (PP) | 320-350 | 160-177 |
| PVC, rigid | 280-300 | 138-149 |

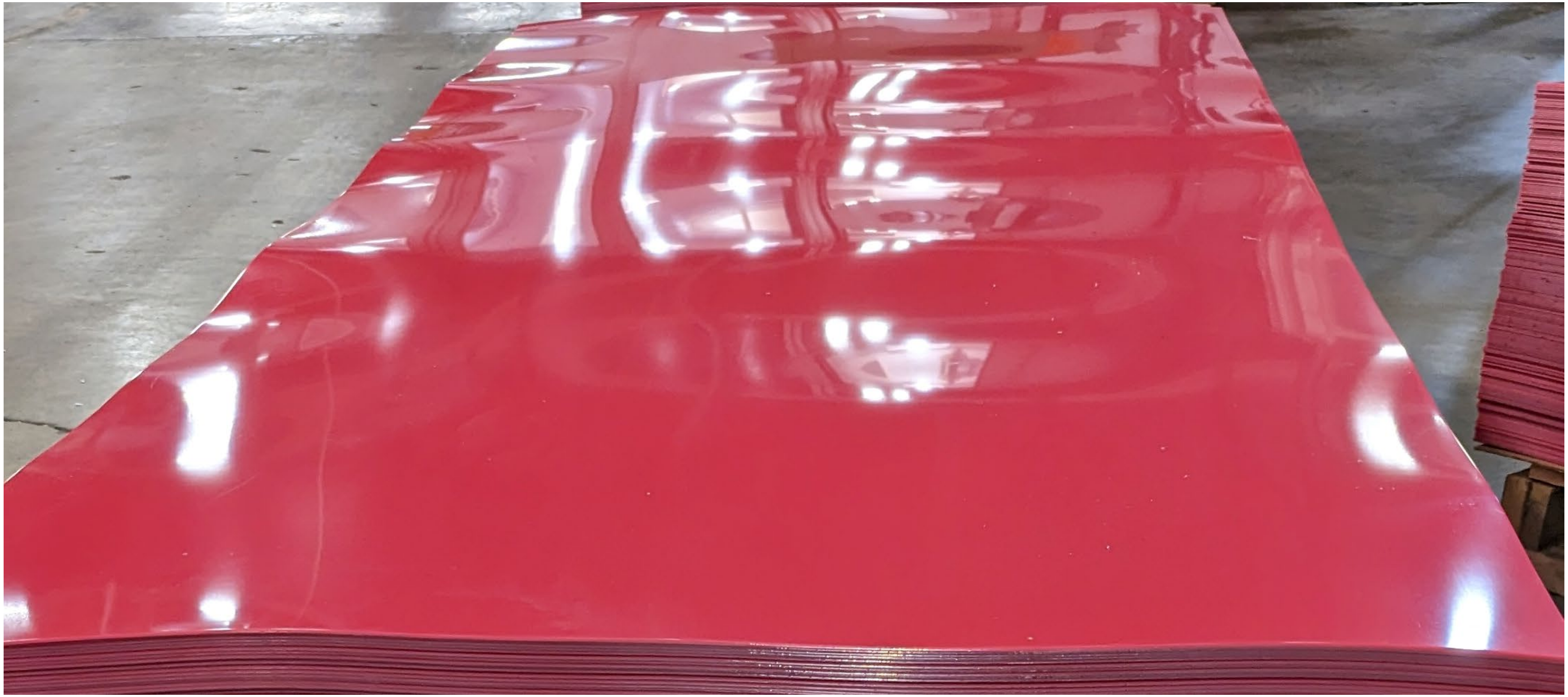
# Scientific Method
# Thermoforming



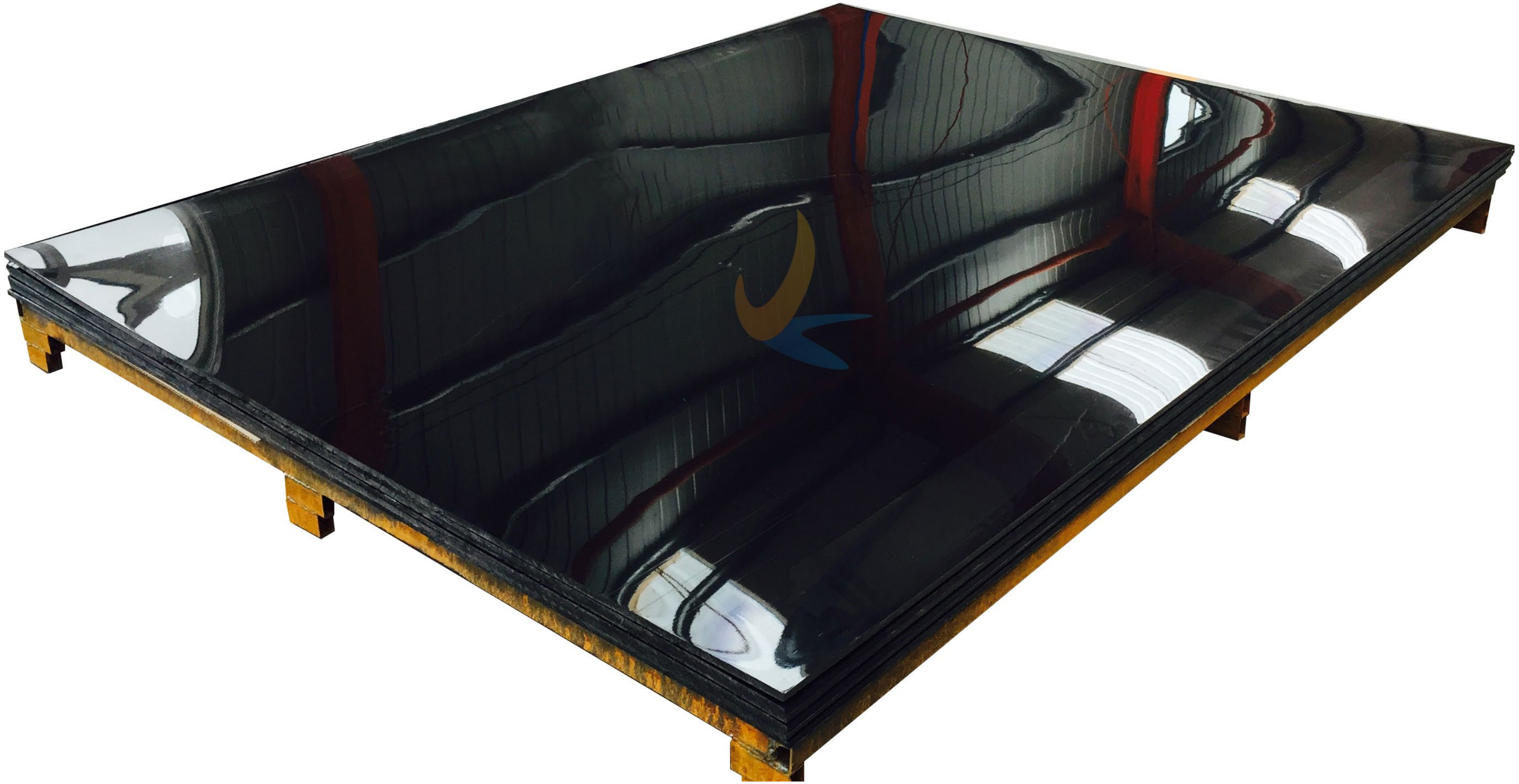
# Tribal Method
# Sheet Extrusion: Cool The Sheet As Fast As Possible



# Tribal Method
# Sheet Extrusion: Cool The Sheet As Fast As Possible



# Scientific Method
## Sheet Extrusion: Cool The Sheet As Fast As Necessary



# Tribal Method
# Injection Molding:  Once We Have Good Parts, The Setup Is Done

## It's In The Numbers

## #1

Learn and Use the Four Plastic Processing Variables
For PPV (Plastics Point of View) Processing
Melt Temperature
Melt Flow Rate
Melt Pressure
Melt Cooling Rate

**These will give you the most important bottom line #, QUALITY**

# Tribal Method
# Injection Molding: Once We Have Good Parts, The Setup Is Done

## #2

### Learn What to Record for the Four Plastic Processing Variables
### For PPV (Plastics Point of View) Processing

Melt Temperature:

Actual Temperature of the Melt (30/30 method)

Melt Flow Rate:

Fill Time or Parison Formation Time

Melt Pressure:

Final Part Weight

Melt Cooling Rate:

Part Temperature At Ejection After The Cooling Time Finishes And The Part Is Ejected

**These will give you the 2nd most important bottom line #, Repeatability.**

# Tribal Method
# Injection Molding:  Once We Have Good Parts, The Setup Is Done

## #3

Learn How To Calculate The Four Plastic Processing Variables
For PPV (Plastics Point of View) Processing
For A First Time Run.

1. Set up a spread sheet with all machine specs on the shop floor.
2. Input part specs and select machine to run it in.
3. Have the spread sheet calculate the Four Plastic Processing Variables as machine input estimates.

**This will give you the 3'rd most important bottom line #, Shortest Set Up Time.**

# Tribal Method
# Injection Molding:  Once We Have Good Parts, The Setup Is Done

## #4

Learn How To Transfer The Four Plastic Processing Variables
For PPV (Plastics Point of View) Processing From One Machine To Another.

1. Using your spread sheet with all machine specs on the shop floor.
2. Select “From” machine
3. Input critical machine settings for the part (those that generate the 4 PPV #’s)
4. Select “To” machine
5. Have the spread sheet estimate critical machine settings for the “To” Machine.

**This will give you the 4’rd most important bottom line #, Transfer Speed.**

# Tribal Method
# Injection Molding:  Once We Have Good Parts, The Setup Is Done

## Now What!

These first 4 will give you the quality you require in a timely manner.
But you’re only ½ way there.
Now you have to fine tune the other end of the machine.

# Scientific Method
# Injection Molding: Once We Have Good Parts, Set Up The Other Half

## #5

1. Set your machine open speeds and positions to give you the fastest/smoothest operation possible.
2. If you are not using a robot, set your core action/ejection point as early as possible during machine open.
3. If you are using a robot, set your ejection operation speed/delay timers (out and back) to compliment the robot operation.
4. Set your mold close speeds as fast as possible with slow downs and safeties to protect you mold and bottom line.

# Scientific Method
# Injection Molding: Once We Have Good Parts, Set Up The Other Half

## #5 Case Study

A small injection molding machine using a robot had been running for 18 hours. Its standard cycle was 20 seconds, but it was running at 22 seconds , 91% efficiency.
When the actual overall efficiency was checked, it was closer to 80% for no apparent reason.
The part being made was relatively simple but required high precision /flatness.

I was asked to come in and check it out to see if this could be improved.

# Scientific Method
# Injection Molding: Once We Have Good Parts, Set Up The Other Half

## #5 Case Study

Using #1, 2, 3, and 4, it was determined that from the PPV, the part was being manufactured with very acceptable quality.

However, when it was looked at from the viewpoint of #5, many improvements could be made. Changes to # 5-1 and #5-4 decreased the cycle time to 18 seconds, 111% efficiency possible.

# Scientific Method
# Injection Molding: Once We Have Good Parts, Set Up The Other Half

## #5 Case Study

The other loss of efficiency was due to poor timing between the ejection system and the robot.

The ejectors would retract before the robot had a consistently secure hold on the part such that it would interfere with the cycle when it errored out.

Not only did this interfere with production, but it was also extremely bothersome to the technicians when they came to reset the machine.

# Scientific Method
# Injection Molding: Once We Have Good Parts, Set Up The Other Half

## #5 Case Study

Adding ½ second of ejection forward time eliminated this issue and added nothing to the overall cycle of the machine as it occurred during the robot-controlled portion of the cycle.

Compared to the original setup, the machine ran for the next 48 hours with 110% efficiency, for an improvement of 30% overall to the machine.

As this required next to no technician intervention during that time, their overall efficiency (and mood) also improved.

# Scientific Method
# Injection Molding: Once We Have Good Parts, Set Up The Other Half

## It's In The Numbers

Is this level of improvement always possible?

Unlikely, but even 1 or 2% is more than worth the effort to learn these simple applications.

If you would like to discuss this more, please see us at booth number W2973

As a member of the Paulson team, I would like to thank you for your attendance and attention.

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please see us in booth # W2973.

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Paulson

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