Expanding Six Sigma to Suppliers

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The Definition of a Lean Enterprise

A group of individuals, functions, which are sometimes separate but operationally synchronized organizations.

The objectives of the lean enterprise are:

- “Correctly specify value for the customer”
- “Identify all the action required to bring a product from concept to launch, from order to delivery, and from raw material into the hands of the customer and on through its useful life.”
- “Remove any actions which do not create value and make those actions which do not create value proceed in continuous flow as pulled by the customer.”
- “Analyze the results and start the evaluation process over again.”

Source: Womack, James P. and Jones, Daniel T., Lean Thinking: Banish Waste and Create Wealth in Your Corporation, Simon & Schuster, New York, NY, 1996.

What is Lean?

- Lean Manufacturing focuses on eliminating waste and improving flow using various Lean principles and their respective approaches.
- VSM, standard work, 5S, SMED, visual management, etc.

Lean Overview

- Lean emphasizes the elimination and prevention of waste.
- Lean is focused on the customer by addressing what is value added and what is non-value added.
- Products and services are delivered Just-in-Time meaning in the right amounts, at the right time and in the right condition.
- Products and services are produced only when a signal is received from the customer and are pulled through the system.
- A lean system allows for an efficient response to fluctuating customer demands and requirements.

Lean Benefits

- Eliminate waste
- Reduce non-value added activities
- Improve process flow

What is Six Sigma?

- Strategy to minimize variation towards the goal of 3.4 defects per million.
- A philosophy to promote excellence in all business processes.
- A 5 phase methodology for continuous improvement.
- A statistic which describes the amount of variation in a process.
- A tool to reduce or eliminate variation.

Six Sigma Overview

- Six Sigma is a customer focused continuous improvement strategy and discipline that minimizes defects and variation towards an achievement of 3.4 defects per million opportunities in product design, production, and administrative processes.

- It is focused on customer satisfaction and cost reduction by reducing variation in processes.

- Six Sigma is also a methodology using a metric based on standard deviation.

- Six sigma targets aggressive goals.

Six Sigma Benefits

- Stronger knowledge of products and processes
- Reduction in defects
- Increased customer satisfaction level that generates business growth and improves profitability
- Increased communication and teamwork
- Common set of tools

Why should we combine them?

- By combining the Six Sigma DMAIC methodology with lean manufacturing tools, companies have a more appropriate toolkit to address all types of process problems and can reap even more dramatic gains.

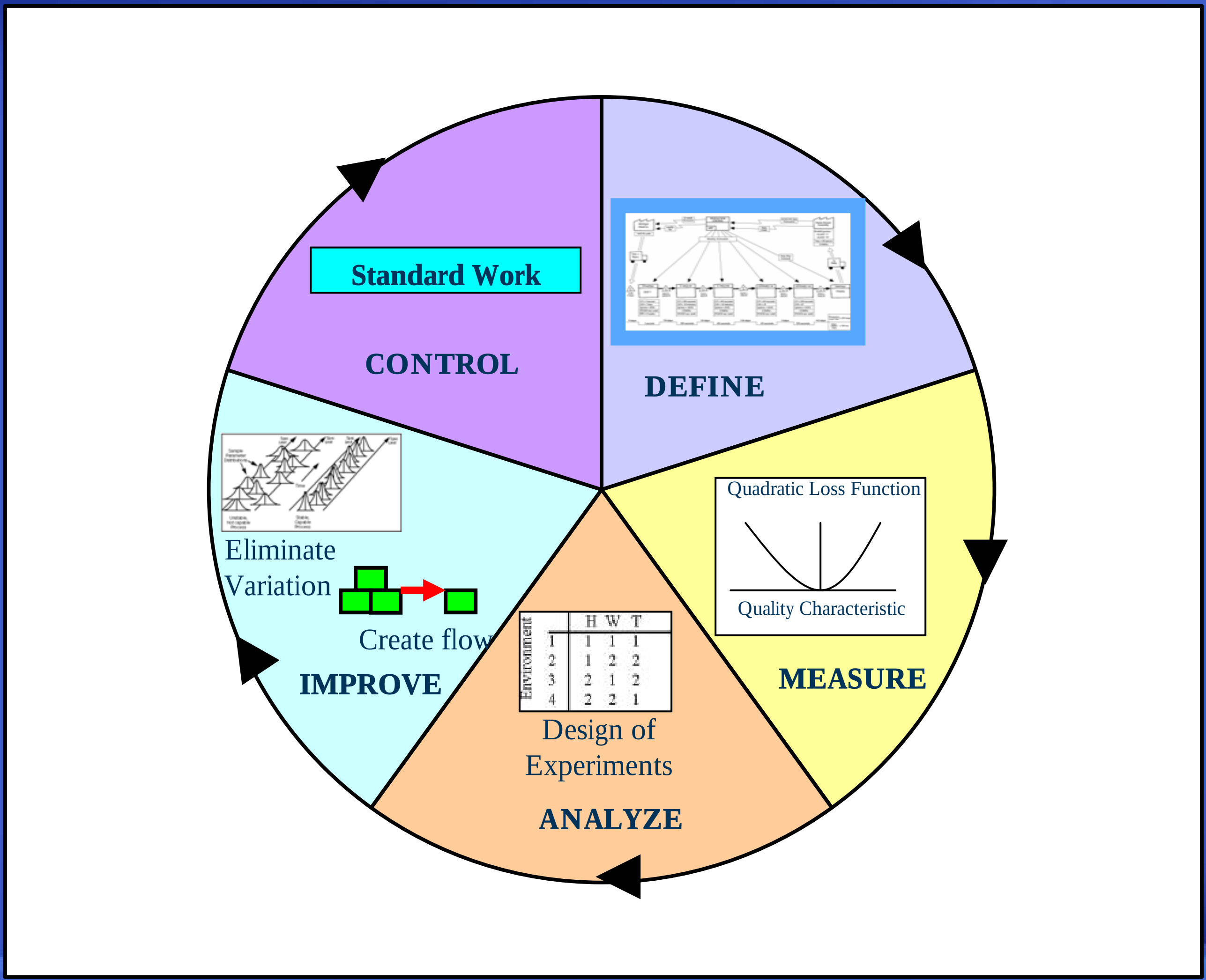
Lean vs. Six Sigma

	Lean	Six Sigma
Goal	Create flow Eliminate waste	Reduce variation Improve process capability
Business Scope	Project oriented Operations level	Strategic
Culture	Operations level (at minimum)	Corporate culture
Application	Mainly manufacturing processes	All business processes
Approach	Lean technique specific Basic principles and best practices	Generic problem solving approach using statistics
Project Selection	Driven by Value Stream Mapping	Various approaches
Length of Projects	Short-term focus	Long-term cyclical improvement
Infrastructure	Ad-hoc – kaizen based	Dedicated resources
Training	Specific training Learn by doing	Broad training Learn by doing

Lean, Six Sigma, or Both?

- Which is better?
- What do we first?
- Can the two approaches be combined?
- How do we reap the biggest reward?

Systematic Approach

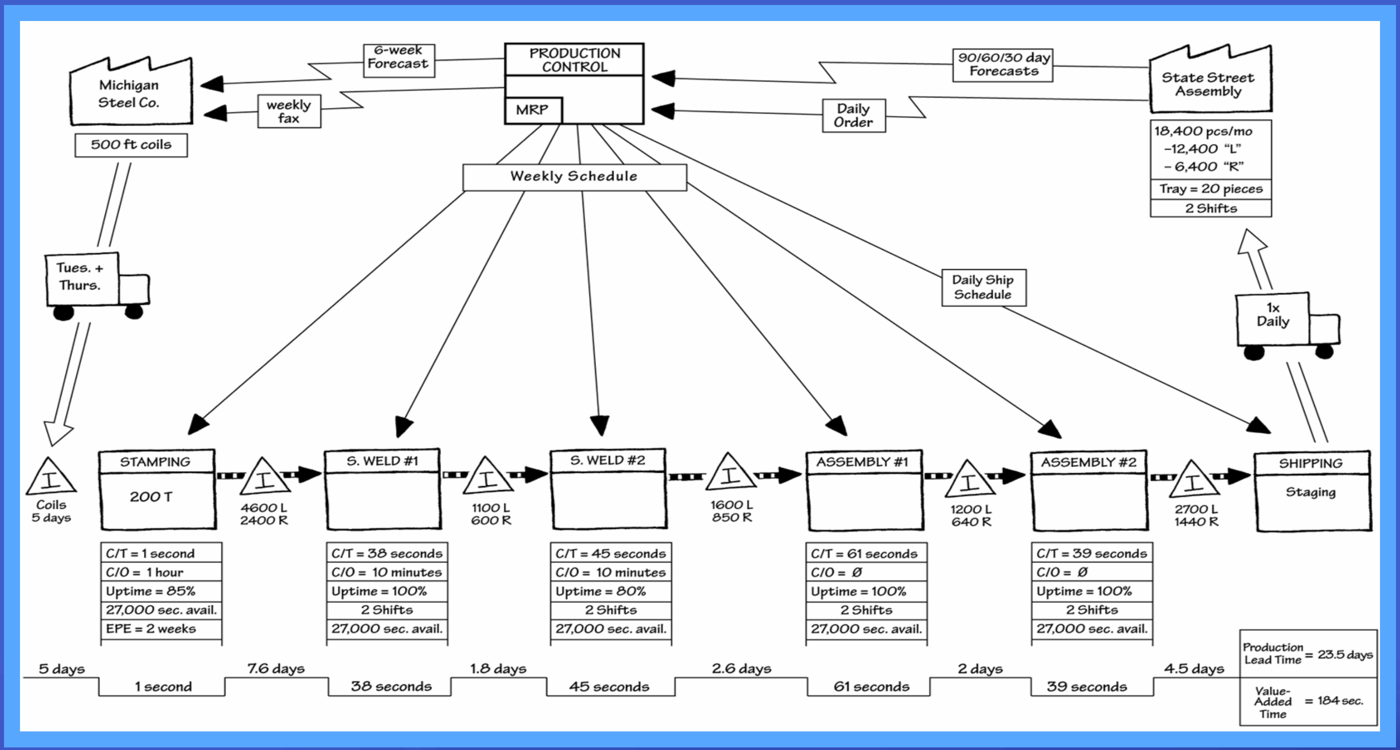


DMAIC Approach to Lean and Six Sigma

		Phase Deliverables
D	Voice of the Customer Value Stream Mapping	**Project Selection**
M	5S, Capability Analysis, Measurement System Analysis, Spaghetti Diagram, Process Flow Diagram	**Understand the process and identify potential factors**
A	TAKT Time, Cause and Effect Diagram, FMEA, Hypothesis Testing	**Confirm the vital few factors**
I	Kanban, Visual Management, Heijunka, Poke-Yoke, Design of Experiments	**Optimize and implement solutions**
C	SPC, Standard Work, Control Plan	**Sustain results**

Define

- Value Stream Mapping



Source: Rother, Mike and Shook, John, Learning to See: Value Stream Mapping to Add Value and Eliminate Muda, The Lean Enterprise Institute, Brookline, MA, 1998.

Value Stream Mapping

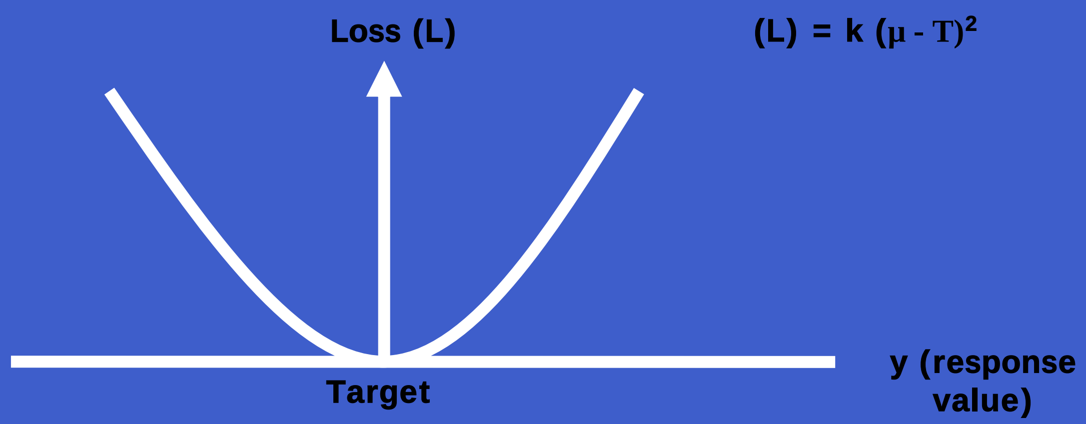
- Value Stream Mapping is the first building block to integrating Lean and Six Sigma.
- The purpose of Value Stream Mapping is to understand the big picture.
- The current value stream consists of all actions necessary to deliver a product including value added and non-value added.
- Value stream mapping must be conducted first to provide an effective blueprint for implementing an improvement strategy.
- A key step in creating the current state map is to calculate TAKT time.

Measure

- Quality Loss Function

Where,

- k is a monetary constant,
- $k = \frac{A_0}{\Delta_0^2}$,
- μ is the mean, and
- T is the target.



- Specifications

EVERYTHING IS NOT EQUALLY GOOD

Beware of the "Goalpost" Mentality

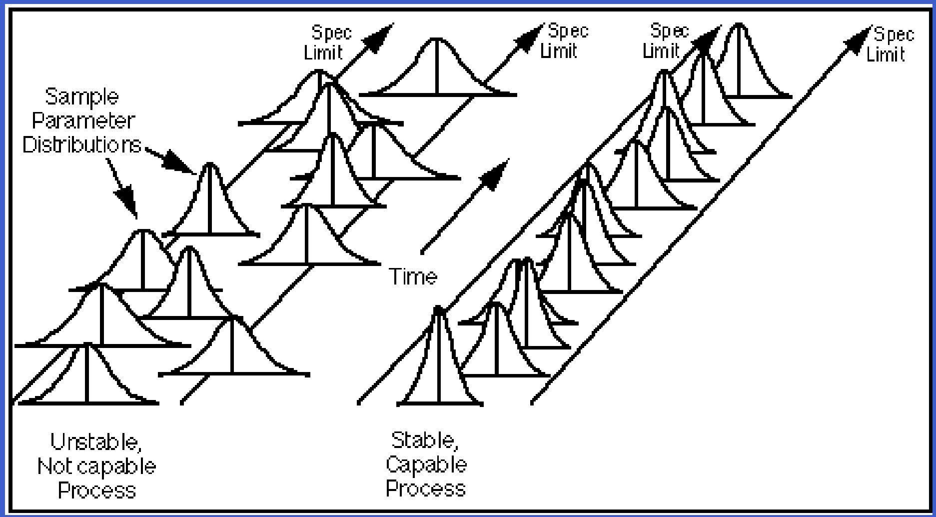
- The value of manufacturing specifications to the customer is only important when they receive a product that is defective.
- Specifications create "goalposts" for product acceptance.
- To the customer, the specifications should be created based on their expectations and requirements.
- A benefit of using the quadratic loss function is that it is in monetary units.

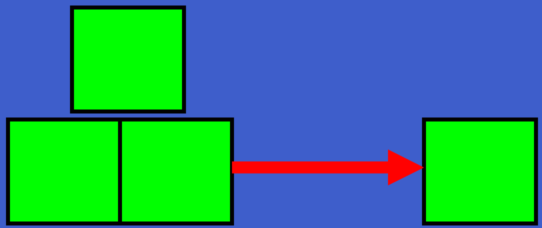
Analyze

- Design of Experiments
  - Structured method to determine the relationship between factors (Xs) that affect a process and the output of the process (Y).

Environment	H	W	T
1	1	1	1
2	1	2	2
3	2	1	2
4	2	2	1

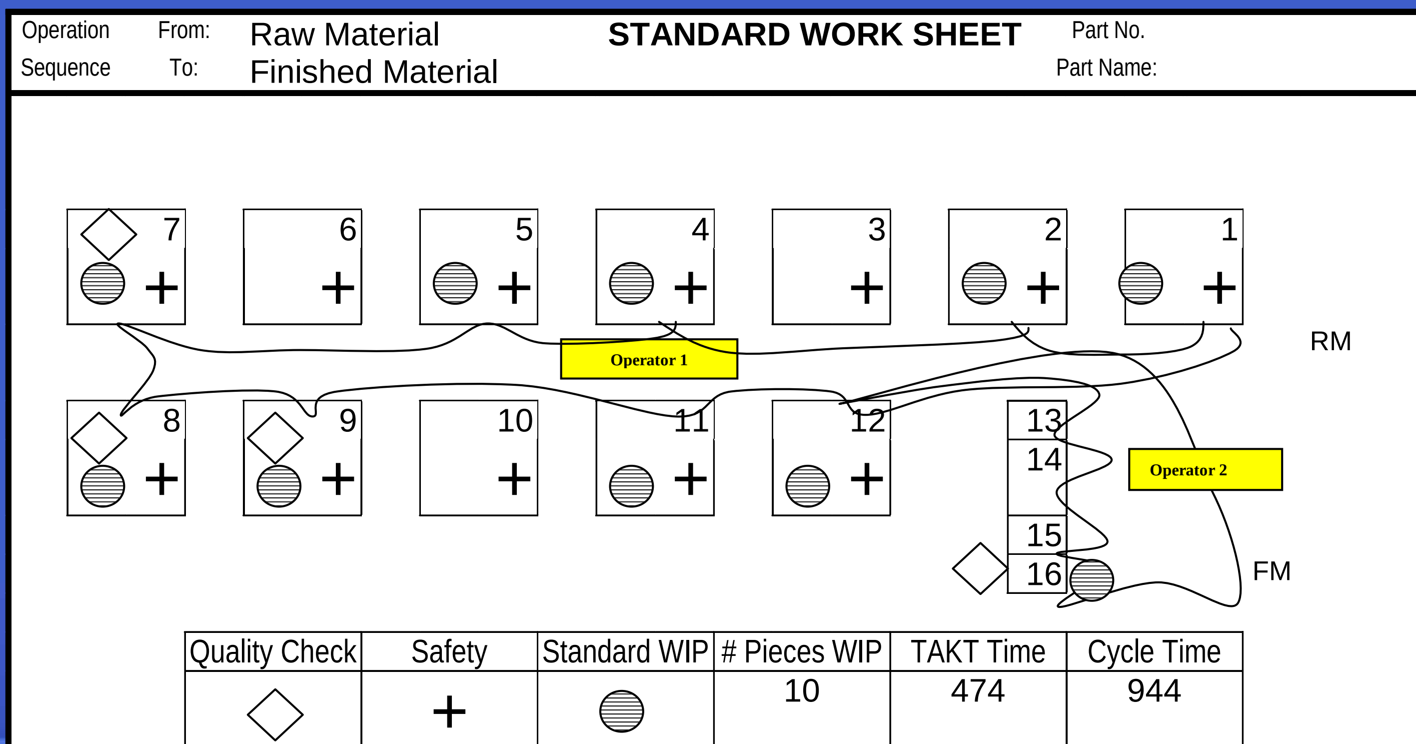
Improve


Spec Limit
Spec Limit
Spec Limit
Spec Limit
Sample Parameter Distributions
Time
Unstable, Not capable Process
Stable, Capable Process



Control

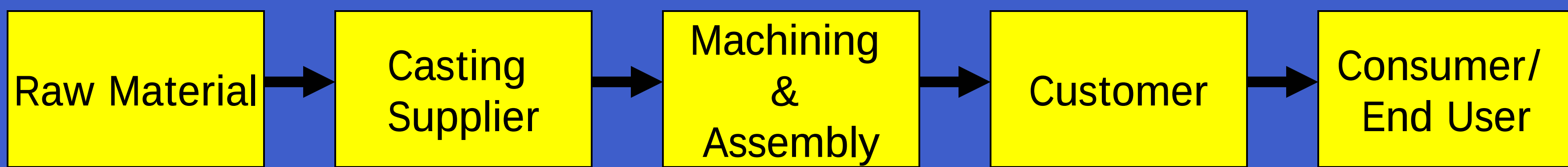
- Standard work
  - A lean tool that defines and documents the interaction between people and their environment.



Case Study

- Six Sigma project performed on the casting process at a casting supplier to reduce center line shrinkage.

Extended Value Stream



Value Chain

Casting Supplier — Casting process capability and variation

Manufacturing & Assembly — Manufacturing and assembly variation

Customer — QDC – Quality, Delivery, Cost

Customer/ End User — Variation in product performance in the hands of the customer

QDC Metrics
Ripple effect throughout the entire value chain

Customer Satisfaction!!!!

Objective

- The objective of this case study was to utilize the Six Sigma DMAIC methodology in conjunction with lean manufacturing techniques to meet customer requirements in terms of both the level of quality performance and production requirements.

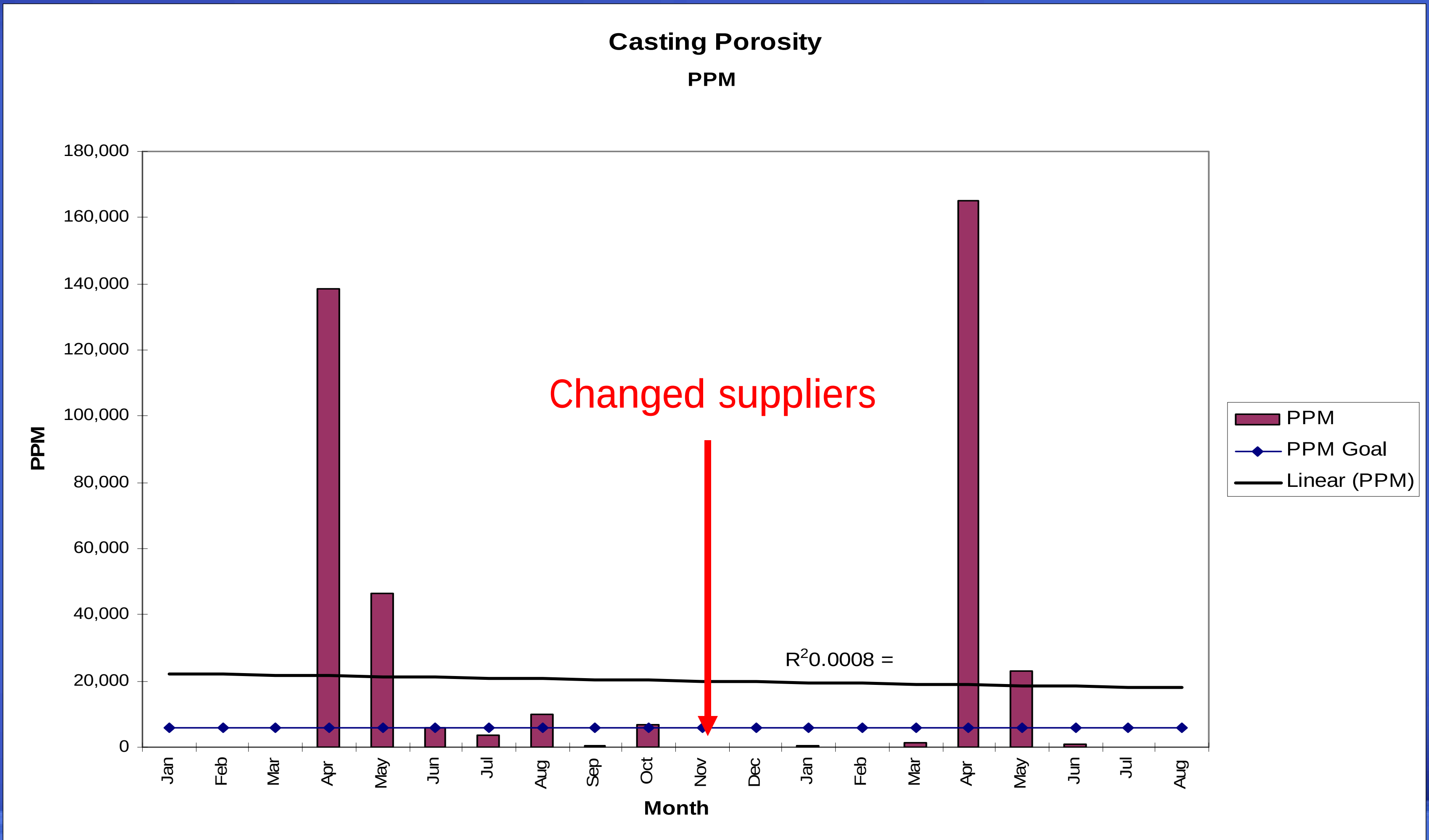
Introduction

- Objectives
  * More Efficient Process
  * Reduce Costs
  * Reduce Quality Defects
  * Improve Delivery
- Performance Measures
  * Production Numbers
  * Scrap Numbers
  * On-time Delivery

Goals

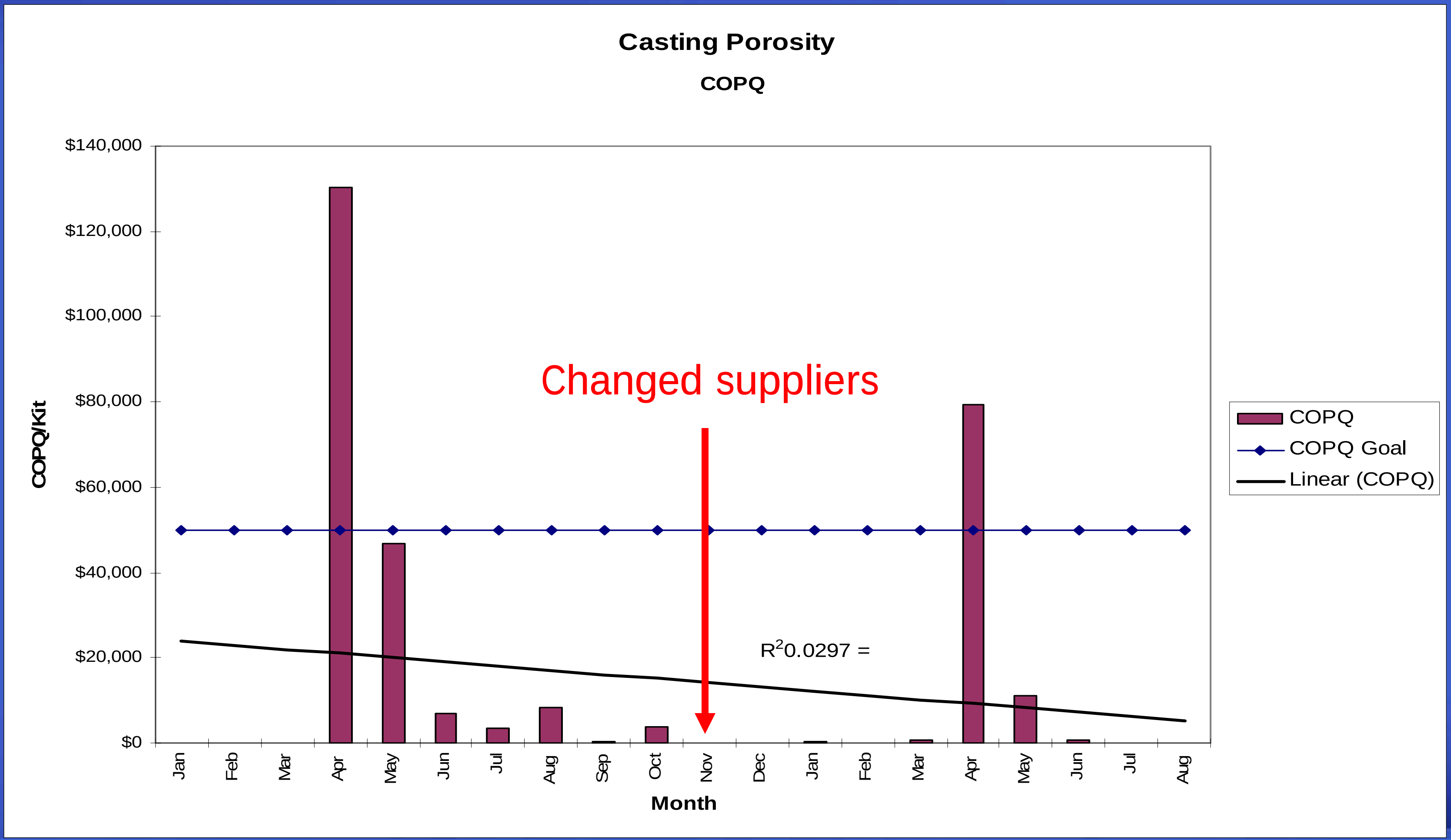
- Reduce internal PPM from 23,309 to 5,827 (75% reduction)
- Reduce annual COPQ from $200,100 to $50,025 (75% reduction)
- PPM savings of 17,482
- COPQ annual savings of $150,075

PPM



Casting Porosity
PPM
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
PPM
Changed suppliers
R2 0.0008 =
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Month
PPM
PPM Goal
Linear (PPM)

COPQ


Casting Porosity
COPQ
$140,000
$120,000
$100,000
$80,000
$60,000
$40,000
$20,000
$0
COPQ/Kit
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Month
Changed suppliers
R2 0.0297 =
COPQ
COPQ Goal
Linear (COPQ)

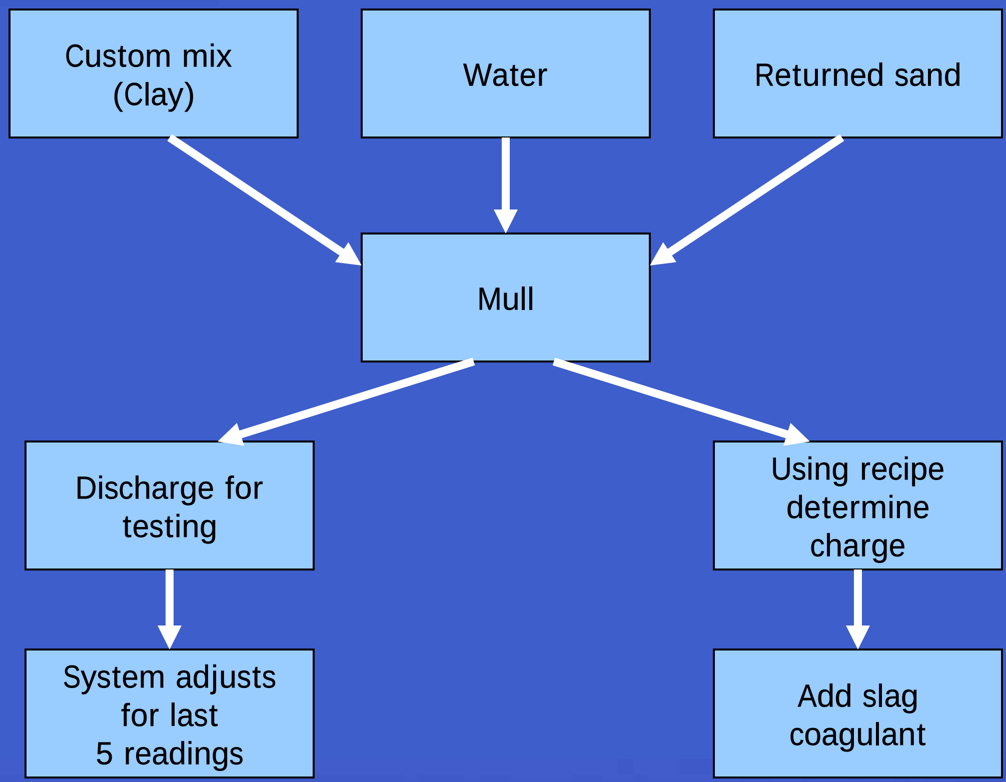
Variation Reduction Kaizen

- One week kaizen format used to kickoff the Six Sigma project.
- Kickoff the Six Sigma Black Belt project by applying Process Flow, Cause and Effect with CNX/SOP to reduce casting centerline shrinkage.
- Goal was to change the number of noise variables to constants by 50%.

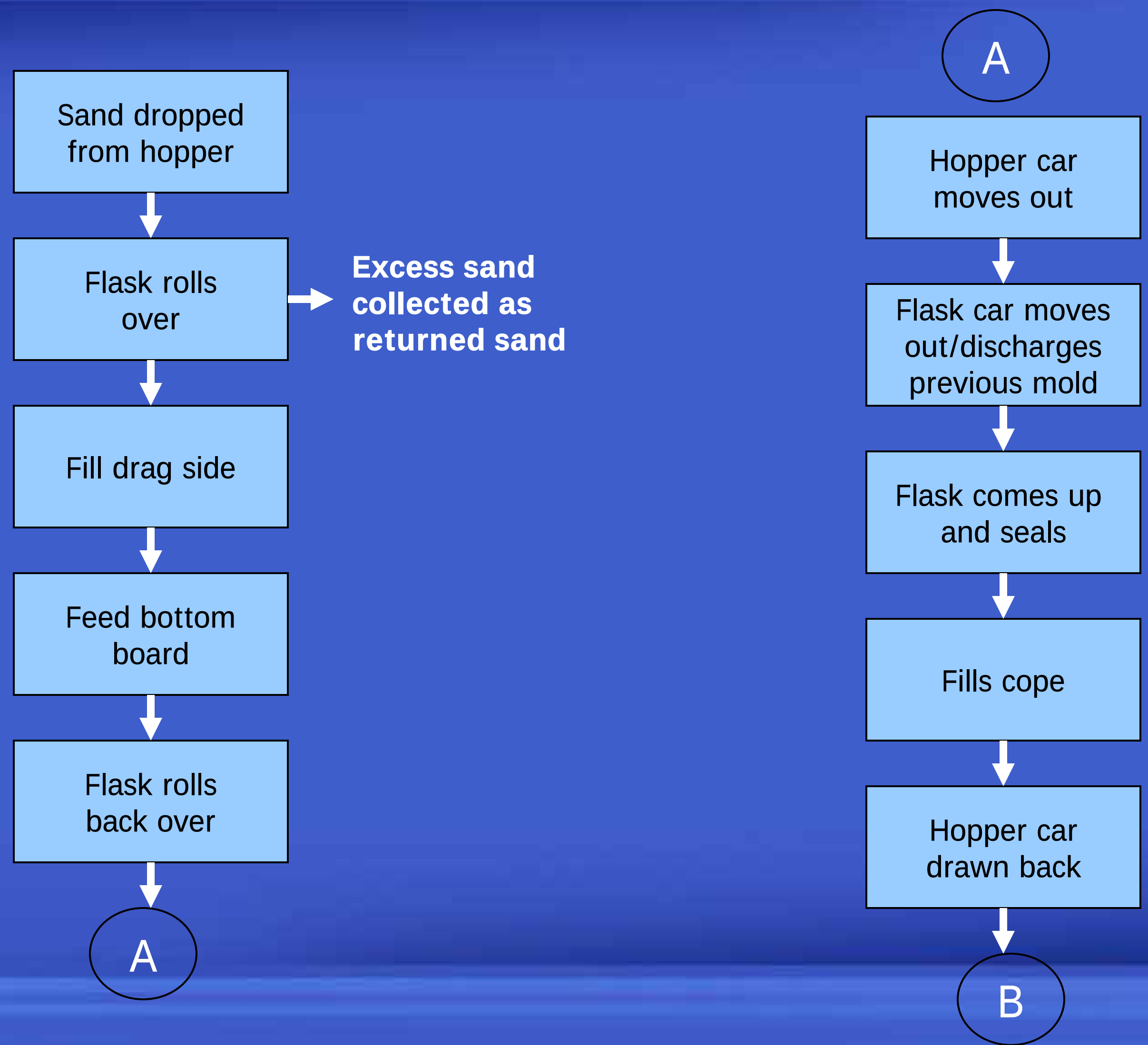
Process Flow Diagrams

- Process flow diagrams for all relevant supplier processes were documented.

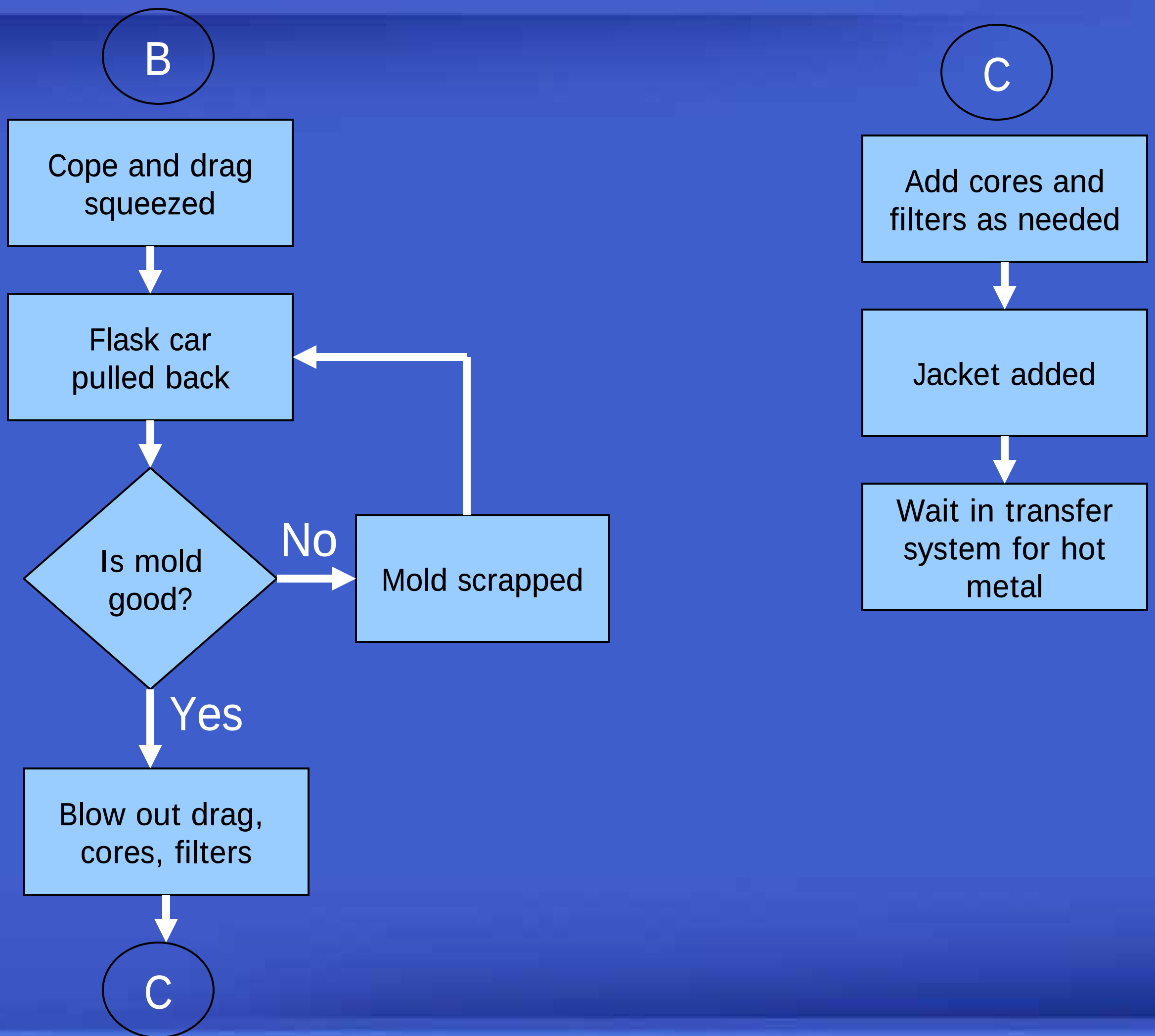
Sand Mullor Process Flow Diagram



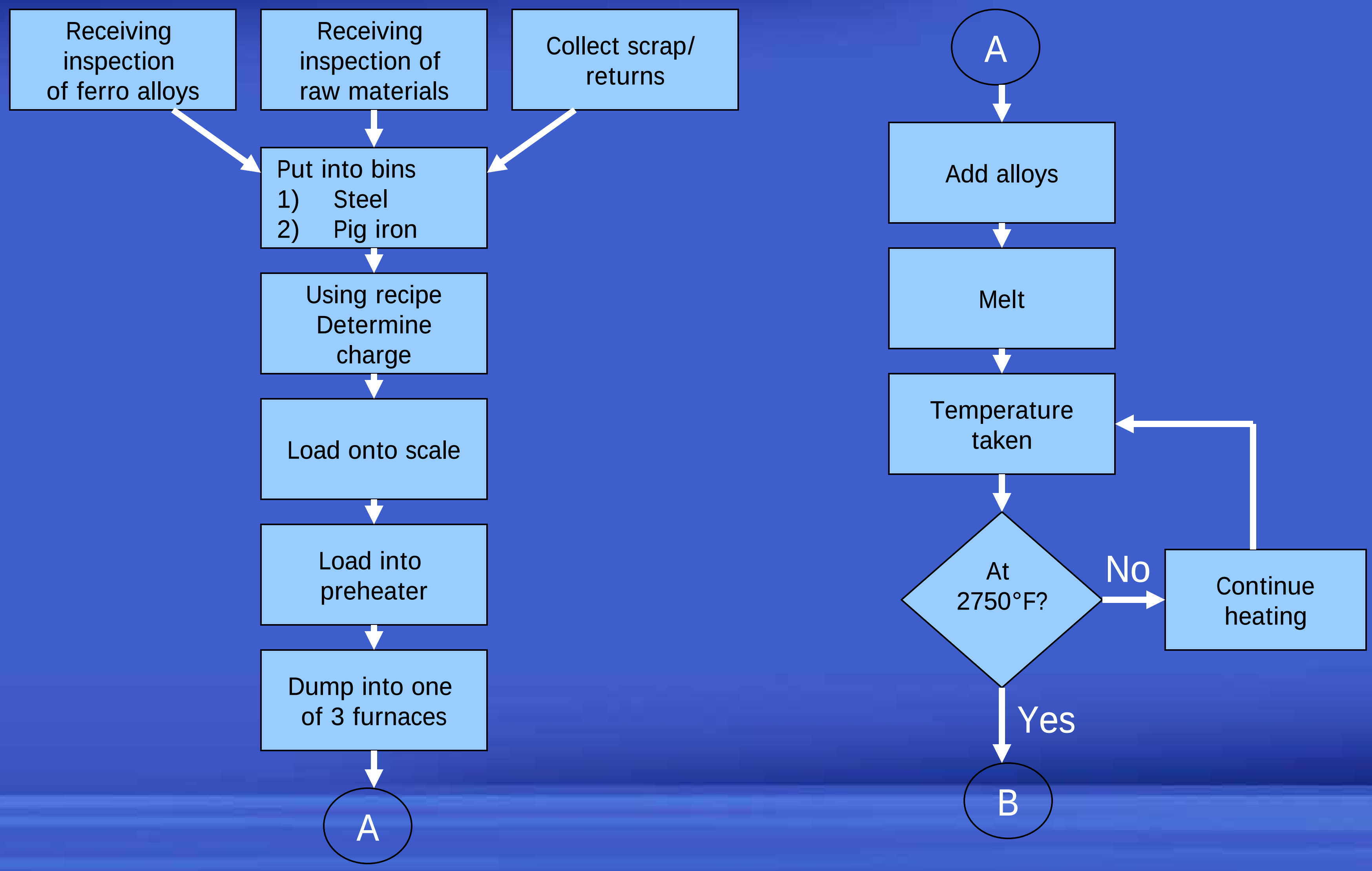
Molding Machine Process Flow Diagram



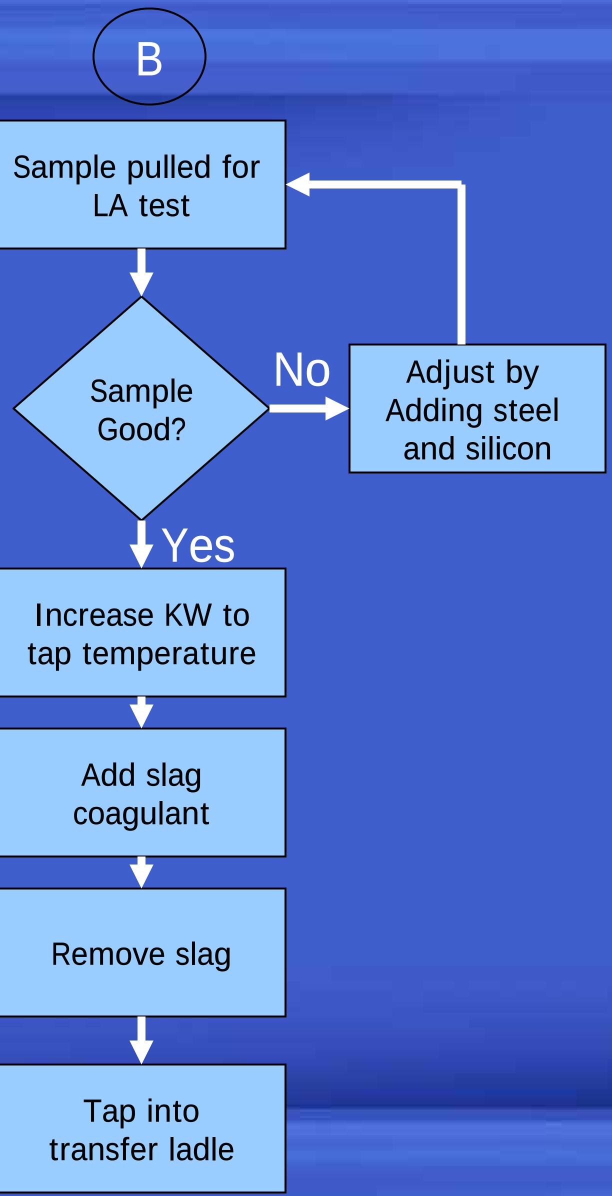
Molding Machine Process Flow Diagram Cont'd



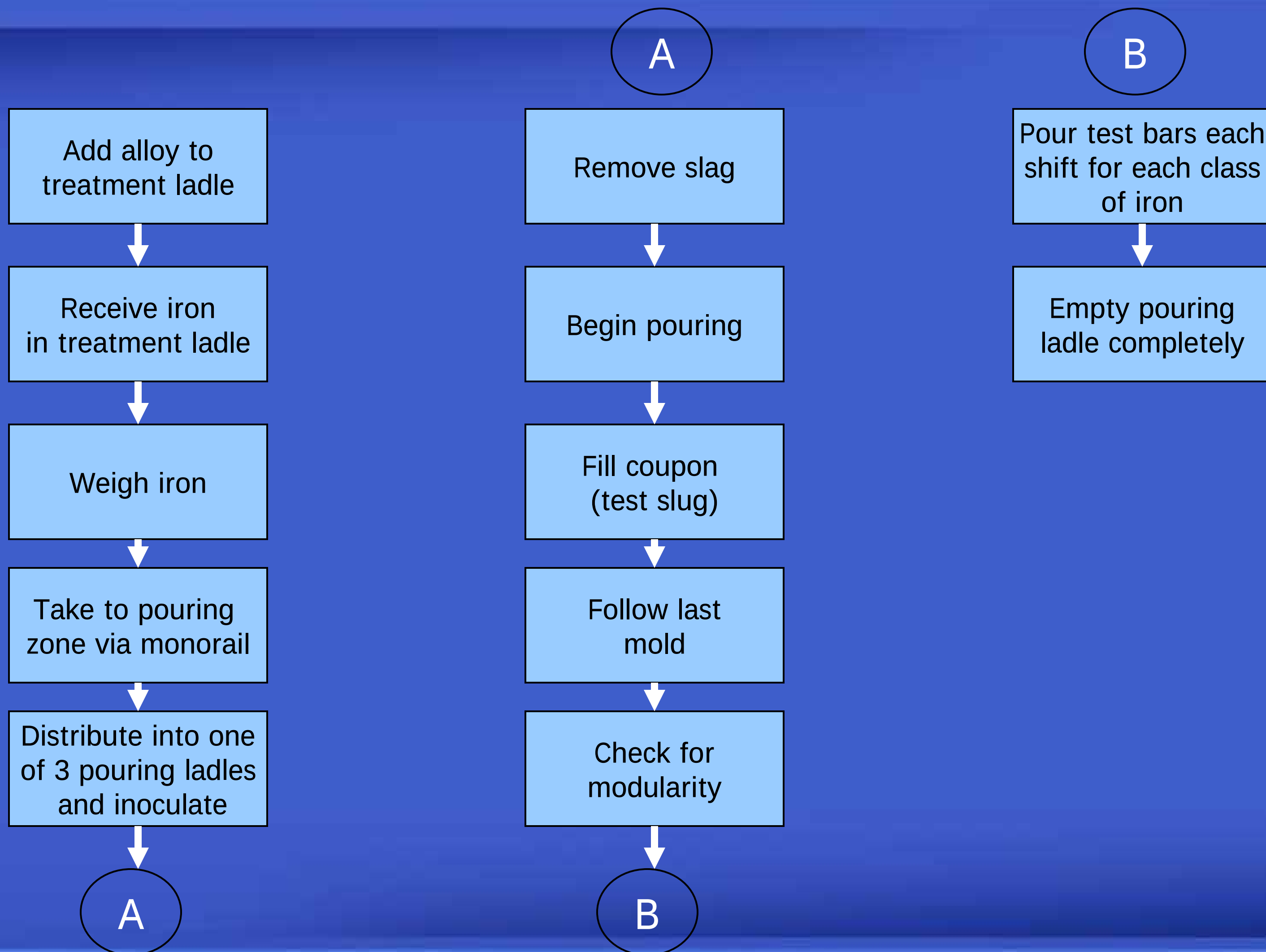
Melting Process Flow Diagram



Melting Process Flow Diagram Cont'd

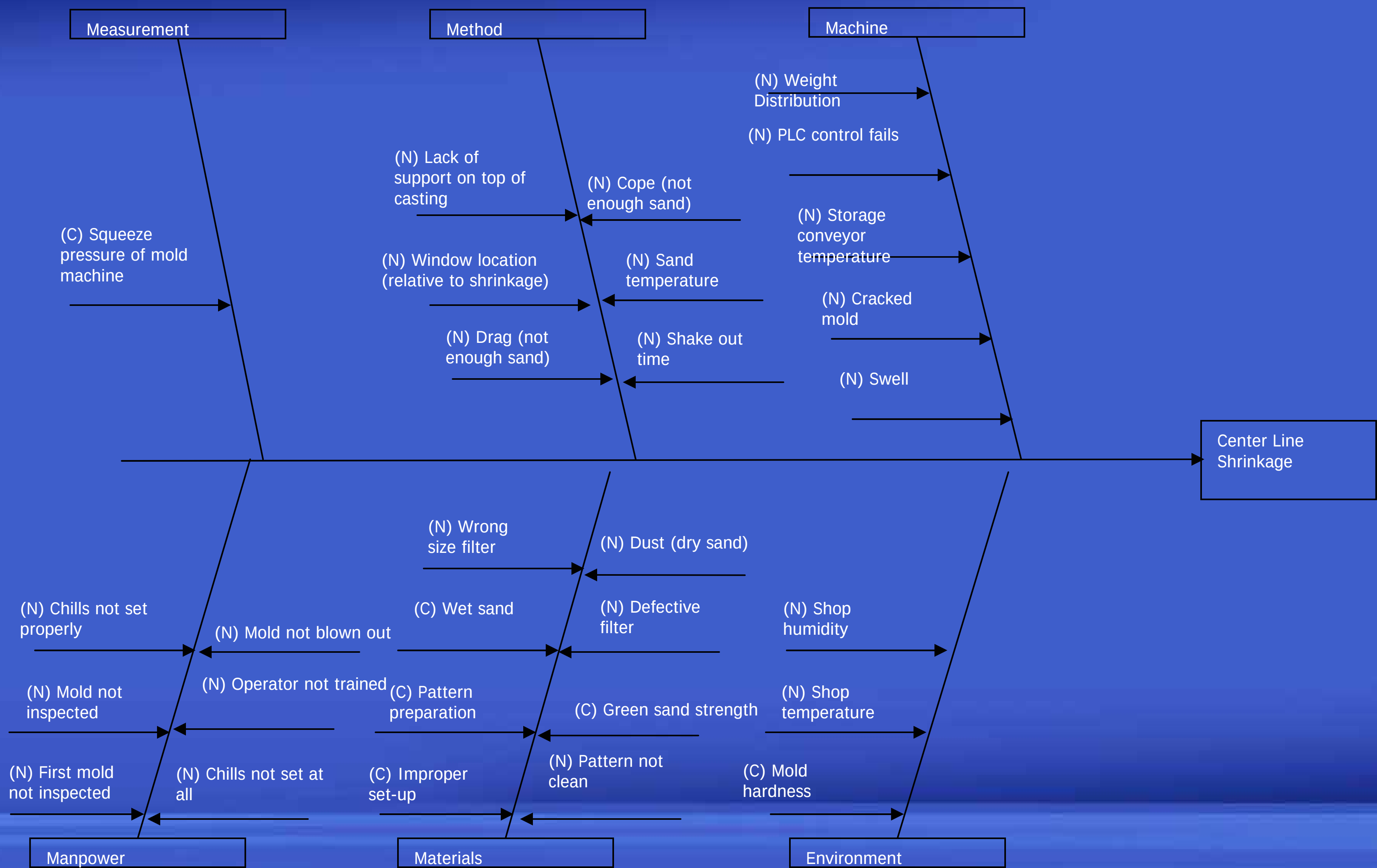


Pouring Process Flow Diagram

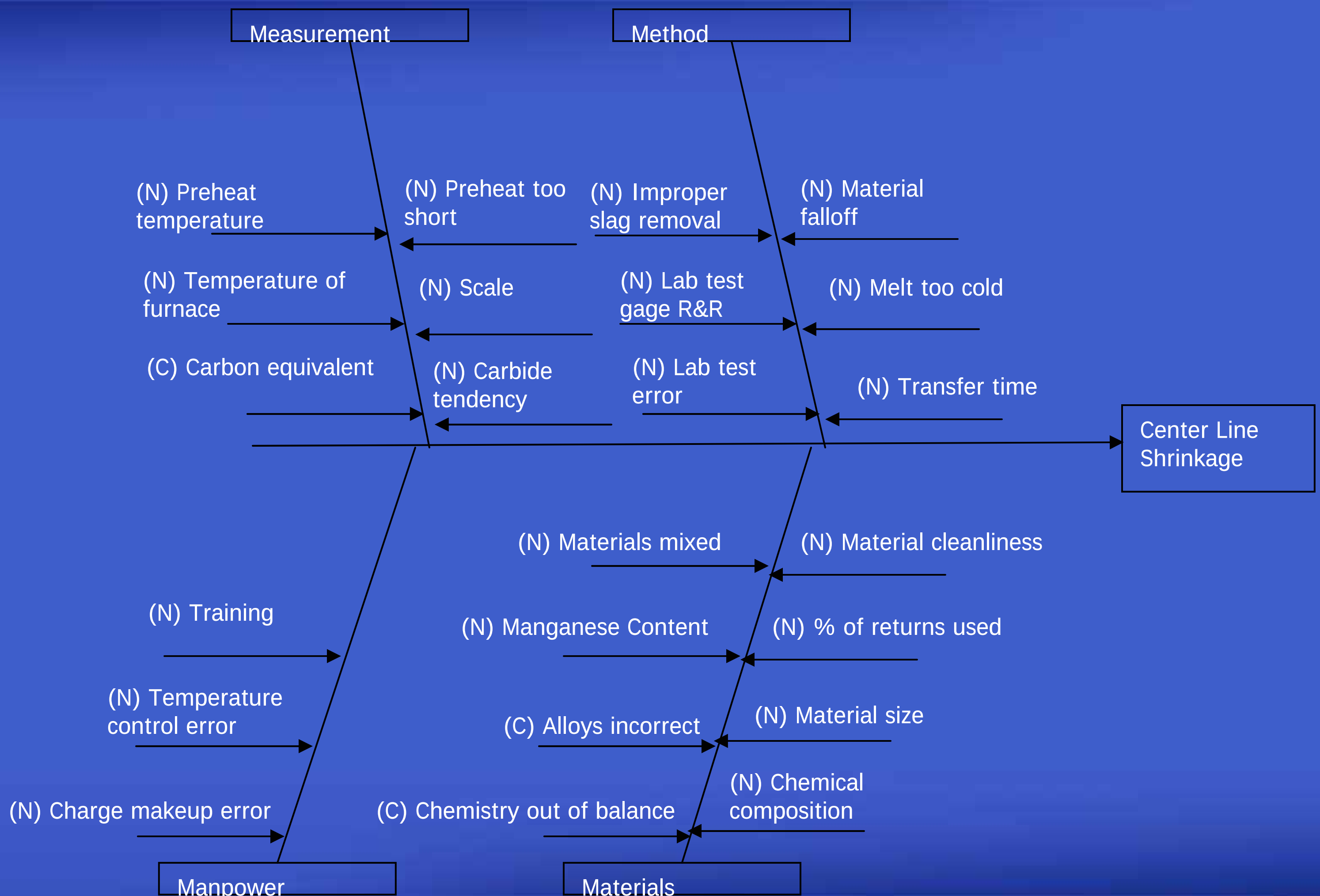


Sand Mullor
Cause and Effect Diagram

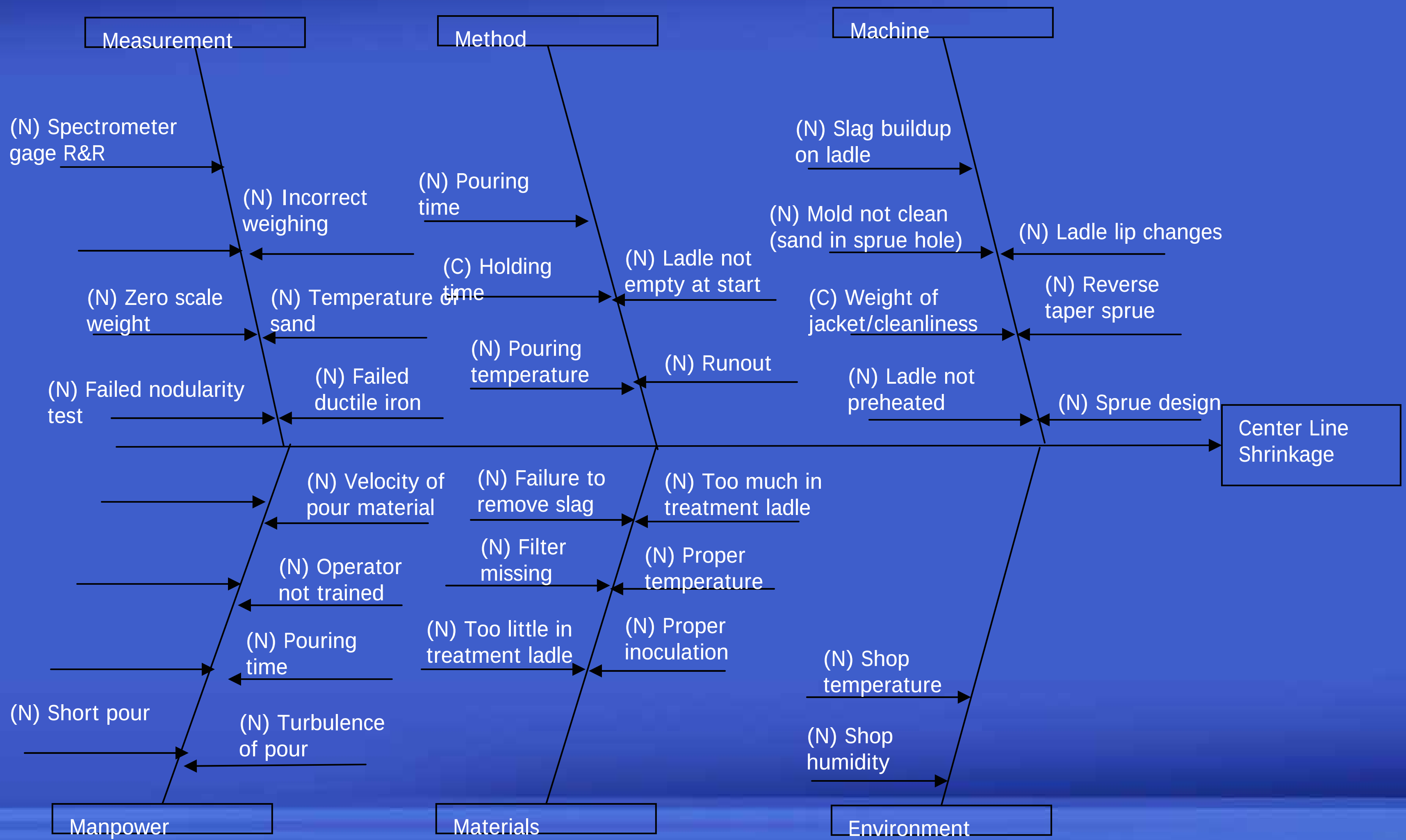
Molding Machine Cause and Effect Diagram



Melting Cause and Effect Diagram



Pouring Cause and Effect Diagram



Noises to Constants

- Action plan created to change noises to constants

- i.e. Pattern Preparation and Set-up
  - Check sheet on Manufacturing Order
  - Check sheet used at every job changeover
  - Procedure established for molding machine setup
  - Standard gating procedure for pattern PM

Process FMEA

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS

PROCESS FMEA

Item _Melting_______________________________________ Process Responsibility_____________________

Model Year(s)/ Vehicle__________________________ Key Date________________________________

Core Team:___________________________________

Process Function Requirements	Potential Failure Mode	Potential Effect(s) of Failure	SEV	Class	Potential Cause(s)/ Mechanism(s) of Failure	Occ	Current Process Controls	Detec.	RPN
Melting	Incorrect weight of charge material	Furnace too full	3		Scales out of calibration	2	PM	7	42
					Operator error when adding charge material	3	Visual, scales	3	27
		Furnace too empty	2		Scales out of calibration	2	PM	7	28
					Operator error when adding charge material	3	Visual, scales	3	18
					Charge hanging up in bucket	4	Visual inspection	4	32
		Chemistry out of spec	8		Scales out of calibration	2	PM	7	112
					Operator error when adding charge material	3	Visual inspection	3	72
					Charge hanging up in bucket	4	Visual inspection	3	96
					Wrong material used	2	Visual inspection	3	48

Design of Experiments

INPUT

PROCESS

OUTPUT

Pouring Temperature
2650 - 2400°F

Squeeze Pressure/
Mold Hardness
1200 - 800

Silicon Content
2.80 – 2.20

Casting Process

Shrink Free Part

DOE Setup

Run	Si Target	Pour Temp	Squeeze Pressure
1	2.80	2650	1200
2	2.80	2650	800
3	2.80	2400	1200
4	2.80	2400	800
5	2.20	2650	1200
6	2.20	2650	800
7	2.20	2400	1200
8	2.20	2400	800

DOE

- Optimal settings for pouring temperature, silicon content and squeeze pressure determined.

Results

- PPM at the start of the project: 23,309
- PPM at the end of the project: 221
- Results are a 99.1% reduction in internal PPM

- COPQ at the start of the project: $200,100
- COPQ at the end of the project: $238
- Results are a 99.5% reduction in COPQ

Key Points

- Build relationships with suppliers
- Train your suppliers
- You are only as good as your suppliers

Thank you