Fault Tree Analysis

For Root Cause Analysis of Sporadic Events

Debra Detwiler, Bridgestone Americas
November 18, 2010
Agenda

- Welcome
- Introduction of MBB Webcast Series
  - Larry Goldman, MoreSteam.com
- “Fault Tree Analysis for Root Cause Analysis of Sporadic Events”
  - Debra Detwiler, Bridgestone Americas
- Open Discussion and Questions
MoreSteam.com – Company Background

- Founded 2000
- Over 250,000 Lean Six Sigma professionals trained
- Serving 45% of the Fortune 500
- First firm to offer the complete Black Belt curriculum online
- Courses reviewed and approved by ASQ
- Registered education provider of Project Management Institute (PMI)
Master Black Belt Program

- Offered in partnership with Fisher College of Business at The Ohio State University
- Employs a Blended Learning model with world-class instruction delivered in both the classroom and online
- Covers the MBB Body of Knowledge with topics ranging from advanced DOE to Leading Change to Finance for MBBs
- Go to http://www.moresteam.com/master-black-belt.cfm for more information about curriculum, prerequisites, and schedule
Debra Detwiler

Master Black Belt, Bridgestone Americas

- Responsible for Six Sigma training and coaching primarily for North American sites
- 33 years experience training, coaching, auditing, operations, management, and quality consulting
- Certified Quality Engineer (CQE)
- B.S. in Statistics from Bowling Green University, M.B.A. from the University of Akron
Today’s Topics

- Bridgestone’s Integrated Quality Strategy
- Problem Solving Challenges
- The use of Fault Tree Analysis
- The Challenger Case Study
- Event Fault Tree Analysis Process
- Tire Manufacturing Example
- Keys to Success
Bridgestone Americas Quality

Major Facilities

- **Tire Plant**: 47 factories in 23 countries
- **Plant For Diversified Products**: 93 factories in 11 countries
- **Tire Technical Center**: 3 facilities in 3 countries

Bridgestone Americas

Bridgestone Americas Holding, Inc.: Tire Technical Center/Akron

Bridgestone Europe N.V/S.A.: Tire Technical Center/Rome

Bridgestone Corporation: Head Office

Technical Center For Diversified Products/Yokohama

Bridgestone Americas Holding, Inc.: Tire Technical Center/Akron
Bridgestone Retail & Commercial Operations

2,200 Tire & Vehicle Service Centers across the U.S.
Integrated Quality Strategy (IQS)

Three Components of IQS enabling Bridgestone Americas to pursue Continuous Improvement by:

- Reducing Variation
- Creating a data driven culture
- Using proven consistent tools
Problem Solving Challenges

- Lack of defined problem solving methodology
- Lack of appropriate triggers and level of activity necessary
- Lack of management attention and critique
- Jumping to conclusions without data and evidence
- Formulating cause and countermeasures before analysis has been conducted
- Focus on physical causes, with little regard to human causes
- Behavior is difficult to modify
The Use of FTA

Problems encountered and application of FTA

- Misproductions
- Accidents
- Environmental Releases
- Explosions
- Product Freezes
- Major Customer Concerns
- Spec Errors
- Mold Problems
- Production Delays
- Manufacturing Errors
- Quality Issues
- Near – miss Accidents or Injuries

Priority
The Use of FTA for Root Cause Analysis of Sporadic Events

The thought process resembles DMAIC, but we use a different set of tools. We are addressing the sporadic event (isolated incident) rather than the chronic variation.
Do you remember where you were on January 28, 1986?

“The Challenger Case Study”
Challenger STS 51-L : 11:38 A.M.

Ellison Onizuka  Christa McAuliffe  Greg Jarvis  Judy Resnik

Michael Smith  pilot
Dick Scobee  commander
Ronald McNair
At 58 seconds into the flight...

Telemetry data showed that there was a loss of pressure in the right Solid Rocket Booster (SRB)
Do you remember what the root cause was reported as?
At 73 seconds...
Oxygen and Hydrogen Escaped at 44,000 ft
Challenger Exploded

- Combustible Material
- Oxygen
- Ignition Source

Why Tree™ - as presented by Bob Nelms, Failsafe Networks

http://failsafe-network.com/
Challenger Exploded

- Combustible Material
  - Release of Hydrogen
    - Hole burned in $\text{H}_2$ tank

- Oxygen
  - Release of Oxygen
    - $\text{O}_2$ tank punctured by right SRB
      - SRB aft attachment point burned
        - Flame escaped from right SRB

- Ignition Source
Why did the Flame Escape?

Investigators ran the tape frame by frame from the launch pad ...

• at t-3 seconds, orbiter engines ignited to create initial thrust

• at t=0 seconds, Solid Rocket Boosters ignited (SRB’s + fuel = 2,400,000 lbs)

• Attachment bolts are popped

• “Wawa” effect begun ( 3 / sec.)

• Multiple smoke puffs timed ( 3 / sec.)

@ 0.5 sec. after ignition, smoke appears
Why did the Flame Escape?...

Why the right SRB and not the left?

- Right SRB was in the shade (internal temp estimated at 32°)
- Left SRB was in the sun (internal temp estimated at 55°)

Why was this launch different?

Challenger was doomed on the launch pad.
Cold temperature launch

This was the launch tower in Cape Canaveral, Florida

This was the coldest launch ever

• 32° at launch
• 26 °earlier that morning
It was the O-Rings

- SRB’s are manufactured in segments
- Shipped from Morton Thiokol (Utah) and sent by railroad to Florida
- SRB segments assembled and sealed using two flexible O-rings
It was the O-Rings

True, but was there more evidence?

- 1977 test using strain gauges at ignition (4 yrs before the first shuttle flight)
- Booster segment walls were more flexible than expected and joints were stiffer than expected
- We must have had an O-Ring leak but there was no leak, no smoke puffs
- The O-Rings were damaged but no leak
- The wall took 15 milliseconds for max deflection
- It took the O-Rings 5 milliseconds to expand (3:1 safety factor)
It was the O-Rings

True, but was there more evidence?

• NASA was presenting the test results to congress

• Dr. Richard Feynman, Noble physicist challenged NASA “What temperature did you run these tests?”

• Demonstration with a C-clamp, a caliper, and a bucket of ice

• How long do you think it took the O-Ring to fully expand?
Flame escaped from right SRB

Hot gasses escaped through O-Ring

O-Ring did not seal at ignition

Too inelastic to fill void at ignition

Temp too cold at launch

Decision to launch despite cold temp
Too inelastic to fill void at ignition

Temp too cold at launch

Decision to launch despite cold temp

Act of God

What is different about this cause?

This is a HUMAN CAUSE
Launch Decision Flow
*2 weeks prior to launch*

1. NASA Hqtrs
   - Initiate FRR

2. Vendors
   - Certify Ready

3. NASA SFCs
   - Certify Ready

4. NASA MMT
   - Countdown Begins

**Flight Readiness Review**

**Space Flight Center**

**Mission Management Team**
Launch Decision Flow

16 hrs prior to launch

Weather Report:
26° launch temp predicted

NASA Hqtrs
Initiate FRR

Vendors
Certify Ready

NASA SFCs
Certify Ready

NASA MMT
Countdown Begins

Lower Launch Limit
40°
Launch Decision Flow

16 hrs prior to launch

In case of problems, NASA uses the Anomaly Feedback Flow

- Every vendor consulted
- All were OK except Morton Thiokol

Are we going to launch or scrub?
Morton Thiokol
Go / No Go Decision on Low Temp Launch

- We suspected O-Ring problems since 1977
- We confirmed it in 1981 after first shuttle launches had 30% O-Ring damage
- Of 24 flights, 7 have experienced O-Ring damage
- This is way beyond the known flight envelope of 53°
- The worst O-Ring damage was at 53°

Conclusion: No Go – delay launch until 53°
NASA
Marshall Spaceflight Center – Huntsville, Ala

- We’ve already had 4 major delays – here’s another schedule we’ll miss
- State of the Union Address is 1/28 and President Reagan intends to speak with Christa McAuliffe in orbit
- The spacecraft is qualified to 40°
- We’ve approved the waivers 24 times before
- The second O-Ring will seal
- There might not even be a temperature problem
  – data inconclusive
- There is an element of risk in every launch

Conclusion: Let’s test them, if they hold, we’ll delay
Morton Thiokol
Go / No Go Decision on Low Temp Launch

- They are the customer and they are resisting
- Contract renewal is tomorrow: It’s Rockwell or us
  (40,000 people depend on these jobs)
- We’ve gotten away with this before, maybe engineering is being too cautious
- The data is inconclusive

**Conclusion**: Go
What Was the True Root Cause?

Was it the design of the SRB?

Was it the O Rings?

Was it the temp at launch?

Was it the decision process of MMT?

Was it the nature of Morton Thiokol’s CEO or NASA’s leadership?
“Root Cause” Analysis
Don’t Neglect the Human factor

“Human beings cause problems”

It’s not always -

• Systems
• Designs
• Culture

Bob Nelms – Failsafe Networks
We All Must Accept Responsibility for Our Role When Problems Occur

It is rare to find individuals who can see their own role in things that go wrong.

If you ask them to, they will!
If we follow the steps...
Let the data drive our search...
We will get to the root of the problem

Stay with the Physical Causes as long as we can, then go to Human Cause
Event FTA Process

1 Define Problem
- Preserve the scene, if appropriate
- Gather data (i.e. statements, photographs and records)
- Genbutsu Genba
- Capture the product and evidence (containment)
- Situation analysis
- Lot traceability
- Temporary countermeasure
- Release / restart of process
Event FTA Process

2 Develop Timeline

- Investigate and discern facts
- Interviews / statements
- Understand the process and what happened
- Analyze data and current state
- **Chronology of events (sequence)**
- Process map / timeline / event analysis
- Compare process to standard
Event FTA Process

3 Conduct Fault Tree Analysis

- Structured brainstorming of possible causes
- Identification of major phenomena
- **Cause analysis**
  - Identification of root cause
  - Develop countermeasures
1. Define Problem
2. Develop Timeline
3. Conduct Fault Tree Analysis
4. Implement Countermeasures
5. Confirm Results and Change Standards

4. Implement Countermeasures
- Develop “Should” process and implement
- Short and long term countermeasures
- Countermeasure causes
- Kaizen (improve) process
- Conduct necessary training
- Develop control plans and/or standards, if appropriate
Event FTA Process

5 Confirm Results and Change Standards

- See countermeasures through
- Monitor “Should” process
- Develop/change standards, as necessary
- Control and standardize
- Standardize and institutionalize
- Evaluate results
- Track progress via audits
Timeline: What Happened

Timeline helps us to avoid jumping to conclusions and is integral to identification of proper phenomena.
Once the proper phenomena have been identified, use the “5-Why” approach to dig into the root cause(s).
Event FTA Roadmap Template

**Define Problem**
- What do I know?
- How do I know it is contained?
- How do I know it is OK to restart?

**Develop Timeline**
- What did I find out?

**Conduct Fault Tree Analysis**
- What caused it?
- Who caused it?
- What are the root causes?
- What are you willing to do?
- What were the circumstances?
- Who did what wrong?
- How did you & your culture contribute?

**Implement Countermeasures**
- 1. Basic Description of Triggering Event
- 2. Summary of Data Gathering Approach
- 3. Process High Level (Actual Schematic)
- 4. Stabilization Overview
- 5. Physical Evidence
- 6. People Evidence
- 7. Paper Evidence
- 8. Summary Sequence of Events
- 9. Should vs. As Is Process (Compare vs. Standard)
- 10. Cause and Effect (Optional)
- 11. Summary of Gaps Identified
- 12. Physical Causes
- 13. Human Causes
- 14. Fault Tree
- 15. Countermeasures
- 16. Understand their Thoughts
- 17. Thought Process (Balance of Consequences)
- 18. Hidden Organizational & Personal Causes

**Confirm Results and Change Standards**

Key Tool

Helps modify behavior
HDCT Tires Treaded with the Wrong Compound

Event FTA Template

Date: February 2009
**Triggering Event**

Insert **basic description** of **TRIGGERING EVENT** here.
Use the word “Anonymous” if the person’s identity must be protected. Keep it simple.

<table>
<thead>
<tr>
<th>Who (did it happen to)?</th>
<th>Des Moines Cold Feed Extruder Area (Agricultural Tire)</th>
</tr>
</thead>
<tbody>
<tr>
<td>What (was the undesired actual/potential consequence)?</td>
<td>18 tires treaded with the wrong tread compound. Employee used V2887 rubber, but spec rubber is V2807</td>
</tr>
<tr>
<td>Where (did it happen)?</td>
<td>B2B3 Dept. 178</td>
</tr>
<tr>
<td>When (did it happen)?</td>
<td>8:10am 1-6-2009</td>
</tr>
<tr>
<td>How do you know it is contained (esp. product)?</td>
<td>Used PICS data to track down tires treaded on B2B3 on 1-6-2009. Held all tires treaded on this shift. Cut rubber samples from each tire and took them to the lab to have the stock tested.</td>
</tr>
<tr>
<td>How did you know it was OK to restart (stabilization)?</td>
<td>All tires that passed the MRC lab retest were released from hold.</td>
</tr>
<tr>
<td>Your Name:</td>
<td>Manager</td>
</tr>
<tr>
<td>Completion Date:</td>
<td>1-8-2009</td>
</tr>
</tbody>
</table>
**Summary of Data Gathering Approach**

A few BULLETS, in GENERAL terms, referring to containment and collection of data

- **Containment**
  - Stop: Once warm up sample was found to test bad, production in curing stopped.
  - Assess: Verified what tires were involved.
  - Isolate: All tires were frozen in PICS and placed in storage with hold tags on them.
  - Stabilize: Due to complications, it took 16 hrs. to locate all tires.
  - Re-Start: Until all suspect tires were verified to have been placed on hold, curing was shut down. Production resumed after 16 hours.

- **Evidence Plan (What do I need to know?)**
  - People:
  - Physical:
  - Paper:

See photo’s on next page for outline

**What is the Problem?** *(what question will you answer in this FTA -- should relate to WHAT on page 2)*

Why were tires treaded with wrong stock?
Collection of data and evidence

People
- Trucker 412
- " " 178
- CFE Operators
- Warm Up Sample
  - Supervision
  - Trucker 178
- Lab Tech
- Lab Supervision
- Person Scanning Carcass

Paper
- WKG STDs
  - 178/412 Truckers
  - Warm Up Sample Process
    - Delivery
  - CFE Operation
- PCP CFE
  - Cons. Std Warm Up Req.
- Lot Trace (Pics History)
- Warm Up Test Data
- B2B3 M/C History
- Operator Check Sheet (C)
  - Load Tag
  - Warm Up Sample Test

Physical (Pictures)
- 412 Storage
- 178 Storage
- Physical Layout (Proximity)
- M/C Staging
  - Place to Stage Tickets
  - Place Scanner Stored
- Act. Sample
- Act. Skid Rubber
- Act. Tires
- Scanning Carcass
Insert labeled schematics identifying the issue so the reader can understand the remainder of this document.

Can be hand drawn. Keep it simple.

Incorrect stock delivered to CFE

Operator loaded stock at 8:10 am

18 tires processed

Sample warm up ticket filled out

Driver gave sample and ticket to supervisor

Sample to lab at 2:10 pm

Warm up sample failed & retest failed

Curing shut down
Insert schematic, drawing, data table, etc. indicating containment and stabilization. Keep it *simple* yet informative.

Review with others to confirm your thinking. Effective **Containment** and **Stabilization** is critical.

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Value 1</th>
<th>Value 2</th>
<th>Value 3</th>
<th>Value 4</th>
<th>Value 5</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>090106-WU</td>
<td>QVGV-1</td>
<td>1/7/2009 02:21</td>
<td>14.95</td>
<td>&gt; 2.50</td>
<td>&gt; 0.43</td>
<td>0.70</td>
<td>0.93</td>
</tr>
<tr>
<td>090106-WU</td>
<td>QVGW-1</td>
<td>1/7/2009 02:22</td>
<td>15.10</td>
<td>&gt; 2.68</td>
<td>&gt; 0.44</td>
<td>0.71</td>
<td>0.94</td>
</tr>
<tr>
<td>090106-WU</td>
<td>QVGX-1</td>
<td>1/7/2009 02:24</td>
<td>14.88</td>
<td>&gt; 2.55</td>
<td>&gt; 0.43</td>
<td>0.71</td>
<td>0.95</td>
</tr>
<tr>
<td>090106-WU</td>
<td>QVMV-1</td>
<td>1/7/2009 02:15</td>
<td>10.62</td>
<td>&gt; 2.07</td>
<td>&gt; 0.39</td>
<td>0.67</td>
<td>1.13</td>
</tr>
<tr>
<td>090106-WU</td>
<td>QVN4-1</td>
<td>1/7/2009 02:16</td>
<td>15.34</td>
<td>&gt; 2.73</td>
<td>&gt; 0.44</td>
<td>0.70</td>
<td>0.93</td>
</tr>
<tr>
<td>090106-WU</td>
<td>QVNB-1</td>
<td>1/7/2009 02:19</td>
<td>14.99</td>
<td>&gt; 2.63</td>
<td>&gt; 0.44</td>
<td>0.71</td>
<td>0.94</td>
</tr>
<tr>
<td>090106-WU</td>
<td>QVTB-1</td>
<td>1/7/2009 02:21</td>
<td>7.96</td>
<td>1.87</td>
<td>0.42</td>
<td>0.75</td>
<td>1.35</td>
</tr>
<tr>
<td>090106-WU</td>
<td>QVT9-1</td>
<td>1/7/2009 02:30</td>
<td>6.95</td>
<td>1.19</td>
<td>&lt;</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>090106-WU</td>
<td>QVTB-1</td>
<td>1/7/2009 02:32</td>
<td>7.66</td>
<td>1.95</td>
<td>0.43</td>
<td>0.74</td>
<td>1.33</td>
</tr>
<tr>
<td>090106-WU</td>
<td>QVTC-1</td>
<td>1/7/2009 02:35</td>
<td>7.99</td>
<td>1.93</td>
<td>0.41</td>
<td>0.76</td>
<td>1.33</td>
</tr>
<tr>
<td>090106-WU</td>
<td>QVTD-1</td>
<td>1/7/2009 02:37</td>
<td>7.99</td>
<td>1.85</td>
<td>0.43</td>
<td>0.74</td>
<td>1.32</td>
</tr>
<tr>
<td>090106-WU</td>
<td>QVTF-1</td>
<td>1/7/2009 02:40</td>
<td>8.06</td>
<td>1.96</td>
<td>0.44</td>
<td>0.76</td>
<td>1.34</td>
</tr>
<tr>
<td>090106-WU</td>
<td>QVTG-1</td>
<td>1/7/2009 02:43</td>
<td>7.99</td>
<td>1.87</td>
<td>0.43</td>
<td>0.74</td>
<td>1.33</td>
</tr>
<tr>
<td>090106-WU</td>
<td>QVTH-1</td>
<td>1/7/2009 02:45</td>
<td>7.96</td>
<td>1.80</td>
<td>0.43</td>
<td>0.74</td>
<td>1.33</td>
</tr>
</tbody>
</table>
Insert labeled photos and sketches of PHYSICAL EVIDENCE here. Make sure ALL items referred-to in other portions of this document are included. Keep it simple.
Physical Evidence

Insert labeled photos and sketches of PHYSICAL EVIDENCE here. Make sure ALL items referred-to in other portions of this document are included. Keep it simple.
Insert **labeled photos and sketches** of **PHYSICAL EVIDENCE** here. Make sure ALL items referred-to in other portions of this document are included. Keep it simple.
WHO said WHAT

Always interview with someone else present to have dual confirmation of who said what. Develop interview guidelines.

Manager: We had an issue on 1-6-2009 with tires that were treaded with the wrong rubber. How did this happen?
Operator: I don’t know, every time I scan a skid I check the ticket and try to find a stamp on the load.
Manager: Why didn’t you scan this load into the extruder?
Operator: I always try to.
Manager: Do you always scan the rubber into the cfe?
Operator: Not always if it is a large skid yes, if it is a small skid no.
Manager: You do know you are suppose to scan every load in correct?
Operator: Yes. But I can tell the difference between the rubbers.
Manager: Do you think you can always tell the difference between the right rubber and wrong rubber?
Operator: Yes, but I always try to find the stamp.
Manager: We have 4 different standards that say we scan and verify loads vs. spec for tires. All 4 of these standards could have prevented this from happening. Why didn’t you follow them?
Operator: I just didn’t scan. It was a small skid and a fast tire.
The follow standards give operator instructions:

- Standard 178-26 loading rubber at cfe’s
- Standard 178-23 cfe rubber sampling
- Standard 178-17 green tire to spec rubber ID
- Standard 763-20 warm up sampling
The follow standards were not followed by operator:

- Standard 178-26 loading rubber at cfe’s
- Standard 178-23 cfe rubber sampling
- Standard 178-17 green tire to spec rubber ID
- Standard 763-20 warm up sampling
### Event Timeline Form

<table>
<thead>
<tr>
<th>Who/What</th>
<th>TIME</th>
<th>Component - Machine</th>
<th>Comments:</th>
</tr>
</thead>
<tbody>
<tr>
<td>loaded wrong rubber into cfe.</td>
<td>8:10am</td>
<td></td>
<td></td>
</tr>
<tr>
<td>didn't scan rubber into extruder</td>
<td>8:11am</td>
<td></td>
<td></td>
</tr>
<tr>
<td>treaded 18 tires using v2887 rubber instead of v2807 rubber</td>
<td>8:50am</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Took rubber sample and information off v2887 ticket</td>
<td>8:51am</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cfe rubber sample was taken to the lab</td>
<td>2pm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAB CALLED DOWN TO TELL TIRE ROOM WARM UP SAMPLE FAILED OFF OF B2B3.</td>
<td>4:15pm</td>
<td>B2B3</td>
<td></td>
</tr>
<tr>
<td>LAB REQUESTED ANOTHER SAMPLE FROM AROUND THE SAME TIME FRAME, CUL CUT A SAMPLE OFF OF A TIRE IN FRONT OF THE PRESS.</td>
<td>4:30pm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DELIVERED SAMPLE TO THE LAB AND WAITED FOR THE SAMPLE TO BE TESTED</td>
<td>4:45pm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAMPLE FAILED TEST</td>
<td>4:50pm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CUL CAME BACK DOWN TO THE AREA AND FOUND WHAT GREEN TIRES WERE PRODUCED WITH THE HELP OF PICS.</td>
<td>5:10pm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CUL CALLED CURING TO HAVE ALL NATI PRESSES SHUT DOWN ON QUALITY.</td>
<td>5:15pm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONTACTED PE TO FREEZE THESE TIRES IN PICS</td>
<td>5:30pm</td>
<td>135 OFFICE</td>
<td></td>
</tr>
<tr>
<td>DID PRODUCTION TURNOVER WITH ON COMING SHIFT</td>
<td>5:45pm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALL TIRES WERE PLACED BY THE 1 &amp; 2 BOOTH WITH HOLD TAGS PLACED ON THE RACKS WITH THE HELP OF CURING.</td>
<td>6:45pm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PULLED PICS INFO NUMBER OF TIRES WERE PLACED ON HOLD, MEETING WITH NORVEL.</td>
<td>8:15pm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DID TIMELINE ON ISSUES IN MAIN CONFERENCE ROOM</td>
<td>8:50pm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CUL PULLED PICS INFO FOR EACH TIRE AND CUT SAMPLES OFF EACH TIRE</td>
<td>12:30am</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MILA TOOK SAMPLES TO THE LAB.</td>
<td>12:45am</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Approximately 10 bullets, IN GENERAL TERMS, referring to the schematic**

More detailed than previous high level map.
**Bridgestone Americas Quality**

**Should vs. As Is Process** *(Brief Description)*

Insert *labeled schematics* so the reader can understand what should have happened vs. what did happen.

Highlight items in the “As Is” process that did not meet standard requirements. Keep it **simple**.
**Should vs. As Is Process (Brief Description)**

Insert labeled schematics so the reader can understand what should have happened vs. what did happen.

---

### Standards Based Improvement Summary

<table>
<thead>
<tr>
<th>Reg. No.</th>
<th>Machine Name</th>
<th>Date:</th>
<th>Shift</th>
<th>Countermeasures to close the gap between standard and actual.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Improvement implemented</td>
</tr>
</tbody>
</table>

---

#### Example of Improvement

**Phonomon cost plant $10,987.00 by not standards we have in place.**

---

#### Define

Did you compare with Work Std, M/C Std, Process Std?

<table>
<thead>
<tr>
<th>Standard</th>
<th>Actual Work</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>178-26 loading rubber at cfe's - Verify stock code of rubber and scan ticket when loading new rubber skid.</td>
<td>rubber not scanned in and stock not verified.</td>
<td>No verification or scanning - employee didn’t follow standard</td>
</tr>
<tr>
<td>178-23 cfe rubber sampling - Deliver warm-up samples to the lab every 2 hours.</td>
<td>Delivered 5 hrs after sample taken.</td>
<td>Delivered 3 hrs late - employee didn’t follow standard</td>
</tr>
<tr>
<td>178-17 green tire to spec rubber id - All tags and impression must match marquee Spec = V2807, tags and impression V2887</td>
<td>No match - employee didn’t follow standard</td>
<td></td>
</tr>
<tr>
<td>763-20 warm up sampling - warm up samples must be delivered at start of shift, after lunch and after each break.</td>
<td>sample taken at 8:51 and and delivered at 2:00 pm.</td>
<td>Sample not taken to lab after morning of lunch breaks - employee didn’t follow standard</td>
</tr>
</tbody>
</table>

---

#### Measure/Analyze

Identify with (X) how issue was exposed

Identify aware of problems, identify issues (Quantify size of problem) Expose work that can’t be done to std from problem detection information

---

#### Improve

(Visual explanation of improvement)

**Before Improvement**

**After Improvement**

**Control**

(Contents and method of education: What controls are in place to follow standards)

**Action**

Education to be done by HR for not following standards.

Re-educate dept, including supervisors, on requirement for delivering samples to lab.
IN GENERAL TERMS, referring to should vs. actual schematics

**Gaps-Tire Room**
Samples taken at 7:15am and 8:10am. Delivered to lab at 2:00pm. We didn’t follow standard.
Scanned multiple tires at the same time.
Scanned same rubber load ticket twice. No system to prevent this from happening.

**Gaps-Curing Room**
Tire was scanned ahead of time at the press. PICS system does not allow backing out tire. As a result another tire was laid in the press without needing to scan.

**Gaps-MRC Lab**
Sample delivered to the lab at 2:00pm. Tire room notification of failed sample at 5:00pm.

**Gaps-All**
Poor turnover/communication
Lack of knowledge to lot trace on all shifts
Unable to access lot trace information i.e. CFE run records, rubber scan information etc...
Curing presses were down 18 hrs awaiting confirmation of containment. Why did it take until 1:00 to confirm all tires were contained.
Why did tires get treaded with wrong stock?

- Wrong stock was delivered to CFE.
- Wrong stock was not identified by operator.
- Rubber not scanned at start of new load.
- Warm up sample delivered to lab 5 hours late.
Complete FTA: Address Man, Material, Machine, and Method. Use “5Why” to get to root.

Phenomena (unusual actions) identified helps with cause analysis. The 5 Why approach and branching drives the name FTA.
Establish SMART (specific, measurable, attainable, realistic, time-sensitive) action items. Keep it **simple** and **realistic**. Address **immediate**, **detection**, and **prevention** needs: from FTA. Utilize SDP process for control.

### Countermeasures

#### Corrective Actions

<table>
<thead>
<tr>
<th>Short Term Corrective Action(s)</th>
<th>Owner</th>
<th>Due Date</th>
<th>Completed Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meeting with employee to ask why he chose not to follow standards</td>
<td>minor</td>
<td>1/31/2009</td>
<td>1/30/2009</td>
</tr>
<tr>
<td>Use this incident at start of shift meeting to re-educate employees on following standards</td>
<td>AM</td>
<td>1/31/2009</td>
<td>1/30/2009</td>
</tr>
<tr>
<td>Re-educate employees and update requirements for samples to lab every 2 hours (in process)</td>
<td>AM</td>
<td>1/31/2009</td>
<td>1/30/2009</td>
</tr>
<tr>
<td>Change from scanning multiple times at once to one at a time as needed</td>
<td>AM</td>
<td>1/31/2009</td>
<td>1/30/2009</td>
</tr>
<tr>
<td>Lot trace daily by shift for dept 176 for rubber compound tickets</td>
<td>AM</td>
<td>2/15/2009</td>
<td></td>
</tr>
<tr>
<td>Add check of sample delivery to supv control points</td>
<td>AM</td>
<td>2/23/2009</td>
<td></td>
</tr>
<tr>
<td>Move items from PRIM bucket to previous bucket if not cured [CCS]</td>
<td>DG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change stock code so they are not similar (Y2867 - Y2867) and verify if other codes need changed</td>
<td>MC</td>
<td>3/11/2009</td>
<td></td>
</tr>
<tr>
<td>Make partial use tag/walk away back out for lot trace</td>
<td>AM</td>
<td>2/21/2009</td>
<td></td>
</tr>
</tbody>
</table>

### Long Term Corrective Action(s)

<table>
<thead>
<tr>
<th>Long Term Corrective Action(s)</th>
<th>Owner</th>
<th>Due Date</th>
<th>Completed Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add pass to 42 then add rubber usage from spec to prevent a consumed product from being scanned in by pass interlocks on machine</td>
<td>SC</td>
<td>next PICS phase</td>
<td></td>
</tr>
<tr>
<td>Get access to data from IS2B machines from scanned rubber loads</td>
<td>JD</td>
<td>3/15/2009</td>
<td></td>
</tr>
<tr>
<td>Audit scanning of loads at IS2B 2 and 3 (in process)</td>
<td>AM/PA</td>
<td>3/15/2009</td>
<td></td>
</tr>
</tbody>
</table>
For each Human Cause, describe the Triggering Situation. The Triggering Situation is the “point in time” when the inappropriate decision was made that led to the Human Cause. Describe the circumstances at this point in time.

**Human Cause #1**  
**B2B3 operator didn’t follow standards**

Manager: We had an issue on 1-6-2009 with tires that were treaded with the wrong rubber. How did this happen?  
Operator: I don’t know, every time I scan a skid I check the ticket and try to find a stamp on the load.  
Manager: Why didn’t you scan this load into the extruder?  
Operator: I always try to.  
Manager: Do you always scan the rubber into the cfe?  
Operator: Not always if it is a large skid yes, if it is a small skid no.  
Manager: You do know you are suppose to scan every load in correct?  
Operator: Yes. But I can tell the difference between the rubbers.  
Manager: Do you think you can always tell the difference between the right rubber and wrong rubber?  
Operator: Yes, but I always try to find the stamp.  
Manager: We have 4 different standards that say we scan and verify loads vs. spec for tires. All 4 of these standards could have prevented this from happening. Why didn’t you follow them?  
Operator: I just didn’t scan. It was a small skid and a fast tire.

**Fill-in ONE copy of this page for each of the identified HUMAN CAUSES.**
Determine the thought process of the person who behaved inappropriately. Capture the **ACTUAL WORDS** that **MIGHT** have been running through the persons mind. Bullet-style. **Complete Balance of Consequences.**

<table>
<thead>
<tr>
<th>As Is - Inappropriate</th>
<th>As Desired - Appropriate</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Identifying codes similar</td>
<td>• Make codes different</td>
</tr>
<tr>
<td>• Machine allowed to run without scan</td>
<td>• Machine recognizes skid change and requires new scan</td>
</tr>
<tr>
<td>• Re-scan of previously scanned ticket</td>
<td>• Machine recognizes previously scanned ticket</td>
</tr>
<tr>
<td>• Operator doesn’t always scan small skids</td>
<td>• Machine forced scan regardless of size</td>
</tr>
<tr>
<td>• Failure to deliver MRC sample for 5 hours</td>
<td>• Delivery to lab every two hours</td>
</tr>
<tr>
<td>• CFE lot trace times on racks of tires the same</td>
<td>• Tires scanned in order of treading when placed back on rack</td>
</tr>
</tbody>
</table>
What is it about the way we ARE that is evident in the above thoughts?
Must be generic, i.e. not specific to only this one incident, and present tense. Bullet-style. Preface all responses with the words “We” and “I”. Think about what you are willing to change – add to FTA if possible.

<table>
<thead>
<tr>
<th>Organizational Causes</th>
<th>Personal Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>• We allow similar stock codes to be used</td>
<td>• I (name)..push for production</td>
</tr>
<tr>
<td>• We have inadequate compound segregation</td>
<td>• I (name)..do not do enough audits</td>
</tr>
<tr>
<td>• We allow machine to run without scan</td>
<td>• I (name)..do not explain why it is important</td>
</tr>
<tr>
<td>• We have no system to detect or alert a failure to deliver sample</td>
<td>to follow standards</td>
</tr>
<tr>
<td>• We give supervisors more tasks than they can complete in a 12 hour shift</td>
<td>• I (name)..assume everyone knows what I know</td>
</tr>
<tr>
<td>• We do not define clear consequences for not following standards</td>
<td>• I (name)..don’t think it is important to scan a small skid</td>
</tr>
<tr>
<td>• We do not enforce scanning</td>
<td></td>
</tr>
</tbody>
</table>
Keys to Success

- Training, coaching, and development of expectations
- Definition of appropriate triggers and level of activity necessary
- Management review, critique, and reinforcement
- Emphasis on “Define & Measure” and development of timeline
- Proper identification of phenomena and follow through on “5-Why” analysis
- Don’t neglect the human factor
- Weave the process into our culture and work to modify behavior
Thank you for joining us
Questions? Comments? We’d love to hear from you.

Debra Detwiler, Master Black Belt – Bridgestone Americas
detwilerdebbie@bfusa.com

Larry Goldman, Vice President Marketing - MoreSteam.com
lgoldman@moresteam.com

Additional Resources:
Archived presentation, slides and other materials:
http://www.moresteam.com/presentations/webcast-fault-tree-analysis.cfm

Master Black Belt Program: http://www.moresteam.com/master-black-belt.cfm