Lean 6 Sigma at Solar Turbines

Gary Higganbotham
Solar Turbines Black Belt
April 16, 2009
Agenda

• Solar Turbines \ Caterpillar
  - Brief background of company and products

• The Burning Platform
  - Why change?

• What is 6 Sigma?
  - Background behind the methodology

• Lean 6 Sigma at Solar Turbines
  - Organizational structure, training, and project execution
  - Successes and lessons learned
Caterpillar is . . .

- The world's largest manufacturer of construction and mining equipment, diesel and natural gas engines and industrial gas turbines.
- Technology leader in logistics, construction, transportation, mining, forestry, energy and electric power generation.
Caterpillar at a glance.

- 277 Company facilities
- 198 Caterpillar dealers (main stores)
- 1,689 Dealer branch stores
- > 400 FG Wilson, MaK, Perkins and Solar Turbines Distributors
- 1,437 Dealer rental outlets
- 3,000+ key suppliers
Solar Turbines

- Industrial Gas Turbines
- Centrifugal Gas Compressors
- Compressor Sets, Mechanical Drives, Generator Sets
- Construction Services
Solar Turbines

- 5600 Employees Worldwide
- 38 Sales / Service Offices
- 16 Overhaul / Repair Centers
- Presence in over 90 Countries
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The Burning Platform - Why change?

• Significant culture change begins with the creation of a “burning platform”, a compelling vision of why change is needed.

• An enterprise cannot move forward unless the need for change is clearly established.

What is the burning platform at your company?
The Burning Platform - Why change?

200'

Change starts at the top!
Caterpillar’s 6 Sigma Journey Began in 2001…
And We Have Learned a Lot.
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What is 6 Sigma?

3.4 defects per million opportunities – it’s near perfection
What is 6 Sigma?

- A *measurement* of variation
- A *method* for improving our processes
- The *disciplined application* of statistical tools

The higher the Sigma value, the lesser the chance of defects occurring.
What is 6 Sigma?

• The *organizational* commitment and involvement that engages and further develops *your* people

• The *strategy* for prioritizing *your* business opportunities

• The proven *methodology* and structure to manage *your* projects and deliver exceptional results
What is 6 Sigma?

Sustains the Gains

Define
Measure
Explore
Develop
Implement

DMEDI

Define
Measure
Explore
Develop
Implement

DMAIC

Define
Measure
Analysis
Improve
Control

PROCESS IMPROVEMENTS

PROCESS CREATION

PROCESS OWNER

Sustains the Gains
What is 6 Sigma?

Elimination of Variation

Desired / Nominal

- +

Squish

Desired / Nominal

- +

Scoot
What is 6 Sigma?

- Problem Identification
- Root Cause Analysis
- Select Optimum Solution
- Satisfy Customers
What is 6 Sigma?

Proven Disciplined Process
- Clear Objectives
- Specific Deliverables
- Stakeholder Involvement

Statistical and Analytical Methods

Proven Quality Tools

Business Philosophy

Project Management
What is 6 Sigma?

- Focus on the Customer
- Fact Based Decision Making
- Process Focus
- Cross Functional Collaboration
- Drive for Perfection; Tolerance for Failure

6 Sigma is Philosophy

Voice of the Customer: Measurements Driven

Process Focus:
- Inputs → Activity → Output → Inputs → Activity
What is 6 Sigma?

- Improve Safety
- Maintainability
- New Product Introduction
- Reduce Cost
- Customer Satisfaction
- Delivery Performance
- Manufacturing Velocity
- ISO
- Product Quality
- 6 SIGMA
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Lean 6 Sigma at Solar Turbines

Structure

• Executive management accountability
• Master Black Belts
• Finance
• Black Belts
• Green Belts
• Subject Matter Experts
Lean 6 Sigma at Solar Turbines

Black Belts

- 2 year commitment
- Certification
- 4 projects per year
- E-Tracker
- Financial Reporting System
- Annual Quality Award competition
Lean 6 Sigma at Solar Turbines

**BB Training**
- 1 week per month over 4 months
- Work first project at same time
- Executive management support
- Facilitated by MBB’s
- Formal graduation ceremony with Solar President
Lean 6 Sigma at Solar Turbines

Project Teams

• Sponsor
• Black Belt
• Green Belts
• Yellow Belts / Subject Matter Experts
• Stakeholders
• Master Black Belt
Project Charter

Business Case
In alignment with Caterpillar’s Critical Success Factor of Velocity, this project is focused on improving the efficiency in completing and cycle time tracking of engineering drawing approval and release. Improvements in this area will yield a reduction in material shortage, the need for rework, and overall labor hours.

The project supports the Velocity Critical Success Factors.

Opportunity Statement
Under the current process, there is little to no visibility to complete and cycle time tracking of drawing approval and release. Drawings are submitted by Design Engineering. Drawings held up in the release process can cause material shortages, expediting fees, etc. Uneven to date, slower teams pay more in expediting fees and have a higher material shortage. The project will address these issues by creating a drawing release tracking system that will allow for more efficient communication between design and manufacturing.

Goal Statement
The goal is to implement a drawing release tracking system and/or process improvements:
- Better definition and understanding of drawing release process requirements
- Implement process improvements where possible
- Create metrics to measure process improvements
- Drawing release tracking (i.e., status info for every drawing in the release cycle)
- Reduce lead-time
- Reduce non-value-added activities

Project Scope

**In Scope:**
- Drawings created by Design Engineering
- Drawing release tracking system
- Speeding up the release process

**Out of Scope:**
- Design Process
- Packaging Processes
- Customer Drawings

Project Plan

<table>
<thead>
<tr>
<th>Define</th>
<th>Measure</th>
<th>Analyze</th>
<th>Improve</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>October</td>
<td>November</td>
<td>December</td>
<td>January</td>
<td></td>
</tr>
</tbody>
</table>

Team Selection

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Belt</td>
<td>Gary Reiglemon</td>
</tr>
<tr>
<td>Sponsor</td>
<td>Daryl Wng</td>
</tr>
<tr>
<td>Green Belt</td>
<td>John Yi</td>
</tr>
<tr>
<td>Green Belt</td>
<td>Mark Harris</td>
</tr>
<tr>
<td>Green Belt</td>
<td>Sam Choo</td>
</tr>
<tr>
<td>Green Belt</td>
<td>Andrew Doman</td>
</tr>
<tr>
<td>Green Belt</td>
<td>Dave Roberts</td>
</tr>
<tr>
<td>Green Belt</td>
<td>Jo Anne Edgerley</td>
</tr>
<tr>
<td>SMEs</td>
<td>Sam Choo, Adrian Garcia, Eric Tetzlaff</td>
</tr>
<tr>
<td>Master BB</td>
<td>Buddy Delmonico, David Olbous, Eric Tetzlaff</td>
</tr>
</tbody>
</table>

Stakeholders

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gary Reiglemon</td>
<td>Daryl Wng</td>
</tr>
<tr>
<td>John Yi</td>
<td>Mark Harris</td>
</tr>
<tr>
<td>Sam Choo</td>
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<tr>
<td>Sam Choo, Adrian Garcia, Eric Tetzlaff</td>
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</tr>
<tr>
<td>Gary Reiglemon</td>
<td>Daryl Wng</td>
</tr>
</tbody>
</table>

CATERPILLAR® Engineering Pharmaceutical Innovation
# DMAIC Tollgate Summary

<table>
<thead>
<tr>
<th>Define</th>
<th>Measure</th>
<th>Analyze</th>
<th>Improve</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Case</td>
<td>Define Y = f(x) and list your measures</td>
<td>Variation shown graphically (Cp, Cpk, SQL)</td>
<td>Generate Multiple Solution Ideas</td>
<td>Pilot/Solution Results vs. Project Goals</td>
</tr>
<tr>
<td>Opportunity Statement</td>
<td>Deployment Map(s) that depict measure locations</td>
<td>Performance gap(s) quantified</td>
<td>Evaluate and select solutions</td>
<td>Budget and Benefits Case</td>
</tr>
<tr>
<td>✓ Goals</td>
<td>Operational Definitions</td>
<td>Problem Statement(s)</td>
<td>Communicate team recommendations to stakeholders</td>
<td>Potential Problem Analysis</td>
</tr>
<tr>
<td>✓ Scope</td>
<td>Data Collection plan</td>
<td>Process Map Analysis (bottlenecks, value-add)</td>
<td>Link solutions to root causes</td>
<td>Detailed Implementation Plan</td>
</tr>
<tr>
<td>✓ Team Resourced &amp; prepared</td>
<td>Measurement System Evaluation</td>
<td>Potential Root Causes quantified and prioritized</td>
<td>New Future State Process Map(s)</td>
<td>Communication Plan</td>
</tr>
<tr>
<td>✓ High Level Project Plan</td>
<td>Output Measure (Y), Baseline Performance quantified (updated in Analyze)</td>
<td>Root Causes Validated Y= f (x)</td>
<td>High Level Implementation Plan</td>
<td>Standards and Procedures</td>
</tr>
<tr>
<td>✓ High Level Process Map (SIPOC)</td>
<td>Financial How/How (updated in Analyze)</td>
<td>Financial Baseline approved</td>
<td>Process Owner(s) confirmed</td>
<td>Training Plan</td>
</tr>
<tr>
<td>✓ Quick Wins</td>
<td>Process Owner(s) Identified</td>
<td>BRM</td>
<td>Projected Benefits</td>
<td>Key Metrics and Process Control System</td>
</tr>
<tr>
<td>✓ VOC Translated to CCR’s</td>
<td>BRM</td>
<td>FRS Forecast Entered</td>
<td>BRM</td>
<td>BRM</td>
</tr>
<tr>
<td>✓ Communication Plan</td>
<td>BRM</td>
<td>FRS Updated</td>
<td>FRS Updated &amp; 2/6 mo control meetings scheduled</td>
<td>E-tracker updated</td>
</tr>
<tr>
<td>✓ BRM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ E-tracker updated</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Replication Opportunities
Lean 6 Sigma at Solar Turbines

SIPOC

Electrical Service Rating Data in MID

<table>
<thead>
<tr>
<th>Suppliers</th>
<th>Inputs</th>
<th>Process</th>
<th>Outputs</th>
<th>Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Management</td>
<td>Master MCC List and trigger logic</td>
<td>Create and maintain standard product trigger logic and electrical service rating data in master MCC List</td>
<td>Std MCC List</td>
<td>HME</td>
</tr>
<tr>
<td>PAE/PE, HME</td>
<td>ACS</td>
<td>HME creates MCC List with CPD, saves file in project folder, and sends copy to Mech DE</td>
<td>MID</td>
<td>PE, EPC, End Customer</td>
</tr>
<tr>
<td>ACS Release</td>
<td>Hydro Design, Supplier Data Sheets</td>
<td>Mech DE copies MCC List to D225 project folder and uploads table to MID via macro (Pos-E) or hand drafting (CADD)</td>
<td>Ancillary and Enclosure DE add service rating information to MCC List</td>
<td></td>
</tr>
<tr>
<td>Ancillary DE</td>
<td>Ancillary Design, Enclosure Design</td>
<td>Mech ME provides battery system definition to Mech DE via loose ship list</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controls DE</td>
<td>Electrical Design, Battery System Definition</td>
<td>Mech DE adds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start Boundary</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>End Boundary</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6 SIGMA

Electrical Service Ratings
Caterpillar Confidential: Generic
# Voice of the Customer

## Voice of the Customer

Actual customer statements and comments which reflect their perception of:

- An attribute of a product or service
- An experience with a product or service or its delivery
- An encounter or experience with a business processes or representative

<table>
<thead>
<tr>
<th>Actual Customer Statements</th>
<th>Key Customer Issue</th>
<th>Critical Customer Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>“This mower is way too hard to start”</td>
<td>The real customer concerns, values or expectations regarding a product or service. Void of emotion or bias, the statement describes the primary issue a customer may have with the product or services. Describes the experience surrounding the attributes of the product or service expected or desired by the customer.</td>
<td></td>
</tr>
<tr>
<td>“I’m always on hold or end up talking to the wrong person”</td>
<td>Wants the mower to start quickly and painlessly</td>
<td></td>
</tr>
<tr>
<td>“This package doesn’t do squat”</td>
<td>Wants to talk to the right person quickly</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The software does what the vendor said it would do</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The specific, precise and measurable expectation which a customer has regarding a product or service.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Mower starts within two pulls on the cord</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Mower starts with an effortless pull on the cord not exceeding 24” in length</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Add additional menu items to the voice system (bad)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Customer reaches correct person the first time within 30 seconds (good)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Every design feature needed is built into the package</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The software is fully operational on the customer’s existing system</td>
<td></td>
</tr>
</tbody>
</table>
Y = f(x), - Measurement Plan

- **Measurement plan**
  - Total Product Cycle Time
  - Total Process Time
  - Cycle Efficiency

- **X1 Elapsed Time**
  - Frequency of Rework
  - Pareto of Root Causes

- **X2 Accuracy of Inputs**
  - Time Lost Due to Rework

- **X3 Problem Resolution Time**

---

**Executing Special Requirements for Package Manifolds**

- Customer
- Business Management
- Quality
- Sales Order Engineering
- Structures

---

**Engineering Pharmaceutical Innovation**

ISPE
Business Risk Management

Risk Map

<table>
<thead>
<tr>
<th>Key Risk Category</th>
<th>Risk Comments</th>
<th>Actions</th>
<th>Owner of Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>External</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Financial</td>
<td>Delayed drawing releases will increase probability of expedite fees.</td>
<td>- Improve efficiency of release process</td>
<td>Project Team</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Provide ability to find lost/delayed items</td>
<td>Group Managers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Metrics to improve process mgmt</td>
<td></td>
</tr>
<tr>
<td>People</td>
<td>Submitters will not understand process and will not provide all required information.</td>
<td>- Revise process documentation</td>
<td>Project Team</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Train submitters</td>
<td>Group Managers</td>
</tr>
<tr>
<td>Operational</td>
<td>Delayed drawing releases will increase probability of material shortages.</td>
<td>- Improve efficiency of release process</td>
<td>Project Team</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Provide ability to find lost/delayed items</td>
<td>Group Managers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Metrics to improve process mgmt</td>
<td></td>
</tr>
<tr>
<td>Strategic</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Structures Lean Journey

Not so good to GREAT!
Packaging's Largest Supplier

Manifolds

Brackets

Manifolds
Business Case
Solar’s volumes were increasing in 2006 and were to grow by 30% in 2007.

That was an additional 11,000 Structures parts for 2007.
Voice of the Customer

In 2006 the Structures department struggled to meet increased production levels; their inability to support the package takt rates put the year's financial plan at risk.

- Director Packaging Systems Operations
Meetings, Meetings, Meetings

Baseline Part Shortages
Structures Rollup
March - Aug 2006

PAIN

100 hours per month !!!
What else did we find? WIP

Pipe Shop Value Stream Map

Structures Value Stream Map

up to 1,000 orders

Machine Shop
Weld Booths
Hydro Test
Supervisor’s Office
Plasma Burn Table
Weld Booths
Structures Baseline

Baseline Performance

Brackets

280 Brackets in WIP

Cycle time of 20.7 days

Baseline Performance

Pipes

718 Pipes in WIP

Cycle Time of 44.8 Days

Demand for 40 to 70 Pipes per Day

Baseline Performance

16/day @ 7 days/wk

Demand for 80-90 Brackets per day

Baseline Performance

14/day @ 7 days/wk

Demand for 80-90 Brackets per day
Baseline Part Shortages

**Summary for Baseline Shortages**

- Anderson-Darling Normality Test
  - A-Squared: 0.19
  - P-Value: 0.810
- Means: 15.617
- Standard Deviation: 7.260
- Variance: 54.542
- Skewness: -0.05956
- Kurtosis: 0.25569
- N: 6

- Minimum: 5.250
- 1st Quartile: 9.075
- Median: 17.260
- 3rd Quartile: 21.250
- Maximum: 57.200

**95% Confidence Intervals**

- Mean: 15.617 ± 2.5
- Median: 17.260 ± 2.5

**Baseline Part Shortages**

Structures Rollup
March - Aug 2006

- UCL = 34.90
- LCL = -2.07
- X = 16.42

**Shortages per Value Stream**

March - August 2006

- Small Gen_1
- MarsTitanCSMD_1
- C40-T70 CSMD_1
- Large GS_1

**700 Pipe Backlog**
PSO Success
PSO Packaging Value Streams
Structures Multi Generation Project Plan

Safety +5S
Safety
Employee Engagement
set, sort, shine, standardize, sustain

Order Management
WIP caps
Visual Control Boards
Green Change Management

Velocity
Cycle Time reductions
Process Optimization
Response Time

Chase Waste
NVA Activities
Waiting
Overproducing
Rework
Motion
Processing
Inventory
Transportation

Lean 6 Sigma
Integrity Excellence Teamwork Commitment

ENGINEERING PHARMACEUTICAL INNOVATION
Safety

Employee Engagement

Quality

Ergonomic

Velocity

Sort – Standard

Safety
Even the Load: Balance the workload to level production and reduce process variability.

Make it Visual: Build the visual workplace so no problems are hidden and opportunities can be realized.
Yet, Structures could not deliver the correct pipe to its customer on time.

After
Employee Lead Kaizen Event

Before
One Bin System

Pain

After
Two Bin System
Customer Interface Panel

80% cycle time reduction

4,200 feet of welding annually

8,000 Feet of welding

1,500 Labor hours
Lean Machining

Continuous Improvement
Operator created a solution for larger pipes, cycle times = 2 minutes

Outlier: Uncommon sized diameter pipes

Reduced cycle times from 30 minutes to 30 seconds
Eliminated daily trips
Barstow 2008

198 Miles
Non-Value Added
Lost opportunities due to poor safety and an underutilized workforce
Production or rework of out-of-specification parts
Excess raw material, work-in-process or finished goods
Excess supply beyond the requirements of the next process
Excess movement of work-in-process
Work that adds no value to the customer or business
Unused Creativity / Capability
Defects
Inventory
Over Production
Waiting
Excess Motion
Transportation
Over Processing
8 Deadly Wastes
Average Part Shortages
Structures Rollup

Metrics Board
Monthly Employee Communication Meetings

Forum for new ideas and feedback to sustain process control

Phase 1
Phase 2

Before
Phase 1
Phase 2

UCL = 2.30
\( \bar{X} = 1.3 \)
LCL = 0.30

Individual Value
March May July September November March May July September

Month
In 2006 the Structures department struggled to meet increased production levels; their inability to support the package takt rates put the year’s financial plan at risk. The Lean 6 Sigma process improvements not only allowed Structures to get caught back up and support our 2006 volumes, the improvements have allowed Structures to successfully supported record levels in 2007, including our 2nd quarter performance of one package a day, 7 days a week, for over 100 days straight! This has been a phenomenal improvement!

Director
Packaging Systems Operations

We have seen excellent benefits related to the Structures organization process improvements and 6 Sigma efforts. Delivery performance from the Structures department to Customer Services went from a very low 25% on time delivery in July 2006 to an outstanding 100% on time delivery in July 2007.

Manager
Customer Services Project Management
Design for Manufacturing
99% first pass x-ray test success
Listening to our people EOS
Meeting our customers needs
Value Proposition $M's
Cycle time reductions
Embedding 6 Sigma culture

VISION 2020

STRATEGIC PROFILE

STRATEGIC GOALS

CRITICAL SUCCESS FACTORS

ENTERPRISE STRATEGIC AREAS OF IMPROVEMENT

OUR VALUES IN ACTION - INTEGRITY, EXCELLENCE, TEAMWORK, COMMITMENT
Worldwide Code of Conduct
Controls Assembly
Major 5S+1 Event

Freed up over 2,000 sq. ft.
Lean Work Centers & Product Flow

Off-Skid
- Lean Work Center

On-Skid
- Lean Work Center

Controls Support
- Lean Work Center

Central Supermarket
- Floor Stock

Project Kitting

Better aligning product flow to our Customers
Single Piece Flow
By implementing the material kitting operation, we eliminated internal excess motion.

Results and Benefits

Before

<table>
<thead>
<tr>
<th>Console Final</th>
<th>Controls Test</th>
<th>System Wiring</th>
<th>Panel Wiring</th>
<th>Panel Build Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offices</td>
<td>Mezzanine</td>
<td>Warehouse</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

After

New Product Flow

Flow to the customer

392 Miles

Excess Motion

392 Miles
Results and Benefits

By changing our internal product flow we were able to change our external product flow.

Before

After

125 Miles

Excess movement of work-in-process

Transportation

Engineering Pharmaceutical Innovation

ISPE
Results and Benefits

**2008 Controls Production WIP after WIP CAPS**

- Before: [Chart showing data]
- After: [Chart showing data]

**2008 Control's Weekly Production Exits**

- Before: [Chart showing data]
- After: [Chart showing data]
Results and Benefits

2008 Control’s Total Cycle Time

UCL = 22.50
\( \bar{x} = 12.25 \)
LCL = 2.00

37 days
12 days

TOTAL CYCLE TIME AFTER
Variable

<table>
<thead>
<tr>
<th>Variable</th>
<th>TCT Before</th>
<th>TCT After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>37.30</td>
<td>12.25</td>
</tr>
<tr>
<td>SD</td>
<td>15.19</td>
<td>1.14</td>
</tr>
<tr>
<td>N</td>
<td>12.25</td>
<td>4.38</td>
</tr>
</tbody>
</table>

ENGINEERING PHARMACEUTICAL INNOVATION
Controlling the New Process
Results and Benefits

2008 Controls Production WIP after WIP CAPS

2008 Control's Weekly Production Exits

2008 Control's Total Cycle Time

2008 Control's On-Time Delivery

ENGINEERING PHARMACEUTICAL INNOVATION
# Drawing Release Project

## Business Case

Engineering drawing release cycle is unclear and inefficient.

## Opportunity Statement

Reduce labor cost, material shortages, and expediting fees.

## Project Goals

- Improve cycle efficiency
- Clean up the process(es)
## Multiple Drawing Types and Processes

<table>
<thead>
<tr>
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**ISPE**

**Engineering Pharmaceutical Innovation**

**Activity Matrix**
Multiple Drawing Types and Processes

Who gets drawing packet first?
What is req’d for certification?
What information is required?
Who authorizes release?
When and how do I expedite?
Where is my drawing packet?
 etc…
MS Word Based Purchased Parts

- Time Study
- Value Add Time
- Span Time
- Cycle Efficiency
All data points are median values.
Simple Process Change

Submit Drawing

Design Services

Compliance

Purchase Part Drafting

Backcheck

Purchase Part Drafting

Create DHR record

On Line Drawings

Excel

Access

Access

SP2

SP2

SP3

SP3

SP3

SP2

SP2

Planning Item Setup

Purchasing Item Setup

PLN

PUR

ENGINEERING PHARMACEUTICAL INNOVATION

ISPE
Simple Process Change

- Deliver to Compliance first
- Eliminate two trips between SP2 and SP3
- Reinstate Compliance spreadsheet
Locator Tool

- Simple VB query on desktop
- Aging file locator
- Cycle time metrics
Many options?
- Process Maps
- Work Instructions
- Guidance Notes

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<th>Controls Design Engineer</th>
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<th>Hydro Mechanical Design Engineer</th>
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Better definition and understanding of drawing release process requirements.
Process Documentation

Better definition and understanding of drawing release process/requirements

Determining Need for a Part
- part searching
- new part creation
- configuration management

Drawing Types
- decision flow
- define drawing types
- applications
- nomenclature
- procurement rules

Drawing Creation (drafting / hand markup)
- when to use electronic or hand markup
- instructions on how to get electronic copies
- instructions on how to do markups

Release process
- process flow
- drawing packet contents
- data requirements
- expediting instructions

5S for Process Docs

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ISPE
Training Material

• Create quick reference material

• Create links for functional departments
Lean Mechanical Drawings
Mechanical Drawing(s)

- PG creates 2 drawings - Mechanical *Installation* Drawing
- OG creates 1 drawing - Mechanical *Interface* Drawing
One Drawing VS Two

Boxplot of Total Mechanical Drawing Hours

- Business Unit (O&G vs. PG)
- Total Mechanical Drawing Hours (0 to 1000)
- 66 hours difference

ENGINEERING PHARMACEUTICAL INNOVATION
One Drawing VS Two - Regression

Dependent Variable = Mech. Design and Draft Hours

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Mech Dsn & Dft Hours

ACS Revisions

Project Span (wks)

Total Releases

Sales Order Items

Custom Features
### Analysis of variation after accounting for ACS Revs, Releases, Sales Order Items, and CF's:

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<td>8.4%</td>
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### Analysis of variation after accounting for impact of Certification:

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<td>.075</td>
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Other factors (Custom Generator, Custom L/O Cooler, Enclosure, Fuel System, Marine, Inlet, and Exhaust) showed no statistical significance.

### Final Equation:

\[
\text{Total Hours} = -275 + 12*(\# \text{ of ACS Revisions}) + 71.3*(\# \text{ of Dwg Releases}) \\
+ .97*(\# \text{ of Sales Order Items}) + 2.02*(\# \text{ of Custom Features}) \\
+ 336(\text{if CE}) +175(\text{if Cenelec}) + 82 (\text{if custom frame})
\]
One Drawing VS Two

Boxplot of Normalized Hours

Hours delta from drawing content

Single drawing adopted!
Content Differences

FN 1, FN 5, FN 3, FN 4, FN 6, FN 7 AND ASSOCIATED ASSEMBLY HARDWARE BELONG TO 1045595-389391 KIT WHICH INCLUDES ENCLOSURE VENT EXHAUST SYSTEM AND GENERATOR VENT EXHAUST SYSTEM.


ENGINEERING PHARMACEUTICAL INNOVATION
Content Differences

FAN FAIL FLEX HOSE TO BE FIELD INSTALLED

FIRE DAMPER CO2 FLEX HOSE—REF PN 1048825 TO BE FIELD INSTALLED.
Content Differences

Orientation of ventilation fans
Content Differences

- Transfer content to ‘Package Installation Guidelines’
- Exploded Views
Content Differences

Multiple views per sheet

One view per sheet
Content Differences

• Single view per sheet adopted
Content Differences

- Single view per sheet adopted
- Changes for enclosure door swings
Content Differences

- Skid edge to device cable requirements
- Content added to ‘Package Installation Guidelines’
- Additional connection information added to MID
Content Differences

- E Generator Terminal Box in MID
- Single source for information
New MID Summary

• Single Mechanical Interface Drawing (MID)
• Content Changes
  • Exploded views
  • Single elevation view per sheet
  • Replacing enclosure door swings with ‘Stay Out Zone’
  • Package component layout
• Adding end device connection info to Table 1
  • Generator terminal box
• Adopting PG datum flags
• MIND Notes Changes
  • Reference to Installation Guidelines
  • References for cable sizes
• Refining Pro-E Drawing Simplified Rep
Conclusion