In-Plant Training
Compressed Air Assessment Basics
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Draw Professional Services
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What is an In-Plant Training?

- In-Plant Trainings (INPLTs) are system-specific workshops led by Better Plants experts that train participants on how to identify, implement, and replicate energy-saving projects.
- Better Plant partners host an on-site, three-day training at one of their facilities, and invite others to attend.
- The training traditionally focus around a topic such as:
  - Compressed air
  - Fans
  - Motor-driven systems.
  - Steam
  - Process heating
  - Pumps
  - Energy Management/ISO 50001
What is an In-Plant Training?

• Technical expertise gained through the INPLTs help companies overcome common, critical barriers to adopting energy management practices and technologies, such as lack of technical expertise and insufficient senior management buy in for implementing energy-saving projects.

• Personnel from other facilities within the company, as well as from other companies in the area and suppliers, may be invited to attend.

• Since April 2011, DOE has conducted 40 INPLTs that have attracted about 765 participants and led to the identification of close to 2.7 TBtu in annual energy savings and more than $14 million in associated cost savings.
• Frank Moskowitz – Draw Professional Services
  – Qualified AIRMaster+ Specialist
    • AIRMaster+ and LogTool Compressed Air Assessment Tools
  – Compressed Air Challenge Instructor for Fundamentals & Advanced Workshop
  – Instructor for AIRMaster+ Qualified Specialist Workshop
  – DOE Compressed Air System Energy Expert
    • In-Plant Training & Save Energy Now Assessments
  – Co-Vice Chair ASME EA-4 Energy Assessment for Compressed Air Systems
  – International Standards Organization Technical Advisory Group Member
    • Air compressors and compressed air systems energy management
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    • 602-809-4195
Today’s Agenda

• Overview – Compressed Air System Energy Savings

• Planning for the Assessment

• Baseline Measurement

• Compressed Air Energy Opportunities

• Software Tool – LogTool

• Software Tool – AIRMaster+

• Agenda
Compressed Air Systems
Total Cost of Ownership

- Equipment cost and maintenance cost represent only a small part of the total cost of operating a compressed air system.

- Electrical cost usually exceeds 75% of the total operating expense.

Source: Compressed Air Challenge®
Compressed Air’s Inefficiency:
- 85% of the power of the prime mover is converted into an unusable form of energy (HEAT)
- And to a lesser extent, into friction, misuse and noise
Typical Components of Demand

- **Production**: 50%
- **Leaks**: 25-30%
- **Artificial Demand**: 10-15%
- **Inappropriate Uses**: 5-10%
Compressed Air Versus Other Energy Sources

- 1 hp air motor = 7-8 hp of electrical power
  - 30 scfm @ 90 psig is required by the air motor
  - 6 - 7 bhp at compressor shaft required for 30 scfm
  - 7 - 8 hp electrical power required for this

- Annual energy cost for a 1 hp air motor versus a 1 hp electric motor, 5-day per week, 2 shift operation, $0.05/kWh

- $ 1,164 vs. $ 194
INPLT – Planning for the Training Assessment
Compressed Air System Energy Savings
Compressed Air System Planning for the Assessment

1. System Approach
2. Block Diagrams
3. Key Issues
4. Energy Costs/ Assessment Costs
There are two basic ways to reduce the energy consumption of a compressed air system: produce compressed air more efficiently; and consume less compressed air.
Look from the System Level Approach

- Improve Compressor Control
- Reduce System Pressure
- Reduce Air Demand
Increase Productivity While Saving Energy

• Compressor manufacturers spend a great deal of money to obtain optimum efficiency of their individual products…….
  – only to see much of the energy savings squandered in a poorly designed and managed system.

• The following information can increase your productivity while Saving Energy
Reduce the number of compressors at reduced capacity

- Base load as many compressors as possible.
Reduce the number of compressors at reduced capacity

- Use Automation with single setpoint control scheme

![Pressure graph]

- Production minimum requirement
- Load pressure
- Single set point control pressure
- Unload pressure

Pressure (psig)
Reduce pressure at points of use

- The total system may be running at a higher pressure to satisfy the needs of only one point of use.
  - If the high pressure application can be modified to operate at lower pressure, make the fix.
  - If the high pressure application is valid, find a better way to serve it.
  - The single higher pressure point of use can be met with an amplifier or booster.
  - The remainder of the system can operate at a lower pressure, reducing leakage and usage rates and at reduced energy consumption.
Reduce pressure at points of use
Review Air Usage Patterns Regularly

• Understand Your Pressure Profile

300 HP Centrifugal

200 HP Dry Screw

Filter

Dryer

Receiver

Other uses

Other uses

Critical user

F R L

Indicates point for pressure measurements
Review Air Usage Patterns Regularly

Supply

110 psig
Operating Range of Compressors

100 psig
Dryer and Filter Pressure Drop

90 psig

Demand

85 psig
FRL, Valve, Hose, and Disconnect Pressure Drop

70 psig
Distribution System Pressure Drop
Pressure Profile

- Understand Your Pressure Profile
  - Pressure drop increase with the square of the flow increase

**Pressure Loss Through Dryer**

1050 cfm / 735 cfm = 30% increase in flow

\[(1.42)^2 = 2 \times \text{original pressure drop}\]
A 1/16 inch equivalent diameter leak

At 120 PSI G

AIR LEAKS
7.62 scfm FLOW

At 80 PSI G

AIR LEAKS
5.36 scfm FLOW

A leak consumes 42% more air at 120 psig than at 80 psig adding to the artificial demand on the system.
Leaks & How Demand is Affected by Pressure

Discharge of air through an orifice (SCFM)

<table>
<thead>
<tr>
<th>Pressure</th>
<th>1/64”</th>
<th>1/32”</th>
<th>1/16”</th>
<th>1/8”</th>
<th>1/4”</th>
<th>3/8”</th>
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<td>70 psi</td>
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<td>5.36</td>
<td>21.4</td>
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<td>193</td>
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<tr>
<td>90 psi</td>
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<td>5.92</td>
<td>23.8</td>
<td>94.8</td>
<td>213</td>
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<tr>
<td>100 psi</td>
<td>.406</td>
<td>1.62</td>
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<td>26.0</td>
<td>104</td>
<td>234</td>
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<td>.494</td>
<td>1.98</td>
<td>7.90</td>
<td>31.6</td>
<td>126</td>
<td>284</td>
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</table>

Leaks are a function of the supply pressure in an uncontrolled system
Higher pressure = greater flow
Lower pressure = less leak flow
Remove Inappropriate Applications

• Many applications can be served more efficiently by: low pressure air from a fan, a blower; or by a vacuum pump, rather than by compressed air.

• Examples of Inappropriate Uses:
  – Cabinet cooling
  – Liquid agitation or stirring
  – Vacuum generation
  – Unregulated Open Blowing
  – Air Motors
  – Atomizing
Where is my air going?

- Production: 50%
- Leaks: 25-30%
- Artificial Demand: 10-15%
- Poor Practices: 5-10%
Compressed Air System Block Diagram

- Graphic representation of compressed air system and the relationship of individual components
Compressor Room 1

Darigold Sunnyside
Compressor Room 1

Compressor #3
QNW 500-C2/S
#920798
100 hp

Compressor #1
QNW 240-C2/S
#910519
50 hp

Compressor #2
QNW 240-C2/S
#910518
50 hp

2000 gallon Receiver Tank

Zecks Dryer
1000HSFA400
#239670

Filter

3" pipe
Darigold Sunnyside
Compressor Room 3
(still under construction)

Compressor #6
QNW-V350-I
#14065519256
350 hp

Compressor #7
QNW-1523
#1406519257
350 hp

3800 gallon Receiver Tank

Filter

Zecks Dryer
3250HSFMW40V
#555240

4" pipe
Darigold Sunnyside
Cheese Packaging

- 1/2" pipe
  - Massman #1 Case Packer
- 3/4" pipe
  - 1/2" pipe to conveyors
  - Massman #2 Case Packer
- 2" pipe
- 1 1/2" pipe
  - 1/2" pipe to conveyors
  - Palletizer
Compressed Air System Issues and Opportunities

- Gather pre-assessment information

**Primary Audit Objectives**

- We need to improve the reliability of the compressed air system in supporting manufacturing operations.

- Production interruptions occur which are a result of poor compressed air system performance; we need to minimize production downtime.

- Product quality is being affected by poor compressed air system performance; we need to reduce our scrap rate.

- Our automated equipment which is operated by compressed air will not achieve its full capacity throughput: we need to know if this is a compressed air related issue.

- We are expanding our production facility and consequently need to expand our existing compressed air system to accommodate the new flows; we want to know if our existing compressors can handle it.

- × We need to reduce air demand and lower energy costs of operating our compressed air system.

- We are replacing older air compressors and want to investigate new more efficient type compressors; we want to improve system efficiency and reduce energy costs.

- We have recently eliminated production equipment which used compressed air but the compressors are still using the same energy as before: we need to reduce the compressed air demand.

- Low pressure occurs on a system wide basis and occasionally impacts production.
Compressed Air System Issues and Opportunities

• Gather pre-assessment information

**Potentially Inappropriate Applications**

Is compressed air being used for any of the applications on this list?

- Open blowing
- Sparging (agitating, stirring, mixing)
- Aspirating
- Atomizing
- Padding
- Dilute phase transport
- Dense phase transport
- Vacuum generation
- Personnel cooling
- Open hand held blowguns or lances
- Cabinet cooling
- Vacuum venturis
- Diaphragm pumps
- Timer drains/open drains
- Air Motors
INPLT – Baseline Measurement Using:
Software Tools; AIRMaster+ and LogTool
AIRMaster+ a Windows based software tool used to model and analyze industrial compressed air systems:

- Measure / Calculate Annual Baseline Energy & Cost
- Input 24-hour metered airflow or power data
- Assign electrical utility energy schedules
- Simulate compressed air system operation
- Model system operation at various loads
- Estimate Savings of Energy Efficiency Measures
- Is not a substitute for an experienced auditor!
**AIRMaster+ System Profile – Data**

### System Profiles

**Select**
- **Facility**: Mineral Processing
- **System**: Main
- **Daytype**: Mon - Fri
- **System pressure control range**: 94.0 - 110.0 psig

### Data Entry

#### Cascade Order - click cell to toggle stage#/"off"

<table>
<thead>
<tr>
<th>Compressor</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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</table>

#### Profile data type:

<table>
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<tr>
<th>Compressor</th>
<th>Power, kW</th>
<th>Airflow, %capacity</th>
<th>Airflow, acfm</th>
<th>CycleTime</th>
<th>Volts/Amps</th>
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</tbody>
</table>

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**U.S. DEPARTMENT OF ENERGY**

Energy Efficiency & Renewable Energy
AIRMaster+
System Profile – Power (kW)
1. Reduce Air Leaks
2. Improve End Use Efficiency
3. Reduce System Air Pressure
4. Use Unloading Controls Adjust Cascading Set Points
5. Use Automatic Sequencer
6. Reduce Run Time
7. Add Primary Receiver Volume

![Energy Efficiency Measures](image-url)

<table>
<thead>
<tr>
<th>Description</th>
<th>Energy Savings kWh</th>
<th>Energy Savings $</th>
<th>Energy Savings %</th>
<th>Demand Savings kWh</th>
<th>Demand Savings $</th>
<th>Installed Cost $</th>
<th>Total Savings $</th>
<th>Simple Payback Years</th>
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<td>Improve Pressure Profile</td>
<td>43.7 kWh</td>
<td>14.475</td>
<td>1.5%</td>
<td>20.2 kWh</td>
<td>41.1</td>
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<td>16,456</td>
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<td>-0.1%</td>
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<td>500</td>
<td>61</td>
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<td>Add Primary Receiver Volume</td>
<td>125.131</td>
<td>4.504</td>
<td>4.3%</td>
<td>50.8</td>
<td>1,027</td>
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<td>215.459</td>
<td>7.686</td>
<td>7.2%</td>
<td>33.2</td>
<td>1,633</td>
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<td>5,318</td>
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<td>779</td>
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**TOTALS**                        | 372.445            | 127.423          | 25.5%            | 95.9               | 4,716            | 16,800           | 32,158          | 0.5                 |

(Double-click row to view corresponding measure input data)
LogTool v2
Version 2.0.80

LogTool is a public domain tool available from SBW Consulting, Inc. and the Compressed Air Challenge (CAC). LogTool was developed in part with funding from CAC. It is designed to assist in the analysis of compressed air system performance measurements. It is a companion tool for AIRMaster+, also available from the CAC.

Continue
LogTool v2

- LogTool is a public domain tool available from SBW Consulting, Inc.
  - Import data from different types of data loggers
  - Display trend plots with one or two Y axes
  - Assist in the analysis of compressed system performance measurements
  - Display DayType plots
  - A companion tool for AIRMaster+, also available from the Compressed Air Challenge
LogTool v2 – Import Data

- The import screen gives you tools to import data from different types of data loggers.
### Logger Data in LogTool/Kraft.mdb

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<td>#11000 KW</td>
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<td>Baseline</td>
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<td>129.7</td>
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<td>Baseline</td>
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<td>Baseline</td>
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<td>#13000 KW</td>
<td>0.0</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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</table>


**Weekend not running** Flow 947.2361 922.6665 944.0294 939.7109 913.2068 904.8779 895.8726 910.1708 893.2721 871.2878 877.7692 873.

**Weekend running** Flow 1764.013 1723.066 1603.593 1662.083 1640.152 1623.76 1688.332 1689.084 1699.662 1698.266 1670.245 1634.
Log Tool Plot

- Understand Your Pressure Profile
  - Pressure drop increase with the square of the flow increase

![Pressure Loss Through Dryer](image)

- 1050 cfm / 735 cfm = 30% increase in flow
  - \((1.42)^2 = 2\times\text{original pressure drop}\)

- 5 PSIG
- 10 PSIG
Create Day Types for AIRMaster+ System Profile
View DayType Profiles in Excel

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
<th>O</th>
<th>P</th>
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</thead>
<tbody>
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<td>1</td>
<td>System</td>
<td>Type</td>
<td>Period</td>
<td>DayTypeName</td>
<td>ChannelName</td>
<td>Hr.01</td>
<td>Hr.02</td>
<td>Hr.03</td>
<td>Hr.04</td>
<td>Hr.05</td>
<td>Hr.06</td>
<td>Hr.07</td>
<td>Hr.08</td>
<td>Hr.09</td>
<td>Hr.10</td>
</tr>
<tr>
<td>4</td>
<td>Main</td>
<td>Not Assign</td>
<td>Baseline</td>
<td>Mon-Tue Production</td>
<td>COMP1 KW</td>
<td>22.95389</td>
<td>23.63535</td>
<td>22.91625</td>
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<td>37.79541</td>
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<td>46.79652</td>
<td>47.95081</td>
</tr>
</tbody>
</table>

The image shows a Microsoft Excel spreadsheet with data related to LogTool v2. It includes columns for System, Type, Period, DayTypeName, ChannelName, and various hours. The spreadsheet is used to View DayType Profiles in Excel.
### AIRMaster+ System Profile – Data

#### System Profiles

**Select**
- **Facility**: Mineral Processing
- **System**: Main
- **Daytype**: Mon - Fri

**System pressure control range**: 84.0 - 110.0 psig

#### Data Entry

**Cascade Order**
- **Compressor**: 350 hp, 150 hp #1, 150 hp #2
- **Stage**:
  - **Compressor**
  - **Airflow, %capacity**
  - **Power, kW**
  - **Airflow, acfm**
  - **CycleTime**
  - **Volts/Amps**

**Profile Summary**

<table>
<thead>
<tr>
<th>Compressor</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>350 hp</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>150 hp #1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>150 hp #2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

**Profile data type**
- **Airflow, %capacity**
- **Power, kW**
- **Airflow, acfm**
- **CycleTime**
- **Volts/Amps**

**Totals**

<table>
<thead>
<tr>
<th>Compressor</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>350 hp</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>10</td>
</tr>
<tr>
<td>150 hp #1</td>
<td>50.0</td>
<td>50.0</td>
<td>50.0</td>
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<tr>
<td>150 hp #2</td>
<td>40.0</td>
<td>40.0</td>
<td>40.0</td>
<td>80.0</td>
<td>80.0</td>
<td>80.0</td>
<td>80.0</td>
<td></td>
</tr>
</tbody>
</table>
Quantifying Opportunities – Tools to Help

- **Software Tool – AIRMaster+**
  - Baseline Measurement & Annual energy use
  - EEM’s (energy efficiency measures) and savings

- **Software Tool – LogTool**
  - Charting trend performance
  - Assess dynamics, and Compressor Control Response
  - Daily System Profiles Define Day Types
INPLT on-site March 24th – 26th, 2015

Compressed Air System Energy Savings
INPLT Compressed Air Training System Approach

• Systems engineering focuses on defining stakeholders’ needs and required system functionality. From energy input to air compressors to work performed in the production process.
  – Understand compressed air point of use as it supports critical plant production functions.
  – Correct existing poor performing applications and those that upset system operation.
  – Eliminate wasteful practices, leaks, artificial demand, and inappropriate use.
  – Create and maintain an energy balance between supply and demand.
  – Optimize compressed air energy storage and air compressor control.
• **Schedule for On-site Assessments**
  
  – The following is a general overview of a typical 3-day, on-site assessment. The schedule may vary based on specific circumstances.
  
  – **Day One:** The Qualified Specialist/Energy Expert conducts a safety briefing for your plant team and tours the plant. Your team agrees on potential energy efficiency opportunities to investigate, and begins data collection for potential opportunities.
  
  – **Day Two:** The data collection continues and the DOE software assessment tool is applied to quantify potential opportunities. The lead person at your plant and the Qualified Specialist/Energy Expert discuss and agree on the opportunities identified.
  
  – **Day Three:** Wrap up the software tool analysis and focus on answering questions. The lead person at the plant and the Qualified Specialist/Energy Expert discuss how to gain management support to implement opportunities identified in the assessment. A close-out meeting is held in the afternoon to review results.
  
• After the assessment, your plant will receive a detailed report identifying opportunities. View assessment reports from other plants.
# Darigold INPLT Training

## On-Site Agenda

### Tuesday March 24th

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Presenter(s)</th>
</tr>
</thead>
</table>
| 8:00-8:30am | Arrival at Darigold Plant, Introductions and In-Plant Training Overview, Opening Remarks etc. Safety Overview | **Frank Moskowitz** (Draw Professional Services, Energy Experts in Compressed Air Systems)  
**Paul Lemar** (DOE Technical account manager)  
**Tom Rouleau** (Technical manager Sunnyside)  
**Uli Schildt** (Darigold Energy Engineer) |
| 8:30-11:00am | Compressed Air Energy Management Training                                 | **Frank Moskowitz** |  
- Energy Savings Assessment Results—Summary  
- Overview on DOE’s Free Compressed Air Software Tool (AirMaster+)  
- Q&A and Discussion |
| 11:00-11:15 | Coffee Break                                                               |                                                                             |
| 11:15-12:00 | Plant Tour: Measurement and Savings Project Demonstration                  | **Frank Moskowitz** |
| 12:00-12:45 | Lunch Break                                                                |                                                                             |
| 12:45-4:00  | Measurement and Savings Project Demonstration Cont’d                        | **Frank Moskowitz** |
| 4:00-4:30   | Complete Training Evaluation Form and Adjourn                               |                                                                             |
Darigold INPLT Training
On-Site Agenda

**Wednesday March 25th**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Presenter</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00-8:30</td>
<td>Introductions and Q&amp;A from previous day</td>
<td>Frank Moskowitz</td>
</tr>
<tr>
<td>8:30-11:00</td>
<td>Data Collection, Field Work and Discussion</td>
<td>Frank Moskowitz</td>
</tr>
<tr>
<td>11:00-11:15</td>
<td><strong>Coffee Break</strong></td>
<td></td>
</tr>
<tr>
<td>11:15-12:00</td>
<td>The data collection continues and the DOE software assessment tool is applied to quantify potential opportunities</td>
<td>Frank Moskowitz</td>
</tr>
<tr>
<td>12:00-12:45</td>
<td><strong>Lunch</strong></td>
<td></td>
</tr>
<tr>
<td>12:45-4:00</td>
<td>More Data Collection, Field Work, Discussion</td>
<td>Frank Moskowitz</td>
</tr>
<tr>
<td>4:00-4:30</td>
<td>Wrap-Up and Complete Evaluations</td>
<td>Frank Moskowitz</td>
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</table>
## Thursday March 26th

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Presenter</th>
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<tbody>
<tr>
<td>8:00-8:30</td>
<td>Introductions and Q&amp;A from previous day</td>
<td>Frank Moskowitz</td>
</tr>
<tr>
<td>8:30-11:00</td>
<td>Wrap up the software tool analysis and focus on answering questions</td>
<td>Frank Moskowitz</td>
</tr>
<tr>
<td>11:00-11:15</td>
<td>Coffee Break</td>
<td></td>
</tr>
<tr>
<td>11:15-12:00</td>
<td>Discuss how to gain management support to implement opportunities identified in the assessment</td>
<td>Frank Moskowitz</td>
</tr>
<tr>
<td>12:00-12:45</td>
<td>Lunch</td>
<td></td>
</tr>
<tr>
<td>12:45-1:30</td>
<td>Close out meeting to review results</td>
<td>Frank Moskowitz</td>
</tr>
<tr>
<td>1:30 – 2:00</td>
<td>Wrap-Up and Complete Evaluations</td>
<td>Frank Moskowitz and</td>
</tr>
</tbody>
</table>
• Questions?

• Paul Lemar
  – DOE Technical Account Mgr.
  – pll@rdcnet.com

• Frank Moskowitz
  – Draw Professional Services
  – fmoskowitz@drawproservices.com
  – 602-809-4195 cell