WHY USE STEAM

- Steam is an efficient heat transfer medium
- Steam is easily controlled
- The equipment and expertise exists to design and install steam systems for many different applications
- We have a lot of knowledge concerning steam

THE 4 PARTS OF A STEAM SYSTEM
PIPING AND TRAPPING FOR CONDENSATE REMOVAL

Steam Distribution Systems

- Steam Mains
- Branch Lines
  - Drip mains and branch lines
  - At natural drainage
  - Points or low spots:
    - Ahead of risers
    - End of main
    - Ahead of expansion Joints or bends
    - Ahead of valves / regulators

EFFECT OF AIR ON STEAM TEMPERATURE

<table>
<thead>
<tr>
<th>Steel</th>
<th>Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% Steam</td>
<td>90% Stm &amp; 10% Air</td>
</tr>
<tr>
<td>Total Pressure</td>
<td>100.0 psia</td>
</tr>
<tr>
<td>Steam Pressure</td>
<td>100.0 psia</td>
</tr>
<tr>
<td>Steam Temperature</td>
<td>327.8 deg F</td>
</tr>
</tbody>
</table>
EFFECT OF AIR ON STEAM TEMPERATURE

<table>
<thead>
<tr>
<th>Pressure (psig)</th>
<th>Temp. of Steam, No Air Present (°F)</th>
<th>Temp. of Steam Mixed With Various Percentages of Air (by Volume) (°F)</th>
</tr>
</thead>
</table>
| 10.3           | 240.1                             | 234.3 233.3 232.9 232.0 231.9 231.6 231.3 231.0 230.7 230.4 230.1 229.8 229.5 229.2 228.9 228.6 228.3 228.0 227.7 227.4 227.1 226.8 226.5 226.2 225.9 225.6 225.3 225.0 224.7 224.4 224.1 223.8 223.5 223.2 222.9 222.6 222.3 222.0 221.7 221.4 221.1 220.8 220.5 220.2 219.9 219.6 219.3 219.0 218.7 218.4 218.1 217.8 217.5 217.2 216.9 216.6 216.3 216.0 215.7 215.4 215.1 214.8 214.5 214.2 213.9 213.6 213.3 213.0 212.7 212.4 212.1 211.8 211.5 211.2 210.9 210.6 210.3 209.9 209.6 209.3 209.0 208.7 208.4 208.1 207.8 207.5 207.2 206.9 206.6 206.3 206.0 205.7 205.4 205.1 204.8 204.5 204.2 203.9 203.6 203.3 203.0 202.7 202.4 202.1 201.8 201.5 201.2 200.9 200.6 200.3 199.9 199.6 199.3 199.0 198.7 198.4 198.1 197.8 197.5 197.2 196.9 196.6 196.3 196.0 195.7 195.4 195.1 194.8 194.5 194.2 193.9 193.6 193.3 193.0 192.7 192.4 192.1 191.8 191.5 191.2 190.9 190.6 190.3 190.0 189.7 189.4 189.1 188.8 188.5 188.2 187.9 187.6 187.3 187.0 186.7 186.4 186.1 185.8 185.5 185.2 184.9 184.6 184.3 184.0 183.7 183.4 183.1 182.8 182.5 182.2 181.9 181.6 181.3 181.0 180.7 180.4 180.1 179.8 179.5 179.2 178.9 178.6 178.3 178.0 177.7 177.4 177.1 176.8 176.5 176.2 175.9 175.6 175.3 175.0 174.7 174.4 174.1 173.8 173.5 173.2 172.9 172.6 172.3 172.0 171.7 171.4 171.1 170.8 170.5 170.2 169.9 169.6 169.3 169.0 168.7 168.4 168.1

Heat exchanger designed for maximum capacity at 60 psig, when supplied with a 30% steam air mixture must raise pressure to 90 psig to regain temperature.

Latent heat at 60 psig = 905 btu/lb
Latent heat at 90 psig = 886 btu/lb = 2% less heat energy available

WHAT IS A STEAM TRAP?

• A steam trap is an automatic valve which stops the flow of steam, while discharging condensate and non-condensable gasses.

THERMOSTATIC TRAP TYPES

• Bellows balanced pressure
  – High capacity
• Wafer/Diaphragm balanced pressure
  – Low capacity
• Bi-metallic
  – High and low capacity
**BELLOWS BALANCED PRESSURE**

- Steams
- Condensate

**BI-METAL DISKS**

Valve in outlet
- Pressure opposes closing.
- Does not toggle.
- Some thermodynamic action; roughly follows steam saturation curve.
- Acts as check valve when pressure is lost.
- Good for use in superheated applications.
HOW MUCH DOES A LB OF STEAM COST?

Last plants audited in 2010. US.

STEAM COST CALCULATION

The Final Steam Cost is dependent on:
- Fuel
- Water
- Chemical
- Electric
- Boiler Efficiency
- Boiler Blowdown
- Steam Pressure
- Condensate Return Rates

TYPICAL OPTIMIZATIONS

Steam and Hot Water Best Practices

ADVANCED PROJECTS
High Savings/Investments

LOW HANGING FRUIT
Low/no investments

BASIC PROJECTS
Low investments

- Leaking Teams
- Condensate Return
- Steam Losses
- FMI: 10% Efficiency
- High B: 164 Generation
THE LOW HANGING FRUIT … STEAM TRAP CHALLENGES

Identifying a failure • When • Where

Magnitude of energy loss • Steam loss • Emissions to atmosphere

Cost of failure • Process loss • Energy loss • Safety • Larger steam equipment damage

PROCESS MANUFACTURERS CONSTANTLY STRIVE TO IMPROVE THEIR BUSINESS PERFORMANCE

The industry faces dynamic business conditions …
• Keep plants in mature markets competitive
• Effectively and safely operate new facilities in emerging markets with a less experienced workforce
• Manage wide variations in raw material cost and quality
• Retain knowledge
• Meet changing regulations
• Meet Energy & Environmental Goals

SPEED OF IMPLEMENTATION

Steam Loss Through a Typical 400 psi Drip Trap

Steam Cost = $10/1000 lbs
Orifice = 5/64”
STEAM ASSET MANAGEMENT

- Web hosted
- Real-time monitoring integration
- Steam loss measurement
- Emissions measurement
- Benchmark & Trending reports
- Work order reports
- Customized Solutions

PYROMETER

- Is used for:
  - Steam temperature measurement
  - Condensate temperature measurement
  - Insulation surface temperatures (radiation losses)
  - System understanding (back pressure, heat exchanger flooding)
**SteamEye® 24/7 Wireless Monitoring**

- Monitors up to 2000 traps “real-time”
- Instant Notification of steam trap failure via ultrasonic, temperature or conductivity.
- Shows current steam trap condition (OK, BT, CD)
- Identifies time and location of failure.
- Alarm Feature for critical applications via text msg or email.

**SteamEye® TRANSMITTERS**

- Conductivity Monitor
- Acoustic Monitor

**STEAMEYE® SYSTEM COMPONENTS**

- Wireless ultrasonic/conductivity transmitters
- Gateway Receiver
- Repeaters (where needed)
- Mounting hardware & accessories
THE APPLICATIONS

- High Pressure Drips
- Critical Process
- Confined Spaces
- Difficult Access

APPLICATIONS (CONT.)
MONITORING DEVICES . . .

CONTINUOUS MONITORING FOR STEAM TRAPS

- Immediate Notification of Trap Condition
  - OK
  - BT
  - CD
- Location Identifier
- WirelessHART
- Non-intrusive Installation

CONTINUOUS MONITORING FOR RELIEF VALVES

- Instant Notification of Occurrence
- Location Identifier
- Leak Detection
- WirelessHART
- Non-intrusive Installation
SMART WIRELESS

- Simple
  - No Wires ... easy, low-cost installation
  - Automatically adjusts for added nodes/devices

- Reliable
  - "Hops" across channels
  - Co-existence with other wireless networks
  - Mesh network and multiple access points

- Secure
  - Multi-layered security to encrypt information
  - Reports message integrity failures and authentication failures

PROJECT PROFILE: PHARMACEUTICAL – EAST, USA

- Steam trap surveys identified large waste
- Investigated various testing methods and monitoring solutions
  - Tested Armstrong's monitoring solutions and found wireless acoustic/temperature to be best method for "predictive" and "proactive" maintenance
- Currently utilizing WirelessHART standard for wireless monitoring solutions
  - Standardized on WirelessHART for all wireless instrumentation
  - Currently monitoring 100 steam traps with a plan to expand to entire plant ~600 traps
  - Estimated annual savings ~ $60,000
PROJECT PROFILE: OIL & GAS FACILITY - UAE

New construction project consisting of (2) areas and (2) EPC's
- Utilities & offsites
- Process plant
- Customer specification calls for continuous monitoring for all steam traps on tracing for sulphur lines
- 3600 steam traps to be monitored
- AIM software
- OPC server solution
- SteamStar® winner solution

PROJECT PROFILE: UNIVERSITY – NORTHEAST, USA

Pipe explosion due to water hammer initiated a plan to improve safety and also address energy efficiency simultaneously
- Steam trap survey to identify, locate, and test
- University identified critical high pressure, difficult to access, traps as priorities
- 123 traps currently monitored utilizing the SteamEye® - SteamEye® solution
- Early results...
  - Safety concerns addressed to identify failed traps that previously were causing water hammer issues
  - Energy savings from capturing failed open steam traps: $11,000/year

PROJECT PROFILE: GRAND VALLEY STATE UNIVERSITY - ALLENDALE, MI

A change occurred in facility maintenance administration
- Philosophy changed toward hiring an internal maintenance staff to become more responsive to steam system problems
- Proactive approach allowed Armstrong to provide support to staff
- SteamEye® trial kit installed with transmitters for (4) orifice traps and (1) steam trap
- 30-day trial identified 213 changes
  - SteamEye® determined that orifice traps were intermittently causing condensate to back up or steam to leak or "blow through"
  - Misapplication, improper sizing, and malfunctioning orifice traps identified
- 225 additional SteamEye® transmitters were installed with two remote gateways
- Over 200 orifice traps were determined to be "leaking" steam
- Payback to replace leaking orifice traps is about one year
- Backing up of condensate was damaging other system components (including a control valve) and reducing system efficiency
- Portable gateway has since been employed
PROJECT PROFILE: VA HOSPITAL – NORTH EASTERN USA

60-year-old VA Hospital with declining infrastructure and reduced staff
- Campus includes multiple buildings and 2,000 steam traps
- Trap monitoring system was unreliable

Armstrong provided beta test for SteamEye®
- Beta test led to complete audit, revealing 60% failure rate
- Armstrong provided complete turnkey installation of SteamEye® while replacing 1,200 failed traps with investment of $1.2m dollars

Armstrong savings totaled $163,000
- Cost of steam at $11.50/1,000 lbs projected payback of 7.3 years
- Project qualified as means to reach energy reduction goals in Executive Order 13123 that mandated 20% reduction by 2005
- Qualified under state program for energy credits that yielded utility savings
- Facility gained control over system costs
- Managers so pleased they began to implement the same system at another nearby facility

PROJECT PROFILE: U.S. ARMY POST – PACIFIC NORTHWEST

Audit established a $750,000 recurring loss annually in steam distribution system

SDVOSB certified contractor performed audit and turnkey installation of SteamEye®
- 800 traps were replaced or retrofitted with monitoring devices
- For security, SteamEye® system reports to a SteamStar® receiver maintained off-post via wireless internet
- Service being maintained on a multi-year service contract
- Result has seen reduced steam and condensate losses

PROJECT PROFILE: NESTLE – WESTERN EUROPE

Steam Trap surveys generated through SteamStar® over 3 years netted the following results

<table>
<thead>
<tr>
<th>Category</th>
<th>SteamTrap</th>
<th>SteamEye®</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>12%</td>
<td>17%</td>
</tr>
<tr>
<td>2006</td>
<td>11%</td>
<td>16%</td>
</tr>
<tr>
<td>2007</td>
<td>10%</td>
<td>15%</td>
</tr>
<tr>
<td>2008</td>
<td>9%</td>
<td>14%</td>
</tr>
<tr>
<td>2009</td>
<td>8%</td>
<td>13%</td>
</tr>
<tr>
<td>2010</td>
<td>7%</td>
<td>12%</td>
</tr>
</tbody>
</table>

Operational Optimizations
- Improved heat exchange (increased productivity)
- Less corrosion and water hammer (decreased maintenance)
- Improved steam quality
- Decreased pressure in condensate return
**PROJECT PROFILE: WESTERN MICHIGAN UNIVERSITY – KALAMAZOO, MI**

- **Scope of Maintenance Services**
  - Two campuses, 1200 acres, 151 buildings, 9 million sq ft of space
  - Energy consumption accounts for 20% of cost to run facilities

- **Steam system includes 15 miles of steam & condensate piping and 4,500 steam traps**

- **Regular trap inspections implemented, aided by SteamEye® wireless monitoring**
  - Steam trap failure rate reduced to 4.5%
  - Campus expanded to 9 million sq ft but steam consumption reduced to 480 million Btu of steam/yr
  - Cumulative cost avoidance estimated at $2.5m through 2007

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**PROJECT PROFILE: METROPOLITAN AIRPORTS COMMISSION – MINNEAPOLIS, MN**

- **Steam system includes 700 steam traps**
- **MAC installed SteamEye® transmitters on 66 traps for one year**

- **Trap maintenance and repair is always on the “to do” list, but frequently doesn’t receive the required attention**
  - They had no way of knowing if a trap was bad unless there was a “...noise in the line or someone complained about the temperature.”

- **Successful trial led to installation of a complete monitoring system in 3 phases**
  - SteamEye® communicates with web based software
  - Failure leads to audible alarm and they check the “failed points” screen
  - MAC estimated a 2.5 year payback before the CenterPoint Energy rebate
  - Estimate savings of 25,000 dekatherms per year, enough to heat over 250 homes

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**Estimate savings of 25,000 dekatherms per year, enough to heat over 250 homes**
Service Solutions

Operations and Maintenance
Operate, maintain, and/or service multiple facilities globally that have lowered operational costs at each facility. Terms: 3-25 years

Energy Audits – System wide
Have conducted thousands of system audits that have recognized upgrade ideas saving millions of $’s in energy at customer sites

Utility Monetization
20 Global facilities owned and/or operated by Armstrong

Turnkey Construction and Project Management
Have implemented hundreds of turnkey energy conservation projects where Armstrong provided the talent and manpower to install project ideas and mitigate cost overruns

Financed Optimization
Have financed millions of $’s of energy projects

CUSTOMERS....
WHAT IS O&M

Operations and Maintenance of Customer Utility Systems
• Utility systems are operated and maintained by direct Armstrong employees
  – Steam generation and distribution (including condensate return)
  – Compressed air generation and distribution
  – Electricity generation & distribution
  – Water & waste water treatment
  – HVAC
  – Hot water
  – Chilled water
  – Refrigeration
• Utility expertise, Best Practices shared globally
• Armstrong focuses on utility systems allowing our customers to focus on their core business (food, textile, paper, manufacturing etc.)

SERVICE SOLUTION – SCOPE

Staffing  Engineering  Training
Materials  Consumables  Turnkey

CURRENT BUSINESS & CUSTOMERS

Heinz
Utility Asset Ownership & Long term O&M Contract, 2 facilities
CURRENT BUSINESS & CUSTOMERS

Beech – Nut, Amsterdam, NY
O&M Agreement

Riviana Foods Inc., Memphis, TN
O&M Agreement