How Can Components Lead to Greater Energy Efficiency?

- Higher Capacity
- Energy Saving Functions
- Optimized Manifold Assemblies
Higher Capacity

- Lower pressure drop for a given flow rate in the same size, or equivalently sized, valve
Higher Capacity: Sun Cavity

- Unique to Sun Hydraulics
- Differs from Industry Common Cavities
  - Centrally located threads
  - Allowance for nose support
  - Defined port usage
How Does the Sun Cavity Improve Efficiency?

• Larger Working Port Diameters
  – Compared to equivalently sized industry common cavities
  – Lower cavity interconnection velocities
    • Lower pressure drop ≈ Improved efficiency
Screw-in Cartridge Cavity Comparison

Working Port Capacity Differences

SAE-10 Cavity
- 7/8 Thread
- SAE and ISO versions are driven by the threaded port, limiting the size of working port connections

ISO-7789 Cavity
- M22 Thread

SUN T-11A Cavity
- M20 Thread
- SUN cavity is specifically designed to optimize port capacity, allowing larger port connections
Higher Capacity in Single Element Blocks

Industry ‘Common’ 3-Port Body

- Port 1: SAE -10
- Port 2: SAE -10
- Port 3: SAE -6

- .28” / 7.1 mm Working Port Diameter

Sun 3-Port Body

- Port 1: SAE -10
- Port 2: SAE -10
- Port 3: SAE -6

- .63” / 15.9 mm Working Port Diameter

5X More Working Flow Area Than Industry Common Body
Lower Cavity Interconnection Velocities

ISO-7789 and SAE 10

<table>
<thead>
<tr>
<th>Flow Rate</th>
<th>.16” (3.96 mm) DIA</th>
<th>.24” (6.35 mm) DIA</th>
<th>.36” (9.25 mm) DIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 gpm (20 L/min.)</td>
<td>80 ft/sec (24.4 m/sec)</td>
<td>35 ft/sec (10.7 m/sec)</td>
<td>16 ft/sec (4.9 m/sec)</td>
</tr>
<tr>
<td>10 gpm (40 L/min.)</td>
<td>160 ft/sec (48.8 m/sec)</td>
<td>70 ft/sec (21.4 m/sec)</td>
<td>32 ft/sec (9.8 m/sec)</td>
</tr>
<tr>
<td>15 gpm (60 L/min.)</td>
<td>240 ft/sec (73.2 m/sec)</td>
<td>105 ft/sec (32 m/sec)</td>
<td>47 ft/sec (14.3 m/sec)</td>
</tr>
</tbody>
</table>

Sun Series 1

ISO / SAE-10 2 Port Cavity
ISO / SAE-10 3 Port Cavity
ISO / SAE-10 2 Port Cavity
ISO / SAE-10 3 Port Cavity
Sun’s 2 Port Cavity (T-13A)
Sun’s 3 Port Cavity (T-11A)
Sun Cavity Recap

Features

• Larger working port diameters
• Equivalent sizes to industry common cavities

Benefits

• Lower interconnection velocities result in less energy loss
• Greater capacity than equivalently sized industry common cavities
Higher Capacity:
Series 4+

• High Capacity Versions of Existing Valves
  – Check and non-modulating logic valves
  – 50-80% more capacity

• Alternative to DIN 25/32 Valves
  – Similar capacity
  – Smaller footprint
How Were the Efficiency Gains Achieved?

• Computational Fluid Dynamics Modeling
  – Computer simulation of valve performance
  – Identified flow restrictions
  – Quantified potential improvements
• Hydraulic Testing for Verification
CFD Findings – Orientation Sensitivity

- Inconsistent performance
  - Alters pressure drop
- Affected by flow rate
  - Greater sensitivity at higher flows
- Cavity can be restrictive
  - Increases at high flows (200+ gpm)
  - Must be considered for optimization
CFD Findings – Hydraulic Eddy

- Hydraulic restriction of flow
- Inlet geometry critical
- Performance affected by upstream and downstream constraints
Results – Critical Geometry

Optimized Cavity
- Widen annulus
- Widen port connection
- Straighten port

Optimized Cartridge
- Angle exit
- Smooth inlet
- Shape Poppet

Performance Improvements
- Manifold Annulus 30%
- Cartridge Inlet 20%
- Cartridge Exit 20%
- Manifold Porting 20%
- Poppet Shape 10%
Results – Hydraulic Validation

Pressure Differential vs. Flow

67% improvement over standard valve ≈ Savings of 28 hp

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Series 4+ Recap

Features
- Streamlined cartridge
- Enlarged cavity annulus
- Enlarged port connections
- Shares form and function with existing Sun valves

Benefits
- 25-40% lower pressure drop with either cartridge or cavity
- 50-80% lower pressure drop with cartridge and cavity
- Can replace existing applications without circuit redesign
Energy Saving Functions

• Interchangeable, industry accepted functions performed in new ways that provide significant energy savings
Energy Saving Functions:
LoadMatch™
Counterbalance Valves
What is a Counterbalance Valve?

- Direct Acting Relief Valve
- Pilot Assist
  - Reduces effective relief setting
- Integrated Reverse Free Flow Check
What Does a Counterbalance Valve Do?

- **Load Control**
  - Prevents unintended motion
  - Requires positive signal to open
  - Modulates opening for smooth control

- **Provides Relief Protection**
Counterbalance Valves Consume Energy

• Create a Variable Resistance to Flow
  – Energy sacrificed for control/stability
• Pilot Assist Reduces Resistance to Flow
  \[
  \text{Pilot Pressure To Open} = \frac{\text{Valve Setting} - \text{Load Pressure}}{\text{Pilot Ratio}}
  \]
• High Pilot Ratios Increase Efficiency
• High Pilot Ratios Decrease Stability
What is a LoadMatch™ Counterbalance Valve?

• Counterbalance Valve + New Control
  – Improved modulation
  – Non-adjustable
  – Fixed relief setting
  – Dynamic load holding setting
What Does a LoadMatch™ Valve Do?

- Counterbalance function
  - Full flow relief protection
  - Excellent modulating characteristics
  - Stable load control
- Low Pilot Pressure Requirements
- Pilot Pressure Independent of Load
LoadMatch™ Cartridge Model MBEP
## LoadMatch™ Advantages

### Dynamic Load Holding Setting

<table>
<thead>
<tr>
<th>Design Features</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Self sets to hold load</td>
<td>• Safe Load Holding</td>
</tr>
<tr>
<td>• Set point is higher than load pressure by a fixed differential</td>
<td>• Good control and stability</td>
</tr>
<tr>
<td>• Low, consistent pilot pressure</td>
<td>• Predictable Metering</td>
</tr>
<tr>
<td></td>
<td>• Energy Savings</td>
</tr>
</tbody>
</table>
LoadMatch™ Function

DYNAMIC ADJUSTMENT RANGE

THERMAL RELIEF SETTING:
4000 PSI

USE ARROWS, LEFT/RIGHT ON KEYBOARD, FOR LOAD PRESSURE
Performance Comparisons

Pilot Pressure Requirements
4000 psi Valve setting

**Standard Counterbalance**

Pilot Pressure vs. Flow

**LoadMatch™**

Pilot Pressure vs. Flow

65% lower pilot pressure over standard valves at 1000 psi load pressure
Where Does LoadMatch™ Apply?

- Off Road Tele-handlers/Forklifts
- Winches
- Cranes
- Battery Operated Equipment
LoadMatch™ Recap

Features

• Dynamic Load Holding Setting
• Lower pilot pressures
• Consistent pilot pressures
• Includes pressure relief

• Shares cavity with other Sun counterbalance valves

Benefits

• Enhanced performance over standard counterbalance
• Reduces energy consumption
• Extends run-time of battery powered machinery

• Can replace existing Sun counterbalance applications
Optimized Manifold Assemblies

• A hydraulic circuit integrated into a single block to minimize pressure losses between valves
Line Mounted Valves Reduce Circuit Efficiency

- Sources of Pressure Loss
  - Fittings
  - Long and undersized hoses or tubing
How Can Manifold Assemblies Improve Efficiency?

- Minimize Pressure Losses
  - Fewer fittings
  - Larger diameter connections
  - No long hoses or tubing

Motor Control Circuit – components manifold mounted
Optimized Manifold Assemblies: 5-Axis Machining

• 3-Axis
  – X, Y, and Z axes

• 5-Axis
  – X, Y, and Z axes
  – Plus A (rotate) and B (tilt)
  – Enables use of compound angles
5-Axis vs. 3-Axis Efficiency Advantages

• Improved Flow Paths
  – Optimized cavity connections
  – Fewer drillings to connect cavities
  – Less restrictive drilling connections
    • Angles greater than 90°
Additional 5-Axis Advantages

• Reduced Package Size
  – Easier packaging
  – Weight savings for mobile applications

• Fewer Construction Holes
  – Potential leak points
Manifold Design Comparison

3-Axis
Straight Hole Drilling
Size: 125 cubic inches
5 x 5 x 5 inches
No. of Plugs: 17

5-Axis
Compound Angle Drilling
Size: 64 cubic inches
4 x 4 x 4 inches
No. of Plugs: 0

Schematic for both designs
Designing 5-Axis Manifolds for Energy Savings

• 5-Axis Designs Typically Reduce Block Size
  – Package size may increase when designing for optimum efficiency

• For Flow Path Efficiency
  – Minimize acute drilling connections
  – Maximize connection diameters
  – Optimize placement of components
5-Axis Recap

Features

• Compound angle drillings
• Connection angles greater than 90°
• Reduced block size
• Fewer construction holes

Benefits

• Improved flow paths
• Optimized cavity hits
• Lower pressure drop between installed components
• Less mass for mobile applications
• Fewer leak points
Considerations About Energy Savings

• Your Savings May Vary
  – Energy efficient components do not guarantee an efficient circuit
  – Simple substitution may not produce savings
  – Savings difficult to predict
  – Consider complete circuit with efficiency in mind
Bringing It All Together

• Higher Capacities
  – Reduce component pressure losses

• Energy Saving Functions
  – Use less power for critical functions

• Optimized Manifold Assemblies
  – Minimizes circuit losses
Bringing It All Together

• Choose Components with Efficiency in Mind
  – Sun Cavities allow large connections
  – Series 4+ valves operate at low pressure drop
  – LoadMatch™ valves reduce energy requirements
  – 5-Axis manifolds leverage efficient circuit design and packaging

• Combine to Optimize System Efficiency
Questions?