HONDA HERITAGE CENTER EGA LIFTER ASSEMBLY

A Baccalaureate thesis submitted to the
School of Dynamic Systems
College of Engineering and Applied Science
University of Cincinnati

in partial fulfillment of the
requirements for the degree of

Bachelor of Science

in Mechanical Engineering Technology

by

Gopal Gaba

April 2015

Thesis Advisor: Janak Dave
ABSTRACT

As a co-op at Honda of America Manufacturing, (HAM), I have been presented with an opportunity to design a car body lifter for the Honda Heritage Center, HHC, in Marysville, Ohio. I work in the Engineering Group, EGA. Below is review how the design came about.
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PROBLEM DEFINITION AND RESEARCH

PROBLEM STATEMENT
Design a display car body lift with an irregular center of gravity. The lift must provide access to a robot with an articulating configuration.

INTERVIEWS
Interview with General Public. Rachel Paniccia
Columbus, OH (September 10, 2014)

Would you be interested in visiting a Honda Manufacturing Heritage Center?
- Yes. Considering my husband to be and I are huge auto-enthusiast, we will definitely visit a car-manufacturing museum and learn about the heritage of Honda. As far as I know, Honda excels in reliability. I would love to see how the company laid the foundation for making quality products.

What would you like to see in an auto-manufacturing showcase cell?
- The functionality of a robot and all the processes that it can perform. I would like to see the speeds at which the work is performed and how precisely it is performed.

What would you like to see highlighted in an assembly that lifts the car?
- Something that draws attention to the eye. It should look very industrial/unyielding.

Interview with Manufacturing Engineer at Honda Mfg., Inc. Joe Beck
Bellefontaine, OH (September 10, 2014)

What are typical design considerations for a car assembly line tool?
- To name a few, we take into account the cycle times, assembly environment, and repeatability.
In order to shell out certain amount of cars each shift, tasks must be performed with in a given amount of time to keep up with the assembly line.
We also take into account the area into which the tooling will be placed. An area may have high dust content; hence we must take steps to protect tooling from it.
Lastly, we would also look how we can offer the customer a consistency. Our goal is to maintain quality with repeatability.

What set backs can one expect when designing a car lift assembly?
- As a designer, you will always run into constraints. In a lift assembly, limitations on the area you have to work with may be a concern. Look to package your product such that the space is used wisely.
Also, take into account the forces, and moments that sliding rails may experience.

As a seasoned Honda Engineer, what advice would you offer to a rookie like me?
- It is easy to build your own constraints, but do not assume any. Always be open minded when creating designs.
**RESEARCH/EXISTING PRODUCTS**

First existing product that was analyzed is the Bendpak 2-Post Floorplate Car lift. See Figure 1. Even though the lift as the ability to lift a car with an irregular center of gravity, the lift fails to allow clearance for a robot arm. The Fanuc R-1000 will not be able to reach the cabin or hood area.

![Figure 1, Bendpak 2-Post Floorplate Car Lift](image1)

Secondly, Challenger CL4P9W Home Car Lift was analyzed. See Figure 2. This lift would have been a perfect off the shelf option for the application. However, this option was infeasible due to the lack of real estate with in the cell.

![Figure 2, Challenger CL4P9W Home Car Lift](image2)
Lastly, consider Bendpak Scissor Lift. Shown in Figure 3. The underlying product lacks the ability to anchor itself to the floor. This could be a major issue because application requires precision.

![Figure 3, Bendpak Scissor Lift](image)

**PRODUCT OBJECTIVES**

Safety
Manufacturability
Easy to maintain
Reliability
Quiet
Is repeatable
Has a cable management system,
Has a caution light mount
Small footprint
Anchoring system to the floor
Able to lift car
DESIGN

DESIGN ALTERNATIVES AND SELECTION

While designing the lifter, two major design concepts were considered. Both concepts integrated similar major design components: a pneumatic cylinder and linear guide rails.

The concepts are differentiated by the mount locations of the linear guide rails.

The first configuration is sketched in Figure 4. As you can see, the linear rails would be mounted close to the pneumatic cylinder. The mount location of the pneumatic cylinder is crucial due to Center of Gravity (CG) of the Upper Frame and the display car. Linear guides closer to CG would entail higher order of bending moments on the rails.

Therefore, a secondary configuration was used. See Figure 5. In this concept, the guide rails would be mounted farthest away from the CG. Such configuration minimizes the moments on the rails. This in-turn elongates the life of the bearings.
BASE FRAME

Concept: Linear Rails w/ Single Pneumatic Cylinder

Linear Rail Mounts (3)

Pneumatic Controls mount

Upper limit

Square Tubing 1020 HRS

Pneumatic Cylinder mount Base

Lower limit (3)

Level/Anchor Bolt holes

Cable Track mount

Upper Frame

Concept: Linear Rails w/ Single Pneumatic Cylinder

Linear Bearings mount (3)

Car Location bracket Mount (3)

Pneumatic Cylinder flange Mount

Square Tubing 1020 HRS

Lower Stop mount holes (3)

Cable Track mount

Figure 4, Concept 1 Sketches
Figure 5: Concept 2 Drawings

**BASE FRAME**
- Concept: Linear Rails w/ Single Pneumatic Cylinder
- Configuration

**UPPER FRAME**
- Concept: Linear Rails w/ Single Pneumatic Cylinder
- Configuration
**LOADING CONDITIONS**

**Pneumatic Cylinder**
In order to determine the loading conditions for the pneumatic cylinder, the weight of the upper frame, and weight of the car itself had to be calculated.

After modeling the upper frame using CAD, material properties were applied to the model using CATIA V5. The software then calculated the weight of the frame to be 4061 N. Remainder of the weight to be lifted by the cylinder was dependent on weight of the display car.

The display car weight was then estimated using CATIA V5 as well. The car body and all components that would be mounted on the display car were assembled in a virtual 3D space with proper material properties assignment to each component. The result was approximately 5000 N.

Therefore the resulting load for the pneumatic cylinder would be the weight of the upper lifter plus the weight the display car, ~9000 N.

**Center of Gravity**
Again, the center of gravity of the upper frame and the display car were calculated using a CAD software. The software was able to calculate the point using material properties that were applied to each component or part.

The calculated center of gravity was then used determine the mount location of the single piston pneumatic cylinder.

**NOTE:** Due to the confidentiality, author is unable to share any data on car parts.

**DESIGN ANALYSIS**
FEA results yielded maximum displacement of 0.18mm and maximum stress of 74 MPa for either frame. The design was then finalized for fabrication.

**COMPONENT SELECTION**

**Actuator**
Selection of the actuating mechanism for the lifter were limit to either a hydraulic or a pneumatic cylinder. A hydraulic actuator would have required an oil pump for the system, whereas a pneumatic cylinder could be actuated via existing facilities. Therefore, a pneumatic cylinder was used to raise and lower the display car. After determining which type of actuator was to be used for the design, the specific make and model was to be determined for the cylinder.

SMC Corporation is a proud pneumatic needs vendor for Honda of America Manufacturing. An existing business relationship encourage the actuator selection to be made using SMC.
products. Considering the force required to lift the upper frame and the display car is over 9000 N, the CS2 Series double acting, single rod cylinder was used. To provide for 1.5 safety factor, the cylinder must be able to lift 15000 N.

The CS2 Series cylinder catalog was reference to determine the correct bore for the cylinder. Knowing that the facility is to provide 0.8-0.9 MPa of operating pressure, a 160 mm bore cylinder was considered sufficient to handle the load. Therefore, CDS2G160-250-M9BW was purchased from SMC USA website. See Appendix E for CS2 Series catalog.

**Linear Guide Rails**
Guide rails and bearings were another major component of the design. The primary selection factor for this component was maintenance-free operation and basic load ratings. The cage ball LM Guides from THK were a perfect fit for the design. The assembly technicians were also comfortable with putting together the guides and bearings as they had used rails from THK numerous times. The model SHS35LCSS+460L was the correct length (460 mm) and held the dynamic load rating of 72.9 kN. Such rating was determined to be more than sufficient after conducting finite element analysis on the assembly.

See Appendix E for rail catalog.

**Other Miscellaneous Components**
Other minor components selections were driven by clearances and material properties.

**FABRICATION AND ASSEMBLY**
Fabrication and assembly responsibilities are typically handed off to other departments at Honda of American Manufacturing Inc. This project was no different. After completing all detail drawings of designed parts, the drawings were sent to various fabricators for fabrication. Purchased parts were ordered from various vendors and arrived in a timely manner. Honda assembly technicians are dedicated to putting together all projects. Two technicians assembled this project on the museum floor within a week.

**TESTING AND PROOF OF DESIGN**
Standard testing procedures were followed when time came for testing. Honda typically runs a “100 hour” test for quality assurance. All projects are run for certain amount of cycles that would entail 100 hours of online operation. Such testing was also conducted on this project and the design was deemed successful.

All conditions were met as stated in the Proof of Design Statement. Also, indicating a successful design.
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**TOTAL** $13,882.60

PROJECT MANAGEMENT

**BUDGET**

Designing this lifter was an irregular project, and was part of a much larger budget. No budget was set in particular for the lifter assembly. However, a 200,000 USD budget was set for the entire work cell.
SCHEDULE

Name: Gopal Gaba  
Project title: Display Car Lifter

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REFERENCES

APPENDIX A - RESEARCH

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Also, take into account the forces, and moments that sliding rails may experience.

As a seasoned Honda Engineer, what advice would you offer to a rookie like me?
- It is easy to build your own constraints, but do not assume any. Always be open minded when creating designs.
Bendpak 2-Post Floorplate Car Lift

Bendpak 2-Post Floorplate Car Lift lets you upgrade your garage with safety and efficiency. An adjustable width design configures for wide or narrow installation.

- Direct-drive lifting system eliminates the need for chains and pulleys
- Drop-end arms provide a lower pad height
- Triple telescoping arms deliver increased range for lifting point access
- Electric/hydraulic power system
- Large 20in. x 19in. steel base plates
- Dual hydraulic lifting cylinders
- Single-piece columns with safety locks
- Automatic arm restraints
- Heavy-duty dual 3/8in. equalizer cables with oversize cable sheaves
- FREE truck and van adapters

$2900 USD
Robot would not have access to cabin or hood area due to reach issues.
Challenger CL4P9W Home Car Lift

Challenger Lifts’ 9,000 lbs. capacity CL4P9X and CL4P9W 4-post home car lifts are perfect for light duty commercial service or storage applications. Bolt it down or leave it free-standing so you can relocate it anywhere. Challenger Lifts 9,000 lbs. home car lift and commercial service lift units give you unlimited options for your shop's layout. With optional rolling jacks, ramp upgrades, oil drain pan, etc., you’ll be able to accommodate just about anything that comes in the garage and afford room to grow with its reasonable cost.

- Heavy-duty commercial grade design with rigid formed columns and runways for superior strength and dependability, yet light enough to move around the garage with optional caster wheel.
- Built-in runway rail system accommodates optional rolling jacks, jack trays, drip trays, and storage platforms.
- 115v standard plug-in power unit with optional 220v version available.
- Large molecular composite slider blocks for minimal wear and maximum dependability.
- Power unit can be mounted on front or rear column for additional versatility in space constraining bays or garages.
- Factory installed mechanical lock system meeting ANSI safety standards.
- Versatile design allows it to be either Free-Standing or Bolted-to-Floor.
- Large 12” x 12” column bases for additional rigidity, especially for free standing setup.

$3500 USD
Large footprint. Showcase cell dimensions would not allow for such larger structure to be placed in the work envelope.
Bendpak Scissor Lift
- Small footprint, easy installation and adaptable 110V/220V power
- Lifts most unibody and frame contact undercarriages
- Ultra strong four parallelogram frame support bars
- Drive-over ramps and side rails support wider vehicles during approach
- Includes a durable full length rubber-topped lifting platform and eight multi-height rubber topped adapters for increased vehicle contact versatility
- Convenient built-in storage trays
- Dual hydraulic cylinders provide a stable 10,000-pound lifting capacity to accommodate a wide range of vehicles
- Diamond plated approach ramps help to prevent slipping
- Three locking positions allow technicians to work at different working heights to increase productivity and minimize fatigue
- Hands-free safety lock release system
- Powder-coat finish provides a long lasting durable finish

$2900 USD
No anchoring system to locate lift
Unable to locate car to exact height
Center of gravity of the car must be near center of the car
APPENDIX B – PRODUCT OBJECTIVES

Safe
Easy to manufacture
Easy to maintain
Reliable
Quiet
Is repeatable
Has a cable management system,
Has a caution light mount
Small footprint
Anchoring system to the floor
Able to lift car
## APPENDIX C - BUDGET

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<td>MISUMI-HARD STOP</td>
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<td>Shim Pack</td>
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<tr>
<td>Shim Pack</td>
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<td>1018 - SHIM</td>
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<td>10</td>
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<td>SMC - 6 STATION MANIFOLD</td>
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<td>WSSB25-8-5</td>
<td>MISUMI - WASHER</td>
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**TOTAL $13,882.60**
### APPENDIX D - SCHEDULE

<table>
<thead>
<tr>
<th>TASKS</th>
<th>2014</th>
<th>2015</th>
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<tbody>
<tr>
<td>Specification Meeting</td>
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<td></td>
</tr>
<tr>
<td>Proof of Design Agreement</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Concepts/Selection</td>
<td>16</td>
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<tr>
<td>3D Model - (Base Frame)</td>
<td>27</td>
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<tr>
<td>3D Model - (Lifter Frame)</td>
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<td>3D Model - (Pins &amp; Risers)</td>
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<tr>
<td>3D Model - (Cable Tracket Assy)</td>
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<td></td>
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<tr>
<td>3D Model - (Misc.)</td>
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<td>Parts Detail</td>
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<td>Parts Order</td>
<td>14</td>
<td></td>
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<tr>
<td>Parts Receive</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Mock up Assembly</td>
<td>30</td>
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<tr>
<td>Showroom Install</td>
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</tbody>
</table>

### APPENDIX E – RAILS AND CYLINDER CATALOGS
## Models SHS-C and SHS-LC

### Diagram
![Diagram of Models SHS-C and SHS-LC](image)

### Table: Outer dimensions, LM block dimensions, and Pilot hole for side nipple

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Outer dimensions</th>
<th>LM block dimensions</th>
<th>Pilot hole for side nipple**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Height (M)</td>
<td>Width (W)</td>
<td>Length (L)</td>
</tr>
<tr>
<td>SHS 15C</td>
<td>24</td>
<td>47</td>
<td>64.4/79.4</td>
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<tr>
<td>SHS 20C</td>
<td>30</td>
<td>63</td>
<td>79/98</td>
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<tr>
<td>SHS 25C</td>
<td>36</td>
<td>70</td>
<td>106/131</td>
</tr>
<tr>
<td>SHS 30C</td>
<td>42</td>
<td>90</td>
<td>106/131</td>
</tr>
<tr>
<td>SHS 35C</td>
<td>48</td>
<td>100</td>
<td>122/152</td>
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<tr>
<td>SHS 45C</td>
<td>60</td>
<td>120</td>
<td>140/174</td>
</tr>
<tr>
<td>SHS 55C</td>
<td>70</td>
<td>140</td>
<td>171/213</td>
</tr>
<tr>
<td>SHS 65C</td>
<td>90</td>
<td>170</td>
<td>221/272</td>
</tr>
</tbody>
</table>

### Model number coding

- **SHS25 LC 2 QZ KKHH C0 +1200L P Z T - I**

  - **Model number**
  - **Type of LM block**
  - **No. of LM blocks used on the same rail**
  - **With QZ Lubricator**
  - **Contamination protection accessory symbol (1)**
  - **Radial clearance symbol (2)**
  - **LM rail length (in mm)**
  - **With steel tape**
  - **Symbol for LM rail jointed use**
  - **Symbol for No. of rails used on the same plane (4)**

**Note:**
- This model number indicates that a single-rail unit constitutes one set. (i.e., required number of sets when 2 rails are used in parallel is 2 at a minimum.)
- Those models equipped with QZ Lubricator cannot have a grease nipple. When desiring a grease nipple for a model attached with QZ, contact THK.

### Symbols

- **Accuracy symbol (3)**
  - Normal grade (No symbol)/High accuracy grade (H)
  - Precision grade (P)/Super precision grade (SP)
  - Ultra precision grade (UP)

- **Contamination protection accessory symbol (4)**

- **Radial clearance symbol (4)**
  - Normal (No symbol)/Light preload (C1)/Medium preload (C0)
<table>
<thead>
<tr>
<th>Width</th>
<th>Height</th>
<th>Pitch</th>
<th>Length</th>
<th>Unit: mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>H_3</td>
<td>W_1</td>
<td>W_2</td>
<td>M_1</td>
<td>F</td>
</tr>
<tr>
<td>3</td>
<td>16</td>
<td>13</td>
<td>60</td>
<td>4.5×7.5×5.3</td>
</tr>
<tr>
<td>4.6</td>
<td>20</td>
<td>16.5</td>
<td>60</td>
<td>6×9.5×8.5</td>
</tr>
<tr>
<td>5.8</td>
<td>23</td>
<td>20</td>
<td>60</td>
<td>7×11×9</td>
</tr>
<tr>
<td>7</td>
<td>28</td>
<td>23</td>
<td>80</td>
<td>9×11×12</td>
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<td>7.5</td>
<td>34</td>
<td>26</td>
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<td>8.9</td>
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<td>32</td>
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<td>12.7</td>
<td>53</td>
<td>38</td>
<td>120</td>
<td>16×23×20</td>
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<tr>
<td>19</td>
<td>63</td>
<td>53</td>
<td>150</td>
<td>18×26×22</td>
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</tbody>
</table>

Note) Pilot holes for side nipples** are not drilled through in order to prevent foreign material from entering the product. THK will mount grease nipples per your request. Therefore, do not use the side nipple pilot holes** for purposes other than mounting a grease nipple.

The maximum length under “Length**” indicates the standard maximum length of an LM rail. (See A1-104.)

Static permissible moment**: 1 block: static permissible moment value with 1 LM block
Double blocks: static permissible moment value with 2 blocks closely contacting with each other
Air Cylinder

Maximum stroke when using rotating bracket
Expanded by **1.6 times** (compared to series CS1)

- Lighter cylinder reduces self-weight deflection.
- Stroke range extended to widen use.

**Double Rod Type**, Smooth Cylinder added to Series CS2!

9 Made to Order types added!

**Series CS2**

- **Large Bore Sizes** \( \varnothing 125, \varnothing 140, \varnothing 160 \)

- Weight Reduced by Max. **58%**

- New

- Weight Comparison

- **Maximum allowable stroke when using clevis bracket**

- **Allowable lateral load equal to Series CS1**

  Even if rod diameter is changed to suit various needs, function remains equal to Series CS1.
Air Cylinder

Series CS2

Improved operability after installation
Operability has been improved by placing the piping port and cushion valve operation position on the same side.

Interchangeability with Series CS1
Cylinder mounting dimensions and rod end thread sizes are interchangeable with Series CS1.

Cushion seals are now replaceable
Maintenance improved by making cushion seals replaceable.

Compact auto switches can be mounted
2-color display auto switches can be mounted, enabling precise determination of mounting position, without error.

Smooth Cylinder
- Minimum operating pressure 0.005 MPa
- Realize stable, low speed operation at even 5 mm/s

Series Variations

<table>
<thead>
<tr>
<th>Series</th>
<th>Action</th>
<th>Type</th>
<th>Standard variations</th>
<th>Bore size (mm)</th>
<th>Made to Order</th>
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</thead>
<tbody>
<tr>
<td>P.2</td>
<td></td>
<td></td>
<td></td>
<td>125 140 160</td>
<td></td>
</tr>
<tr>
<td>Standard CS2</td>
<td>Double acting</td>
<td>Single rod</td>
<td>With rod boot/Copper-free</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P.17</td>
<td></td>
<td>Double acting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smooth Cylinder CS2Y</td>
<td>NEW</td>
<td>Double acting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Double rod</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P.17</td>
<td></td>
<td>Double acting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smooth Cylinder CS2Y</td>
<td>NEW</td>
<td>Double acting</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Feature 1
## Combination of Standard Products and Made to Order Specifications

### Series CS2

- **Standard**
- **Made to Order specifications**
- **Special product (Contact SMC for details)**
- **Not available**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Specification</th>
<th>Applicable bore size</th>
<th>CS2 (Standard)</th>
<th>CS2Y (Smooth Cylinder)</th>
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<tbody>
<tr>
<td>Ø125 to Ø160</td>
<td>Single rod</td>
<td>Double acting</td>
<td>Double rod</td>
<td>Single rod</td>
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<tr>
<td>Non-lube</td>
<td>Non-lube</td>
<td>Non-lube</td>
<td>Non-lube</td>
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<table>
<thead>
<tr>
<th>Standard</th>
<th>Standard</th>
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<tbody>
<tr>
<td>CDS2</td>
<td>Built-in magnet</td>
</tr>
<tr>
<td>CS2</td>
<td>With rod boot</td>
</tr>
<tr>
<td>20-</td>
<td>Copper and Fluorine-free</td>
</tr>
<tr>
<td>-XA</td>
<td>Change of rod end shape</td>
</tr>
<tr>
<td>-XB5</td>
<td>Oversized rod cylinder</td>
</tr>
<tr>
<td>-XB6</td>
<td>Heat-resistant cylinder (–10 to 150 °C)</td>
</tr>
<tr>
<td>-XB7</td>
<td>Cold-resistant cylinder</td>
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<tr>
<td>-XB9</td>
<td>Low speed cylinder (5 to 50 mm/s)</td>
</tr>
<tr>
<td>-XC3</td>
<td>Special port position</td>
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<tr>
<td>-XC4</td>
<td>With heavy duty scraper</td>
</tr>
<tr>
<td>-XC5</td>
<td>Heat resistant cylinder (0 to 110 °C)</td>
</tr>
<tr>
<td>-XC6</td>
<td>Made of stainless steel</td>
</tr>
<tr>
<td>-XC7</td>
<td>Tie-rod, cushion valve, tie-rod nut, etc. made of stainless steel</td>
</tr>
<tr>
<td>-XC8</td>
<td>Adjustable stroke cylinder/Adjustable extension type</td>
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<td>Adjustable stroke cylinder/Adjustable retraction type</td>
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<td>Dual stroke cylinder/Double rod type</td>
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<td>Tandem cylinder</td>
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<td>-XC14</td>
<td>Change of trunnion bracket mounting position</td>
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<td>-XC15</td>
<td>Change of tie-rod length</td>
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<td>-XC22</td>
<td>Fluororubber seal</td>
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<td>-XC26</td>
<td>Double clevis pin/Double knuckle pin with split pin and flat washer</td>
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<td>-XC27</td>
<td>Double clevis pin and double knuckle pin made of stainless steel</td>
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<tr>
<td>-XC30</td>
<td>Rod side trunnion mounted on the front of the rod cover</td>
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<tr>
<td>-XC35</td>
<td>With coil scraper</td>
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<td>-XC39</td>
<td>Special trunnion bearing</td>
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<td>-XC40</td>
<td>Clevis hole with bushing</td>
</tr>
<tr>
<td>-XC50</td>
<td>Knuckle fixed with nut</td>
</tr>
<tr>
<td>-XC68</td>
<td>Made of stainless steel (With hard chrome plated piston rod)</td>
</tr>
<tr>
<td>-XC86</td>
<td>With rod end bracket</td>
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---

*SMC*
Air Cylinder

**Series CS2**

**ο125, ο140, ο160**

### How to Order

<table>
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<th>B</th>
<th>L</th>
<th>F</th>
<th>G</th>
<th>C</th>
<th>D</th>
<th>T</th>
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<tbody>
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<td>Head flange</td>
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<td>Single clevis</td>
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<td>D</td>
<td>Double clevis</td>
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<td>Center trunnion</td>
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### Built-in Magnet Cylinder Model

If a built-in magnet cylinder without auto switch is required, there is no need to enter the symbol for auto switch.

(Example) CDS2B125-200

### Applicable Auto Switches

<table>
<thead>
<tr>
<th>Type</th>
<th>Special function</th>
<th>Electrical entry</th>
<th>Wiring (Output)</th>
<th>Load voltage</th>
<th>Tie-rod mounting</th>
<th>Band mounting</th>
<th>0.5 (Nil)</th>
<th>1</th>
<th>3</th>
<th>5</th>
<th>Pre-wired connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid state switch</td>
<td>—</td>
<td>—</td>
<td>3-wire (PNP)</td>
<td>5, 12 V</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Diagnostic indication (2-color indication)</td>
<td>—</td>
<td>—</td>
<td>3-wire (PNP)</td>
<td>5, 12 V</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Water resistant (2-color indication)</td>
<td>—</td>
<td>—</td>
<td>3-wire (PNP)</td>
<td>5, 12 V</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Diagnostic indication (2-color indication)</td>
<td>—</td>
<td>—</td>
<td>4-wire (PNP)</td>
<td>5, 12 V</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Reed switch</td>
<td>—</td>
<td>—</td>
<td>3-wire (PNP)</td>
<td>5</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Diagnostic indication (2-color indication)</td>
<td>—</td>
<td>—</td>
<td>4-wire (PNP)</td>
<td>24 V</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

* Since there are applicable auto switches other than listed, refer to page 23 for details.
* For details about auto switches with pre-wired connector, refer to Best Pneumatics No. 2.
* Α96, Α93, Α90, Α54, Α64, Α33, Α34, Α59W, M9NR, M9PW, M9BW, M9NA, M9PA, M9BA are shipped together (but not assembled). (Only auto switch mounting bracket is assembled at the time of shipment.)

**Suffix for cylinder**

Without auto switch

<table>
<thead>
<tr>
<th>Rod boot</th>
<th>Nil</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>Nylon tarpaulin</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>Heat resistant tarpaulin</td>
<td></td>
</tr>
</tbody>
</table>

* With air cushions on both sides only.

**Cylinder stroke (mm)**

Refer to the next page for the "Maximum Stroke" table.

### Made to Order

For details, refer to the next page.

### Number of auto switches

- Nil: 2 pcs.
- 3: 3 pcs.
- S: 1 pc.
- n: n pcs.

### Auto switch

<table>
<thead>
<tr>
<th>With auto switch</th>
<th>(Built-in magnet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>With auto switch</td>
<td></td>
</tr>
</tbody>
</table>

* For details about auto switches with pre-wired connector, refer to Best Pneumatics No. 2.

**With auto switch**

<table>
<thead>
<tr>
<th>B</th>
<th>L</th>
<th>F</th>
<th>G</th>
<th>C</th>
<th>D</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>125</td>
<td>125 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>125</td>
<td>140 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>160</td>
<td>160 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Made to Order

For details, refer to the next page.

### Number of auto switches

- Nil: 2 pcs.
- 3: 3 pcs.
- S: 1 pc.
- n: n pcs.

### Auto switch

<table>
<thead>
<tr>
<th>With auto switch</th>
<th>(Built-in magnet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>With auto switch</td>
<td></td>
</tr>
</tbody>
</table>

* For details about auto switches with pre-wired connector, refer to Best Pneumatics No. 2.

**With auto switch**

<table>
<thead>
<tr>
<th>B</th>
<th>L</th>
<th>F</th>
<th>G</th>
<th>C</th>
<th>D</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>125</td>
<td>125 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>125</td>
<td>140 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>160</td>
<td>160 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Made to Order

For details, refer to the next page.

### Number of auto switches

- Nil: 2 pcs.
- 3: 3 pcs.
- S: 1 pc.
- n: n pcs.

### Auto switch

<table>
<thead>
<tr>
<th>With auto switch</th>
<th>(Built-in magnet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>With auto switch</td>
<td></td>
</tr>
</tbody>
</table>

* For details about auto switches with pre-wired connector, refer to Best Pneumatics No. 2.

**With auto switch**

<table>
<thead>
<tr>
<th>B</th>
<th>L</th>
<th>F</th>
<th>G</th>
<th>C</th>
<th>D</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>125</td>
<td>125 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>125</td>
<td>140 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>160</td>
<td>160 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Specifications

<table>
<thead>
<tr>
<th>Bore size (mm)</th>
<th>125</th>
<th>140</th>
<th>160</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action</td>
<td>Double acting, Single rod</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluid</td>
<td>Air</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proof pressure</td>
<td>1.57 MPa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum operating pressure</td>
<td>0.97 MPa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum operating pressure</td>
<td>0.05 MPa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piston speed</td>
<td>50 to 600 mm/s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cushion</td>
<td>Air cushion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambient and fluid temperature</td>
<td>Without auto switch: 0 to 70°C (No freezing) With auto switch: 0 to 60°C (No freezing)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lubrication</td>
<td>Not required (Non-lube)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Stroke length tolerance (mm)

<table>
<thead>
<tr>
<th>Stroke</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>250 or less</td>
<td>+1.0</td>
</tr>
<tr>
<td>251 to 1000</td>
<td>+1.4</td>
</tr>
<tr>
<td>1001 to 1500</td>
<td>+1.8</td>
</tr>
<tr>
<td>1501 to 1600</td>
<td>+2.2</td>
</tr>
</tbody>
</table>

Mounting | Basic, Foot, Rod flange, Head flange, Single clevis, Double clevis, Center trunnion

Maximum Stroke

<table>
<thead>
<tr>
<th>Bore size</th>
<th>Maximum stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic, Head flange, Single clevis, Double clevis, Center trunnion</td>
<td>Foot, Rod flange</td>
</tr>
<tr>
<td>125</td>
<td>1000 or less</td>
</tr>
<tr>
<td>140</td>
<td>1600 or less</td>
</tr>
<tr>
<td>160</td>
<td>1200 or less</td>
</tr>
</tbody>
</table>

Accessory

<table>
<thead>
<tr>
<th>Mounting</th>
<th>Basic</th>
<th>Foot</th>
<th>Rod flange</th>
<th>Head flange</th>
<th>Single clevis</th>
<th>Double clevis</th>
<th>Center trunnion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard equipment</td>
<td>Clevis pin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rod end nut</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single knuckle joint</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double knuckle joint (Knuckle pin, Split pin)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rod boot</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rod Boot Material

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Material (Max. ambient temperature)</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>Nylon tarpaulin (70°C)</td>
</tr>
<tr>
<td>K</td>
<td>Heat resistant tarpaulin (110°C)</td>
</tr>
</tbody>
</table>

For the specifications of cylinders with auto-switch, please refer to pages 21 to 24.

- Minimum stroke for auto switch mounting
- Auto switch proper mounting position (detection at stroke end) and its mounting height
- Operating range
- Auto switch mounting bracket part no.

Mounting Bracket Part No.

<table>
<thead>
<tr>
<th>Bore size (mm)</th>
<th>125</th>
<th>140</th>
<th>160</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foot**</td>
<td>CS2-L12</td>
<td>CS2-L14</td>
<td>CS2-L16</td>
</tr>
<tr>
<td>Flange</td>
<td>CS2-F12</td>
<td>CS2-F14</td>
<td>CS2-F16</td>
</tr>
<tr>
<td>Single clevis</td>
<td>CS2-C12</td>
<td>CS2-C14</td>
<td>CS2-C16</td>
</tr>
<tr>
<td>Double clevis**</td>
<td>CS2-D12</td>
<td>CS2-D14</td>
<td>CS2-D16</td>
</tr>
</tbody>
</table>

* Order two foot brackets per cylinder.
** When ordering the double clevis style, the clevis pin and 2 split pins are included as accessories.
### Weight

<table>
<thead>
<tr>
<th>Bore size (mm)</th>
<th>Basic</th>
<th>Foot</th>
<th>Rod flange</th>
<th>Head flange</th>
<th>Single clevis</th>
<th>Double clevis</th>
<th>Trunnion</th>
<th>Additional weight with magnet</th>
<th>Additional mass per each 100 mm of stroke</th>
<th>Rod end nut</th>
</tr>
</thead>
<tbody>
<tr>
<td>125</td>
<td>5.46</td>
<td>7.49</td>
<td>8.51</td>
<td>8.51</td>
<td>8.99</td>
<td>9.59</td>
<td>0.07</td>
<td>0.91</td>
<td>1.55</td>
<td>0.16</td>
</tr>
<tr>
<td>140</td>
<td>6.50</td>
<td>9.50</td>
<td>12.03</td>
<td>12.03</td>
<td>11.54</td>
<td>12.23</td>
<td>0.07</td>
<td>1.16</td>
<td>1.67</td>
<td>0.16</td>
</tr>
<tr>
<td>160</td>
<td>9.07</td>
<td>12.45</td>
<td>15.80</td>
<td>15.80</td>
<td>15.41</td>
<td>15.47</td>
<td>0.08</td>
<td>1.56</td>
<td>2.23</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Calculation: (Example) CS2L160-500
- **Basic weight**.............. 12.45 (kg)
- **Additional weight**......... 2.23 (kg/100 mm)
- **Cylinder stroke**.......... 500 (mm)

\[ 12.45 + 2.23 \times \frac{500}{100} = 23.60 \text{ (kg)} \]

### Theoretical Output / Double Acting

<table>
<thead>
<tr>
<th>Bore size (mm)</th>
<th>Rod size (mm)</th>
<th>Operating direction</th>
<th>Operating pressure (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Piston area (mm²)</td>
<td>0.2</td>
</tr>
<tr>
<td>125</td>
<td>32</td>
<td>OUT</td>
<td>12300</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IN</td>
<td>11500</td>
</tr>
<tr>
<td>140</td>
<td>32</td>
<td>OUT</td>
<td>15400</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IN</td>
<td>14600</td>
</tr>
<tr>
<td>160</td>
<td>38</td>
<td>OUT</td>
<td>20100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IN</td>
<td>19000</td>
</tr>
</tbody>
</table>

**Warning**

1. **Do not use the cylinder as a shock absorber.**
   Using the cylinder as a shock absorber may cause damage.
2. **Do not open the cushion valve beyond the stopper.**
   As a retaining mechanism for the cushion valve, retaining ring is installed, and the cushion valve should not be opened beyond that point.
   If not operated in accordance with the above precautions, the cushion valve may be ejected from the cover when air pressure is supplied.
3. **Use the air cushion at the end of cylinder stroke.**

**Caution**

1. **Regarding the installation of a knuckle joint**
   Please contact SMC if a knuckle joint must be installed on the piston rod by using the rod end nut.
2. **Regarding the screw-in of fittings when piping**
   When ports and fittings are screwed in, tighten them with the proper tightening torque below.

<table>
<thead>
<tr>
<th>Bore size (mm)</th>
<th>Connecting thread nominal size</th>
<th>Proper tightening torque N·m</th>
</tr>
</thead>
<tbody>
<tr>
<td>125, 140</td>
<td>1/2</td>
<td>28 to 30</td>
</tr>
<tr>
<td>160</td>
<td>3/4</td>
<td></td>
</tr>
</tbody>
</table>

3. **Do not deform cushion rings when removing and assembling.**
   Cushion rings are press molded products.
   If a cushion ring bumps with something when removing and assembling, the air cushion may not function properly due to cushion ring deformation.
**Relation between Cylinder Size and Maximum Stroke**

The below table shows the applicable maximum stroke (in cm units), found by calculation assuming the case where the force generated by the cylinder itself acts as buckling force on the piston rod, or piston rod and cylinder tube. Therefore, it is possible to find the applicable maximum stroke for each cylinder size using the relationship between the size of the operating pressure and the cylinder support type, regardless of the load ratio.

[Reference] If it is stopped with the external stopper on the cylinder extension side, even with a light load, the maximum generated force of the cylinder will act on the cylinder itself.

<table>
<thead>
<tr>
<th>Support bracket nominal symbol and schematic diagram</th>
<th>Operating pressure (MPa)</th>
<th>Applicable max. stroke according to buckling strength (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>125</td>
</tr>
<tr>
<td>Foot: L, Rod flange: F, Head flange: G</td>
<td>0.3</td>
<td>103</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>66</td>
</tr>
<tr>
<td>G</td>
<td>0.3</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>26</td>
</tr>
<tr>
<td>Clevis: C, D, Center trunion: T</td>
<td>0.3</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>0.3</td>
<td>135</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>84</td>
</tr>
<tr>
<td>Foot: L, Rod flange: F, Head flange: G</td>
<td>0.3</td>
<td>301</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>231</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>193</td>
</tr>
<tr>
<td>G</td>
<td>0.3</td>
<td>144</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>109</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>90</td>
</tr>
<tr>
<td>Foot: L, Rod flange: F, Head flange: G</td>
<td>0.3</td>
<td>433</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>334</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>281</td>
</tr>
<tr>
<td>G</td>
<td>0.3</td>
<td>210</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>160</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>134</td>
</tr>
</tbody>
</table>
Series CS2

Construction

Component Parts

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Material</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rod cover</td>
<td>Aluminum die-cast</td>
<td>Chromium</td>
</tr>
<tr>
<td>2</td>
<td>Head cover</td>
<td>Aluminum die-cast</td>
<td>Chromium</td>
</tr>
<tr>
<td>3</td>
<td>Cylinder tube</td>
<td>Aluminum alloy</td>
<td>Chromium</td>
</tr>
<tr>
<td>4</td>
<td>Piston</td>
<td>Aluminum alloy</td>
<td>Chromium</td>
</tr>
<tr>
<td>5</td>
<td>Piston rod</td>
<td>Carbon steel</td>
<td>Hard chrome plated</td>
</tr>
<tr>
<td>6</td>
<td>Bushing</td>
<td>Oil-impregnated sintered alloy</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Tie-rod</td>
<td>Carbon steel</td>
<td>Zinc chromated</td>
</tr>
<tr>
<td>8</td>
<td>Tie-rod nut</td>
<td>Rolled steel</td>
<td>Nickel plated</td>
</tr>
<tr>
<td>9</td>
<td>Cushion ring</td>
<td>Stainless steel</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Cushion valve</td>
<td>Rolled steel</td>
<td>Nickel plated</td>
</tr>
<tr>
<td>11</td>
<td>Piston nut</td>
<td>Carbon steel</td>
<td>Nickel plated</td>
</tr>
<tr>
<td>12</td>
<td>Flat washer</td>
<td>Carbon steel</td>
<td>Nickel plated</td>
</tr>
<tr>
<td>13</td>
<td>Wear ring</td>
<td>Resin</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Magnet</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Retaining ring</td>
<td>Spring steel</td>
<td>Phosphate coated</td>
</tr>
</tbody>
</table>

Component Parts

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Material</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Rod seal</td>
<td>NBR</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Cushion seal</td>
<td>Urethane</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Piston seal</td>
<td>NBR</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Valve seal</td>
<td>NBR</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Tube gasket</td>
<td>NBR</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Piston gasket</td>
<td>NBR</td>
<td></td>
</tr>
</tbody>
</table>

Replacement Parts: Seal Kit

<table>
<thead>
<tr>
<th>Bore size (mm)</th>
<th>Kit no.</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>125</td>
<td>CS2-125A-PS</td>
<td>Set of nos. 16, 17, 18, 19, 20</td>
</tr>
<tr>
<td>140</td>
<td>CS2-140A-PS</td>
<td></td>
</tr>
<tr>
<td>160</td>
<td>CS2-160A-PS</td>
<td></td>
</tr>
</tbody>
</table>

*Seal kit includes a grease pack (40 g). Order with the following part number when only the grease pack is needed. Grease pack part number: GR-S-010 (10 g), GR-S-020 (20 g)
Dimensions

Basic: CS2B

With rod boot

Foot: CS2L

With rod boot

<table>
<thead>
<tr>
<th>Bore size (mm)</th>
<th>Stroke range (mm)</th>
<th>A</th>
<th>AL</th>
<th>□B</th>
<th>□C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>J</th>
<th>V</th>
<th>W</th>
<th>K</th>
<th>KA</th>
<th>M</th>
<th>MM</th>
</tr>
</thead>
<tbody>
<tr>
<td>125</td>
<td>Up to 1000</td>
<td>50</td>
<td>47</td>
<td>143</td>
<td>115</td>
<td>32</td>
<td>71</td>
<td>43</td>
<td>15</td>
<td>15</td>
<td>17</td>
<td>15</td>
<td>27</td>
<td>27</td>
<td>M30 x 1.5</td>
<td></td>
</tr>
<tr>
<td>140</td>
<td>Up to 1000</td>
<td>50</td>
<td>47</td>
<td>157</td>
<td>128</td>
<td>32</td>
<td>71</td>
<td>43</td>
<td>15</td>
<td>15</td>
<td>17</td>
<td>15</td>
<td>27</td>
<td>27</td>
<td>M30 x 1.5</td>
<td></td>
</tr>
<tr>
<td>160</td>
<td>Up to 1200</td>
<td>56</td>
<td>53</td>
<td>177</td>
<td>144</td>
<td>38</td>
<td>78.5</td>
<td>42</td>
<td>18</td>
<td>15</td>
<td>20</td>
<td>17</td>
<td>34</td>
<td>30.5</td>
<td>M36 x 1.5</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bore size (mm)</th>
<th>N</th>
<th>P</th>
<th>S</th>
<th>Without rod boot</th>
<th>With rod boot</th>
</tr>
</thead>
<tbody>
<tr>
<td>125</td>
<td>30.5</td>
<td>1/2</td>
<td>98</td>
<td>110 235 75 40 133</td>
<td>½ stroke 258</td>
</tr>
<tr>
<td>140</td>
<td>30.5</td>
<td>1/2</td>
<td>98</td>
<td>110 235 75 40 133</td>
<td>½ stroke 258</td>
</tr>
<tr>
<td>160</td>
<td>34.5</td>
<td>3/4</td>
<td>106</td>
<td>120 256.5 75 40 141</td>
<td>½ stroke 277.5</td>
</tr>
</tbody>
</table>

* The minimum stroke with rod boot is 30 mm or more.
** For auto switch mounting position and its mounting height, refer to page 21.
*** Refer to “Minimum Stroke for Auto Switch Mounting” on page 22.

Foot: CS2L

With rod boot
### Dimensions

#### Rod flange: CS2F

<table>
<thead>
<tr>
<th>Bore size (mm)</th>
<th>Stroke range (mm)</th>
<th>A</th>
<th>AL</th>
<th>□B</th>
<th>B</th>
<th>□C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>FD</th>
<th>FT</th>
<th>FX</th>
<th>FY</th>
<th>FZ</th>
<th>G</th>
<th>J</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>125</td>
<td>Up to 1600</td>
<td>50</td>
<td>47</td>
<td>143</td>
<td>145</td>
<td>115</td>
<td>32</td>
<td>71</td>
<td>43</td>
<td>19</td>
<td>14</td>
<td>190</td>
<td>100</td>
<td>230</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>140</td>
<td>Up to 1600</td>
<td>50</td>
<td>47</td>
<td>157</td>
<td>160</td>
<td>128</td>
<td>32</td>
<td>71</td>
<td>43</td>
<td>19</td>
<td>20</td>
<td>212</td>
<td>112</td>
<td>255</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>160</td>
<td>Up to 1600</td>
<td>56</td>
<td>53</td>
<td>177</td>
<td>180</td>
<td>144</td>
<td>38</td>
<td>78.5</td>
<td>42</td>
<td>19</td>
<td>20</td>
<td>236</td>
<td>118</td>
<td>275</td>
<td>18</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>

* The minimum stroke with rod boot is 30 mm or more.
** For auto switch mounting position and its mounting height, refer to page 21.
*** Refer to "Minimum Stroke for Auto Switch Mounting" on page 22.

#### Head flange: CS2G

<table>
<thead>
<tr>
<th>Bore size (mm)</th>
<th>Stroke range (mm)</th>
<th>W</th>
<th>K</th>
<th>KA</th>
<th>M</th>
<th>MM</th>
<th>N</th>
<th>P</th>
<th>S</th>
<th>Without rod boot</th>
<th>With rod boot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>H</td>
<td>ZZ</td>
<td>e</td>
<td>f</td>
<td>h</td>
<td>ZZ1+ Stroke</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>125</td>
<td>Up to 1000</td>
<td>17</td>
<td>15</td>
<td>27</td>
<td>13</td>
<td>M30 x 1.5</td>
<td>30.5</td>
<td>1/2</td>
<td>98</td>
<td>110</td>
<td>221</td>
</tr>
<tr>
<td>140</td>
<td>Up to 1000</td>
<td>17</td>
<td>15</td>
<td>27</td>
<td>13</td>
<td>M30 x 1.5</td>
<td>30.5</td>
<td>1/2</td>
<td>98</td>
<td>110</td>
<td>221</td>
</tr>
<tr>
<td>160</td>
<td>Up to 1200</td>
<td>20</td>
<td>17</td>
<td>34</td>
<td>15</td>
<td>M36 x 1.5</td>
<td>34.5</td>
<td>3/4</td>
<td>106</td>
<td>120</td>
<td>241</td>
</tr>
</tbody>
</table>

* The minimum stroke with rod boot is 30 mm or more.
** For auto switch mounting position and its mounting height, refer to page 21.
*** Refer to "Minimum Stroke for Auto Switch Mounting" on page 22.
### Dimensions

#### Single clevis: CS2C

With rod boot

<table>
<thead>
<tr>
<th>Width across flats KA</th>
<th>Width across flats KA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z₁ + ℓ + Stroke</td>
<td>ZZ₁ + ℓ + Stroke</td>
</tr>
</tbody>
</table>

#### Double clevis: CS2D

With rod boot

<table>
<thead>
<tr>
<th>Width across flats KA</th>
<th>Width across flats KA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z₁ + ℓ + Stroke</td>
<td>ZZ₁ + ℓ + Stroke</td>
</tr>
</tbody>
</table>

#### Table of Dimensions

<table>
<thead>
<tr>
<th>Bore size (mm)</th>
<th>Stroke range (mm)</th>
<th>A</th>
<th>AL</th>
<th>＄B</th>
<th>＄C</th>
<th>＄CB</th>
<th>CDH₁₀</th>
<th>CT</th>
<th>Single clevis</th>
<th>Double clevis</th>
</tr>
</thead>
<tbody>
<tr>
<td>125</td>
<td>Up to 1000</td>
<td>50</td>
<td>47</td>
<td>143</td>
<td>115</td>
<td>145</td>
<td>25</td>
<td>17</td>
<td>32 ±0.084</td>
<td>64 ±0.084</td>
</tr>
<tr>
<td>140</td>
<td>Up to 1000</td>
<td>50</td>
<td>47</td>
<td>157</td>
<td>128</td>
<td>160</td>
<td>28</td>
<td>17</td>
<td>36 ±0.084</td>
<td>72 ±0.084</td>
</tr>
<tr>
<td>160</td>
<td>Up to 1200</td>
<td>56</td>
<td>53</td>
<td>177</td>
<td>144</td>
<td>180</td>
<td>32 ±0.084</td>
<td>20</td>
<td>40 ±0.100</td>
<td>80 ±0.100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bore size (mm)</th>
<th>Without rod boot</th>
<th>With rod boot</th>
</tr>
</thead>
<tbody>
<tr>
<td>125</td>
<td>98</td>
<td>110</td>
</tr>
<tr>
<td>140</td>
<td>98</td>
<td>110</td>
</tr>
<tr>
<td>160</td>
<td>106</td>
<td>120</td>
</tr>
</tbody>
</table>

#### Notes

- The minimum stroke with rod boot is 30 mm or more.
- For auto switch mounting position and its mounting height, refer to page 21.
- Refer to “Minimum Stroke for Auto Switch Mounting” on page 22.
### Dimensions

**Center trunnion: CS2T**

#### With rod boot

<table>
<thead>
<tr>
<th>Bore size (mm)</th>
<th>Stroke range (mm)</th>
<th>A</th>
<th>AL</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>J</th>
<th>V</th>
<th>W</th>
<th>K</th>
<th>KA</th>
<th>M</th>
<th>MM</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>125</td>
<td>25 to 1000</td>
<td>50</td>
<td>47</td>
<td>143</td>
<td>115</td>
<td>32</td>
<td>71</td>
<td>43</td>
<td>15</td>
<td>M14 x 1.5</td>
<td>15</td>
<td>17</td>
<td>15</td>
<td>27</td>
<td>13</td>
<td>M30 x 1.5</td>
<td>30.5</td>
</tr>
<tr>
<td>140</td>
<td>30 to 1000</td>
<td>50</td>
<td>47</td>
<td>157</td>
<td>128</td>
<td>32</td>
<td>71</td>
<td>43</td>
<td>15</td>
<td>M14 x 1.5</td>
<td>15</td>
<td>17</td>
<td>15</td>
<td>27</td>
<td>13</td>
<td>M30 x 1.5</td>
<td>30.5</td>
</tr>
<tr>
<td>160</td>
<td>35 to 1200</td>
<td>56</td>
<td>53</td>
<td>177</td>
<td>144</td>
<td>38</td>
<td>78.5</td>
<td>42</td>
<td>18</td>
<td>M16 x 1.5</td>
<td>15</td>
<td>20</td>
<td>17</td>
<td>34</td>
<td>15</td>
<td>M36 x 1.5</td>
<td>34.5</td>
</tr>
</tbody>
</table>

*The minimum stroke with rod boot is 30 mm or more for ø125, ø140 and 35 mm or more for ø160.*

*For auto switch mounting position and its mounting height, refer to page 21.

*Refer to "Minimum Stroke for Auto Switch Mounting" on page 22.*
APPENDIX F – SHOP DRAWINGS
NOTES:

1. 記号番号を完全に各製品にマーキング（印刷）すること
   (STAMP FULL DETAIL NUMBER ON EACH PART)

2. ブレーキや凸部を取りること
   (BREAK ALL SHARP EDGES / REMOVE ALL BURRS)

3. [JIS]、[BS]は、日本の国際標準に示されている。
   (JIS AND BS ARE MATERIAL NOTATION IN JAPAN
   AND THE UK)

4. エンド・化学製品管理標準に適合していること
   (THE PART SHALL COMPLY WITH THE CHEMICAL
   SUBSTANCE CONTROL STANDARD FOR EG PRODUCTS.)
NOTES:

1. 詳細番号を完全に各部品にマーキング（刻印）すること
   STAMP FULL DETAIL NUMBER ON EACH PART

2. 指示なく、部品パリ取りのこと。
   BREAK ALL SHARP EDGES / REMOVE ALL BURRS

3. [JIS] [BS] は、日本および英国の材料に対応している。
   (JIS) AND (BS) ARE MATERIAL NOTATION IN JAPAN
   AND THE U.K.

4. EG製品化学物質管理基準に適合していること。
   THE PART SHALL COMPLY WITH THE CHEMICAL SUBSTANCE
   CONTROL STANDARD FOR EG PRODUCTS.
6. **ECG製品化物質管理標準に適合していること。**
THE PART SHALL COMPLY WITH THE CHEMICAL SUBSTANCE...

5. **機械加工前におけるのしつけを行うこと。**
STRESS RELIEVE PRIOR TO FINISH MACHINING

4. **溶解部：指示部を含む全表面を溶解すること。**
AND WELD ALL JOINTS 100%

3. **JUT B 10：日本国内製品が含まれている。**
JUST B 10: MATERIAL NOTATION IN JAPAN AND THE U.K.

2. **磨きすぎない（錆）を考慮すること。**
SAND ALL SHARP EDGES / REMOVE ALL BURRS

1. **詳細番号を完全に各部分にマーキング（記入）すること。**
STAMP FULL DETAIL NUMBER ON EACH PART

NOTES:

| WEIGHT | 2.47 kg |
NOTES:

1. 詳細番号を完全に各部品にマーク（刻印）すること

   STAMP FULL DETAIL NUMBER ON EACH PART

2. 指示角部を（筒）部パリ取りのこと。

   BREAK ALL SHARP EDGES / REMOVE ALL BURRS

3. [JIS]（日語）は、日本と英国の材料に示されている。

   (JIS) AND (BS) ARE MATERIAL NOTATION IN JAPAN
   AND THE U.K.

4. EG製品化学物質管理基準に適合していること。

   THE PART SHALL COMPLY WITH THE CHEMICAL SUBSTANCE
   CONTROL STANDARD FOR EG PRODUCTS.