IMH Handbook of Hydraulics and Pneumatics

Innovation in Miniature

THE LEE COMPANY
Industrial Microhydraulics Group
THE LEE COMPANY

For over 68 years, The Lee Company has pioneered the design and manufacture of miniature precision fluid control components for a wide range of industries such as aerospace, oil production, Formula 1 car racing and medical/scientific instrumentation. To date, more than 100,000,000 Lee Plugs®, Restrictors, Valves and Safety Screens have been delivered to aerospace manufacturers alone, worldwide. A typical commercial jet employs an average of 4,000 such Lee Parts. Lee Products are specifically engineered to enable designers to reduce the size and weight of their designs, while improving quality and manufacturability.

The Lee Company employs over 1,000 people at its Technical Centers in Westbrook and Essex, Connecticut where all manufacturing is performed. Lee Company sales offices, staffed by degreed sales engineers, are located throughout the United States and Europe, and the company’s distribution network spans the entire globe. Lee's unique capabilities in miniaturization and engineering expertise (one of every eight employees is an engineer) keep the company at the forefront of fluid flow technology, and enable it to work effectively with customers to solve difficult fluid control problems.

IMH DIVISION

In 1991, The Lee Company founded the Industrial Microhydraulics (IMH) Division to adapt its proven design concepts to meet the higher volume production, performance and cost requirements of automotive, industrial hydraulic and medical applications. Using design techniques similar to those used for the Lee Plugs, valves, restrictors and safety screens that have logged millions of flight hours in aerospace applications, The IMH Division can now offer products of the same reliability and consistent performance, in very high quantities. These products are produced in an efficient, automated factory to the exacting standards of TS16949. The Lee Company continues to expand the product offerings in The IMH Division. Should you need a product not shown in this handbook, please contact a Lee Sales Engineer to discuss your specific requirements.

MISSION STATEMENT

The Mission of The Lee Company is to design and build state of the art products that exceed customers’ expectations for utility, performance and quality. The Lee Company constantly strives to improve the product designs, the manufacturing process and the quality system. The ultimate goal is zero defects and a satisfied customer.

SALES AND SERVICE

The Lee Company is committed to full professional service to our customers through a worldwide sales network of graduate engineers. Lee has sales offices in Huntington Beach and San Bruno, Chicago, Tampa, Dallas, Detroit, and at the Technical Center in Westbrook. Lee also has wholly owned sales and service subsidiaries in London (Gerrards Cross), Frankfurt, Paris (Voisins-Le-Bretonneux), Milan and Stockholm, and is represented in over forty countries.

If you have a fluid control problem and would like to talk to an engineer, or would like product information, please contact us here at the Technical Center, or contact the field sales office (see page C76) nearest you.

IMH HANDBOOK

This handbook is divided into 3 sections: Components intended to be installed into metal, components intended to be installed into plastic and a technical reference section.
### Section I - Products For Installation into Metal

- Insert Check Valves .......................................................... A3 – A18
- Insert Relief Valves .......................................................... A19 – A24
- Insert Orifices ................................................................. A25 – A50
- Insert Restrictor Check Valves .......................................... A51 – A56
- Insert Flow Controls ........................................................ A57 – A62
- Insert Shuttle Valves ....................................................... A63 – A66
- Insert Safety Screens ...................................................... A67 – A78
- Lee BetaPlugs ................................................................. A79 – A88

### Section II - Products For Installation into Plastic

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- Relief Valves ................................................................. B12 – B18
- Orifices ........................................................................ B19 – B26
- Flow Controls ................................................................ B27 – B30
- Restrictor Check Valves ................................................... B31 – B32
- Safety Screens ................................................................ B33 – B38
- Products in Plastic Fittings ............................................. B39 – B46

### Section III - Engineering Reference

- General Information ..................................................... C74 – C76
The first section of the Handbook contains products intended for installation into metals (Section Two products are to be installed into plastic). The inserts are designed using the insert principle, which uses a pin to expand a grooved section of the insert’s body into the housing wall to effect a seal and retain the component. The pin, which has been pre-installed, is driven into the body. Using friction and penetration, the lands bite into the housing material. The Lee Company does not recommend the use of coatings or surface treatments in the area of the installation hole where the Lee component is to be installed. Do not clean the insert prior to installation. The assembly is prelubricated for proper installation.

The insert principle eliminates the need for threads and o-rings. Simply insert the component into a drilled hole and drive the expander pin flush to within 0.25mm (0.010”) above flush of the insert. The installation tool can bottom on the insert body. Lee Installation Tools are available for each product and part numbers are listed on each page.

Since inserts can only be installed in one direction, most come in forward and reverse flow versions to provide design flexibility.

**REVERSE FLOW VALVE**

**FORWARD FLOW VALVE**

Installation forces required to install inserts vary for different model parts and are listed on each page. The force specification may be a maximum or a range.
Features and Benefits

- Compact Designs
  - Minimize housing size.

- Integral locking end
  - Long life.
  - No o-rings to fail.

- Pre-assembled
  - Easy to integrate into automated assembly lines.

- 100% tested
  - Eliminates rework.

- All metal design
  - Wide operating temperature range.
  - Compatible with most fluids.

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Lee Betaplugs®......... A79 – A88
The IMH Chek™ is a threadless, cartridge-style insert designed for simple, low cost installation into manifolds, and is based on the same hard seat Lee Chek® designs used in flight control systems of almost every aircraft flying today.

A robust design and 100% testing ensures consistent, long-term performance up to 28 MPa (4060 psid) and 149°C (300°F) or higher depending on specific application requirements.

A high quality metal to metal seat limits leakage in the checked direction to no more than 20 sccm of air at 172 kPa (25 psi) differential. The valves are compatible with hydraulic fluids, brake fluids, fuels and oils. Integral safety screen protection is available, (see drawings below).

IMH Cheks come in two styles, “axial” and “side exit”, (see drawings below). 558, 855 and 400 Bar models are axial flowing and the 832 models are side exit flowing. Some models are available with a ceramic ball as standard.
Features and Benefits

- Metal to metal seating
  - Provides high reliability.
  - Long life.
- Leak tight
  - Efficient system performance.
- Guided ball design
  - Fast response.
  - Low hysteresis.
- Positive ball stop
  - Infinite spring life.
  - Stable performance.
- Screened versions
  - Blocks rogue contamination.
- Ceramic ball versions
  - Compatible with aggressive fluids.
- Axial and side exit versions
  - Design flexibility.

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400 BAR CHECK VALVES
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**558 SERIES CHEK VALVE - REVERSE FLOW**

**REVERSE CHEK VALVE**

ΔP vs. Flow on Water @80°F (27°C)

**INSTALLATION HOLE**

ACTUAL SIZE

(As Installed)

* LOA before installation.
* All dimensions in millimeters.

**PERFORMANCE**

- Lohm Rate: 250 Lohms
- Leakage: 20 sccm/min. (max.) @ 172 kPa (25 psid) on air
  - 1 Drop/min. (max.) on hydraulic fluid
- Maximum Working Pressure:
  - 28 MPa (4,060 psid) (Checked Direction)
  - 4 MPa (580 psid) (Flow Direction)

**MATERIALS**

- Body ........ 303 Stainless Steel
- Cage ........ 305 Stainless Steel
- Pin .......... 416 Stainless Steel
- Spring ...... 302 Stainless Steel
- Ball.......... 440C Stainless Steel

**INSTALLATION**

- Tool Part Number ..... CCRT0900120S
- Force ..................... 625 Kg F (max.)
- For installation procedure see page A1.
558 SERIES CHEK VALVE - FORWARD FLOW

FORWARD CHEK VALVE

INSTALLATION HOLE

ACTUAL SIZE

* LOA before installation.
All dimensions in millimeters.

ΔP vs. Flow on Water @80°F (27°C)

Pressure (kPa)

Flow (GPM)

Flow Curve for 40 kPa Valve

PERFORMANCE

Lohm Rate: 250 Lohms
Leakage: 20 sccm/min. (max.) @ 172 kPa (25 psid) on air
1 Drop/min. (max.) on hydraulic fluid
Maximum Working Pressure:
28 MPa (4,060 psid)
(Checked Direction)
4 MPa (580 psid)
(Flow Direction)

MATERIALS

Body ........... 303 Stainless Steel
Cage .......... 305 Stainless Steel
Pin ............. 416 Stainless Steel
Spring ........... 302 Stainless Steel
Ball.............. 440C Stainless Steel

INSTALLATION

Tool Part Number ..... CCRT0900120S
Force ....................... 625 Kg F (max.)
For installation procedure see page A1.
**PERFORMANCE**

- **Lohm Rate:** 400 Lohms
- **Leakage:** 20 sccm/min. (max.) @ 172 kPa (25 psid) on air
  - 1 Drop/min. (max.) on hydraulic fluid
- **Screen Size:** 125 Micron Absolute
- **Maximum Working Pressure:**
  - 28 MPa (4,060 psid) (Checked Direction)
  - 4 MPa (580 psid) (Flow Direction)

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**MATERIALS**

- **Body:** 303 Stainless Steel
- **Cage:** 305 Stainless Steel
- **Pin:** 416 Stainless Steel
- **Spring:** 302 Stainless Steel
- **Ball:** 440C Stainless Steel
- **Screen:** 316 Stainless Steel

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**INSTALLATION**

- **Tool Part Number:** CCRT0900120S
- **Force:** 625 Kg F (max.)
- For installation procedure see page A1.
**558 SERIES CHEK VALVE - SCREENED**

**FORWARD CHECK VALVE**

- Lohm Rate: 400 Lohms
- Leakage: 20 sccm/min. (max.) @ 72 kPa (25 psid) on air
- 1 Drop/min. (max.) on hydraulic fluid

**Screen Size:** 125 Micron Absolute

**Maximum Working Pressure:**
- 28 MPa (4,060 psid) (Checked Direction)
- 4 MPa (580 psid) (Flow Direction)

**INSTALLATION HOLE**

**MATERIALS**

- **Body:** 303 Stainless Steel
- **Cage:** 305 Stainless Steel
- **Pin:** 303 Stainless Steel
- **Spring:** 302 Stainless Steel
- **Ball:** 440C Stainless Steel
- **Screen:** 316 Stainless Steel

**INSTALLATION**

- Tool Part Number: CCRT0900120S
- Force: 625 Kg F (max.)

For installation procedure see page A1.

---

* LOA before installation.  
All dimensions in millimeters.

---

**PERFORMANCE**

- Lohm Rate: 400 Lohms
- Leakage: 20 sccm/min. (max.) @ 172 kPa (25 psid) on air
- 1 Drop/min. (max.) on hydraulic fluid
- Screen Size: 125 Micron Absolute
- Maximum Working Pressure: 28 MPa (4,060 psid) (Checked Direction)
- 4 MPa (580 psid) (Flow Direction)

---

**Actual Size**

(As Installed)
558 SERIES CHEK VALVE - CERAMIC BALL
REVERSE FLOW

PERFORMANCE

Lohm Rate: 250 Kohms
Leakage: 20 sccm/min. (max.) @ 172 kPa (25 psid) on air
1 Drop/min. (max.) on hydraulic fluid
Maximum Working Pressure:
28 MPa (4,060 psid) (Checked Direction)
4 MPa (580 psid) (Flow Direction)

MATERIALS

Body ........... 303 Stainless Steel
Cage ........... 305 Stainless Steel
Pin .............. 416 Stainless Steel
Spring ........... 302 Stainless Steel
Ball............... Ceramic

INSTALLATION

Tool Part Number ..... CCRT0900120S
Force ...................... 625 Kg F (max.)
For installation procedure see page A1.
**558 SERIES CHEK VALVE - CERAMIC BALL FORWARD FLOW**

**FORWARD CHEK VALVE**

- Pressure: 28 MPa (4,060 psid) (Checked Direction)
- Pressure: 4 MPa (580 psid) (Flow Direction)

**INSTALLATION HOLE**

- 5.1 MIN. x 5.4 MIN.
- 5.50 x 5.43 mm
- 5.65 x 5.55 mm
- ø 0.05 ± 0.10
- ø 4.45 ± 0.10
- ø 0.05 ± 0.10

**ACTUAL SIZE**

* LOA before installation.
All dimensions in millimeters.

**PERFORMANCE**

Lohm Rate: 250 Ohms
Leakage: 20 sccm/min. (max.) @ 172 kPa (25 psid) on air
1 Drop/min. (max.) on hydraulic fluid
Maximum Working Pressure:
- 28 MPa (4,060 psid) (Checked Direction)
- 4 MPa (580 psid) (Flow Direction)

**MATERIALS**

- Body: 303 Stainless Steel
- Cage: 305 Stainless Steel
- Pin: 416 Stainless Steel
- Spring: 302 Stainless Steel
- Ball: Ceramic

**LEE PART NO.**

<table>
<thead>
<tr>
<th>CRACKING PRESSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CCFM2550800S</strong> 0 kPa (No Spring)</td>
</tr>
<tr>
<td><strong>CCFM2550814S</strong> 14 ± 5 kPa (2 ± 0.7 psid)</td>
</tr>
<tr>
<td><strong>CCFM2550840S</strong> 40 ± 30 kPa (6 ± 4.4 psid)</td>
</tr>
</tbody>
</table>

**INSTALLATION**

Tool Part Number: CCRT0900120S
Force: 625 Kg F (max.)
For installation procedure see page A1.
855 SERIES CHEK VALVE - REVERSE FLOW

**PERFORMANCE**

Lohm Rate: 75 Lohms
Leakage: 20 sccm/min. (max.) @ 72 kPa (25 psid) on air
1 Drop/min. (max.) on hydraulic fluid
Maximum Working Pressure:
- 28 MPa (4,060 psid) (Checked Direction)
- 4 MPa (580 psid) (Flow Direction)

**MATERIALS**

Body .......... 303 Stainless Steel
Cage .......... 305 Stainless Steel
Pin .......... 416 Stainless Steel
Spring .......... 302 Stainless Steel
Ball .......... 440C Stainless Steel

**INSTALLATION**

Tool Part Number ..... CCRT0900150S
Force ....................... 680 Kg F (max.)
For installation procedure see page A1.

* LOA before installation.
All dimensions in millimeters.

** ΔP vs. Flow on Water @80°F (27°C) **

Flow Curve for 40 kPa Valve

** INSTALLATION HOLE **

** ACTUAL SIZE **

(As Installed)
855 SERIES CHEK VALVE - FORWARD FLOW

FORWARD CHEK VALVE

INSTALLATION HOLE

ACTUAL SIZE

* LOA before installation.
All dimensions in millimeters.

∆P vs. Flow on Water @80°F (27°C)

Flow Curve for 40 kPa Valve

PERFORMANCE

Lohm Rate: 75 Lohms
Leakage: 20 sccm/min. (max.) @ 172 kPa (25 psid) on air
1 Drop/min. (max.) on hydraulic fluid
Maximum Working Pressure:
28 MPa (4,060 psid) (Checked Direction)
4 MPa (580 psid) (Flow Direction)

MATERIALS

Body .......... 303 Stainless Steel
Cage .......... 305 Stainless Steel
Pin ............. 416 Stainless Steel
Spring .......... 302 Stainless Steel
Ball............. 440C Stainless Steel

INSTALLATION

Tool Part Number ..... CCRT0900150S
Force ....................... 680 Kg F (max.)
For installation procedure see page A1.
**PERFORMANCE**

Lohm Rate: 130 Lohms
Leakage: 20 sccm/min. (max.)@72 kPa (25 psid) on air
1 Drop/min. (max.) on hydraulic fluid
Screen Size: 125 Micron Absolute

Maximum Working Pressure:
- 28 MPa (4,060 psid) (Checked Direction)
- 4 MPa (580 psid) (Flow Direction)

**MATERIALS**

- Body .......... 303 Stainless Steel
- Cage .......... 305 Stainless Steel
- Pin ............ 416 Stainless Steel
- Spring ........ 302 Stainless Steel
- Ball............ 440C Stainless Steel
- Screen ......... 316 Stainless Steel

**INSTALLATION**

Tool Part Number ..... CCRT0900150S
Force ..................... 680 Kg F (max.)
For installation procedure see page A1.
855 SERIES CHEK VALVE - SCREENED
FORWARD FLOW

**PERFORMANCE**

- **Lohm Rate:** 170 Lohms
- **Leakage:** 20 sccm/min. (max.) @ 72 kPa (25 psid) on air
- **1 Drop/min. (max.)** on hydraulic fluid

**Screen Size:** 125 Micron Absolute

**Maximum Working Pressure:**
- 28 MPa (4,060 psid) (Checked Direction)
- 4 MPa (580 psid) (Flow Direction)

**MATERIALS**

- **Body:** 303 Stainless Steel
- **Cage:** 305 Stainless Steel
- **Pin:** 303 Stainless Steel
- **Spring:** 302 Stainless Steel
- **Ball:** 440C Stainless Steel
- **Screen:** 316 Stainless Steel

**INSTALLATION**

- **Tool Part Number:** CCRT0900150S
- **Force:** 680 Kg F (max.)

For installation procedure see page A1.

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* LOA before installation.
All dimensions in millimeters.
832 SERIES SIDE EXIT CHEK VALVE

**REVERSE CHEK VALVE**

Flow Rate: 55 Lohms max. (3.6 GPM @ 100 psid)
Leakage: 1 Drop/min. (max.) after 2 minute wait on hydraulic fluid in checked direction at 6.9-27.6 MPa (1,000 - 4,000 psid)

Maximum Working Pressure: 28 MPa (4,060 psid)

**Tool Part Number**

CCRM8321000S 0 kPa (No Spring)
CCRM8321014S 14 ± 5 kPa (2 ± 0.7 psid)
CCRM8321040S 40 ± 30 kPa (6 ± 4.4 psid)

**PERFORMANCE**

Flow Rate: 55 Lohms max. (3.6 GPM @ 100 psid)
Leakage: 1 Drop/min. (max.) after 2 minute wait on hydraulic fluid in checked direction at 6.9-27.6 MPa (1,000 - 4,000 psid)
Maximum Working Pressure: 28 MPa (4,060 psid)

**MATERIALS**

Upper Body........303 Stainless Steel
Lower Body........303 Stainless Steel
Pin ..................416 Stainless Steel
Spring...............302 Stainless Steel
Ball..................440C Stainless Steel

**INSTALLATION**

Tool Part Number ..... CCRT0900150S
Force .................. 545 Kg F (min.)
635 Kg F (max.)
For installation procedure see page A1.
### INSTALLATION

**FORWARD FLOW**

**FORWARD CHECK VALVE**

- Flow Rate: 65 Lohms max. (3.1 GPM @ 100 psid)
- Leakage: 1 Drop/min. (max.) after 2 minute wait on hydraulic fluid in checked direction at 6.9-27.6 MPa (1,000 - 4,000 psid)
- Maximum Working Pressure: 28 MPa (4,060 psid)

**ACTUAL SIZE**

(As Installed)

**PERFORMANCE**

- Flow Rate: 65 Lohms max. (3.1 GPM @ 100 psid)
- Leakage: 1 Drop/min. (max.) after 2 minute wait on hydraulic fluid in checked direction at 6.9-27.6 MPa (1,000 - 4,000 psid)
- Maximum Working Pressure: 28 MPa (4,060 psid)

**MATERIALS**

- Upper Body: 303 Stainless Steel
- Lower Body: 303 Stainless Steel
- Pin: 416 Stainless Steel
- Spring: 302 Stainless Steel
- Ball: 440C Stainless Steel

**INSTALLATION**

- Tool Part Number: CCRT0900150S
- Force: 545 Kg F (min.)
- 635 Kg F (max.)

For installation procedure see page A1.
**PERFORMANCE**

Lohm Rate: 250 Lohms
Leakage: 20 sccm/min. (max.) @ 172 kPa (25 psid) on air
1 Drop/min. (max.) on hydraulic fluid
Maximum Working Pressure:
- 400 Bar (5,800 psid) (Checked Direction)
- 40 Bar (580 psid) (Flow Direction)

**MATERIALS**

- Body ........ 303 Stainless Steel
- Cage ........ 416 Stainless Steel
- Pin .......... 416 Stainless Steel
- Spring ...... 302 Stainless Steel
- Ball .......... 440C Stainless Steel

**INSTALLATION**

Tool Part Number ..... CCRT0900120S
Force ......................... 625 Kg F (max.)
For installation procedure see page A1.

* LOA before installation.
All dimensions in millimeters.
**PERFORMANCE**

Lohm Rate: 320 Lohms  
Leakage: 20 sccm/min. (max.) @ 172 kPa (25 psid) on air  
1 Drop/min. (max.) on hydraulic fluid  
Maximum Working Pressure:  
- 400 Bar (5,800 psid) (Checked Direction)  
- 40 Bar (580 psid) (Flow Direction)

**MATERIALS**

Body .......... 303 Stainless Steel  
Cage .......... 416 Stainless Steel  
Pin .......... 416 Stainless Steel  
Spring ......... 302 Stainless Steel  
Ball............. 440C Stainless Steel

**INSTALLATION**

Tool Part Number ..... CCRT0051078S  
Force ..................... 910 Kg F (max.)  
For installation procedure see page A1.
IMH Relief Valves are designed to protect systems from over pressurization or to attenuate pressure spikes. These valves are not suited for upstream pressure regulation.

As with the IMH Chek, the relief valve is a threadless, cartridge style insert designed for simple, low cost installation into manifolds, in the most compact package available anywhere.

A high quality, metal-to-metal seat provides long life and extremely low leakage, as well as compatibility with a wide range of fluids.

The Relief Valve is available in a 5.5mm size and an 8.0mm for more flow.
Features and Benefits

• Metal to metal seat
  – Provides high reliability.
  – Long life.
  – Repeatable crack.

• Leak tight
  – Efficient system performance.

• Guided ball design
  – Fast response.
  – Low hysteresis.

• 100% tested
  – Eliminates rework.

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8.0mm RELIEF VALVES
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855 Forward....................... A24
558 SERIES RELIEF VALVE - REVERSE FLOW

**PERFORMANCE**

- **Lohm Rate:** 250 Lohms
- **Leakage:** 20 sccm/min. (max.)
  - @172 kPa (25 psid) on air
  - 1 Drop/min. (max.) on hydraulic fluid
- **Maximum Working Pressure:** 28 MPa (4,060 psid)
  - Checked Direction
  - Flow Direction
- **Cracking Pressure Tolerance:** ±15%

**MATERIALS**

- **Body:** 303 Stainless Steel
- **Cage:** 305 Stainless Steel
- **Pin:** 416 Stainless Steel
- **Spring:** 302 Stainless Steel
- **Ball:** 440C Stainless Steel

**INSTALLATION**

- Tool Part Number: CCRT0900120S
- Force: 625 Kg F (max.)
- For installation procedure see page A1.
558 SERIES RELIEF VALVE - FORWARD FLOW

FORWARD RELIEF VALVE

INSTALLATION HOLE

ACTUAL SIZE

All dimensions are in millimeters.
* LOA before installation

∆P vs. Flow on Water @80°F (27°C)

PERFORMANCE

Lohm Rate: 250 Lohms
Leakage: 20sccm/min. (max.)
@172 kPa (25 psid) on air
1 Drop/min. (max.) on hydraulic fluid
Maximum Working Pressure:
28 MPa (4,060 psid)
Checked Direction
4 MPa (580 psid)
Flow Direction
Cracking Pressure Tolerance: ±15%

MATERIALS

Body .......... 303 Stainless Steel
Cage .......... 305 Stainless Steel
Pin .......... 416 Stainless Steel
Spring ......... 302 Stainless Steel
Ball.......... 440C Stainless Steel

INSTALLATION

Tool Part Number ..... CCRT0900120S
Force .................... 625 Kg F (max.)
For installation procedure see page A1.
**855 SERIES RELIEF VALVE - REVERSE FLOW**

**MATERIALS**

<table>
<thead>
<tr>
<th>LEE PART NO.</th>
<th>CRACKING PRESSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCRM3800210S</td>
<td>100 kPa (14.5 psid)</td>
</tr>
<tr>
<td>PCRM3800215S</td>
<td>150 kPa (21.8 psid)</td>
</tr>
<tr>
<td>PCRM3800220S</td>
<td>200 kPa (29 psid)</td>
</tr>
<tr>
<td>PCRM3800225S</td>
<td>250 kPa (36.6 psid)</td>
</tr>
<tr>
<td>PCRM3800230S</td>
<td>300 kPa (43.5 psid)</td>
</tr>
<tr>
<td>PCRM3800235S</td>
<td>350 kPa (50.8 psid)</td>
</tr>
<tr>
<td>PCRM3800240S</td>
<td>400 kPa (58 psid)</td>
</tr>
<tr>
<td>PCRM3800250S</td>
<td>500 kPa (72.5 psid)</td>
</tr>
<tr>
<td>PCRM3800255S*</td>
<td>550 kPa (79.8 psid)</td>
</tr>
</tbody>
</table>

**INSTALLATION**

Tool Part Number ..... CCRT0900150S
Force ....................... 680 Kg F (max.)
For installation procedure see page A1.

**PERFORMANCE**

Lohm Rate: 120 Lohms
Leakage: 20sccm/min. (max.)
@ 172 kPa (25 psid) on air
1 Drop/min. (max.) on hydraulic fluid
Maximum Working Pressure:
28 MPa (4,060 psid)
4 MPa (580 psid)
Flow Direction
Cracking Pressure Tolerance: ±15%

**ACTUAL SIZE**

All dimensions are in millimeters.
* LOA before installation
**855 SERIES RELIEF VALVE - FORWARD FLOW**

### MATERIALS

- **Body**: 303 Stainless Steel
- **Cage**: 416 Stainless Steel
- **Pin**: 416 Stainless Steel
- **Spring**: 302/17-7* Stainless Steel
- **Ball**: 440C Stainless Steel

### INSTALLATION

- **Tool Part Number**: CCRT0900150S
- **Force**: 680 Kg F (max.)

For installation procedure see page A1.
IMH Orifices are economical, reliable, highly accurate miniature restrictors. These orifices are 100% flow tested to ensure that every part is within ±5% of its nominal flow rate. Tighter flow tolerances are available as specials. Tight flow tolerances are only possible if entrance and exit conditions are closely controlled. This provides far more accuracy than an orifice specified by hole tolerance. An ordinary hole held to a very tight hole tolerance will not result in a tight flow tolerance.

IMH orifices are so consistent because they are produced in high volume by automated processes. Installation is simple using the field proven controlled expansion principle which provides retention up to 21 mPa (3,045 psid) and creates a leak tight seal. Constructed entirely of stainless steel, these orifices will not change flow rate over time due either to corrosion or erosion. Integral safety screens are incorporated where the orifice diameter is 0.5mm (.020") or below.

Orifices come in three body diameters; 2.5mm, 5.5mm and 8.0mm to offer choices in size and screen capacity. The 2.5mm model is the smallest self retained, screened restrictor in the world, allowing designers to save space and weight, while reducing overall design and assembly time.

All three sizes are available in gas and liquid versions. Gas orifices are tested on clean dry nitrogen and liquid orifices on distilled water. Great care is taken to ensure the accuracy of the automated test systems. To further increase accuracy, orifices are tested in the direction of use. Simply refer to the diagram illustrating forward and reverse flow.
Features and Benefits

- **Accurate flow**
  - Eliminate expensive alternative components.
  - More consistent system performance.
- **Self retained**
  - Easy installation.
  - Maintains flow accuracy.
- **Integral safety screens**
  - Saves space and weight.
  - Simplifies assembly.
  - Ensures reliability.
- **100% flow tested**
  - All parts within flow tolerance.
  - Consistent batch to batch performance.

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### 2.5mm ORIFICES FOR LIQUIDS
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- Screened Reverse .......... A31
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- Unscreened Forward .......... A34

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- Unscreened Forward .......... A38

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- Screened Reverse .......... A39
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- Screened Reverse .......... A47
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- Unscreened Reverse .......... A49
- Unscreened Forward .......... A50
**2.5mm INSERT ORIFICE FOR LIQUIDS**

**SCREENED – REVERSE FLOW**

**IMH ORIFICE SCREENED**

**INSTALLATION HOLE SCREENED REVERSE**

* LOA before installation.

All dimensions in millimeters.

### ACTUAL SIZE

(As Installed)

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### PERFORMANCE

- Metered Flow
- Lohm Rate Tolerance: ± 5%
- Test Fluid: Distilled Water
- Maximum Working Pressure: 21 MPa (3,045 psid)  
  (In Aluminum)

### MATERIALS

- Body .................. 303 Stainless Steel
- Pin ................... 416 Stainless Steel
- Screen .............. 316 Stainless Steel

### INSTALLATION

- Tool Part Number..... CCRT0029354S
- Force.................. 178 Kg F (max.)
- For installation procedure see page A1.

---

**MATERIALS**
2.5mm INSERT ORIFICE FOR LIQUIDS
SCREENED - FORWARD FLOW

**PERFORMANCE**

- Metered Flow
- Lohm Rate Tolerance: ± 5%
- Test Fluid: Distilled Water
- Maximum Working Pressure: 21 MPa (3,045 psid) (In Aluminum)

**MATERIALS**

- Body ................. 303 Stainless Steel
- Pin ................. 303 Stainless Steel
- Screen ............... 316 Stainless Steel

**INSTALLATION PROCEDURE**

Insert the IMH orifice into a drilled installation hole. Seal and lock in place by driving in the screened expander pin. Surface A and B will be flush within +0.25mm (+0.010”) of each other.

**INSTALLATION**

- Tool Part Number..... CCRT0029354S
- Force.................... 178 Kg F (max.)
- For installation procedure see left.

**ACTUAL SIZE**

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**2.5mm INSERT ORIFICE FOR LIQUIDS UNSCREENED - REVERSE FLOW**

**IMH ORIFICE UNSCREENED**

**INSTALLATION HOLE UNSCREENED**

* LOA before installation.  
All dimensions in millimeters.

**ACTUAL SIZE**

(As Installed)

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**PERFORMANCE**

Metered Flow  
Lohm Rate Tolerance: ± 5%  
Test Fluid: Distilled Water  
Maximum Working Pressure:  
21 MPa (3,045 psid)  
(In Aluminum)

**MATERIALS**

Body .................. 303 Stainless Steel  
Pin ..................... 416 Stainless Steel

**INSTALLATION**

Tool Part Number..... CCRT0029354S  
Force.................... 178 Kg F (max.)  
For installation procedure see page A1.
**INSERT ORIFICES**

---

**2.5mm INSERT ORIFICE FOR LIQUIDS**

**UNSCREENED - FORWARD FLOW**

---

**IMH ORIFICE UNSCREENED**

**INSTALLATION HOLE UNSCREENED**

* LOA before installation.

All dimensions in millimeters.

---

**ACTUAL SIZE**

(As Installed)

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**PERFORMANCE**

- Metered Flow
- Lohm Rate Tolerance: ± 5%
- Test Fluid: Distilled Water
- Maximum Working Pressure: 21 MPa (3,045 psid) (In Aluminum)

---

**MATERIALS**

- Body .................. 303 Stainless Steel
- Pin ..................... 416 Stainless Steel

---

**INSTALLATION**

- Tool Part Number..... CCRT0029354S
- Force.................... 178 Kg F (max.)
- For installation procedure see page A1.
**2.5mm INSERT ORIFICE FOR GASES**

**SCREENED - REVERSE FLOW**

---

**ACTUAL SIZE**

* LOA before installation.
* All dimensions in millimeters.

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**PERFORMANCE**

- Metered Flow
- Lohm Rate Tolerance: ± 5%
- Test Fluid: Clean & Dry Nitrogen
- Maximum Working Pressure: 21 MPa (3,045 psid)
  
  *(In Aluminum)*

---

**MATERIALS**

- Body .................. 303 Stainless Steel
- Pin .................... 416 Stainless Steel
- Screen ................ 316 Stainless Steel

---

**INSTALLATION**

- Tool Part Number..... CCRT0029354S
- Force..................... 178 Kg F (max.)
- For installation procedure see page A1.
**INSERT ORIFICES**

### 2.5mm INSERT ORIFICE FOR GASES

**SCREENED - FORWARD FLOW**

---

**ACTUAL SIZE**

(As Installed)

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**PERFORMANCE**

- Metered Flow
- Lohm Rate Tolerance: ± 5%
- Test Fluid: Clean & Dry Nitrogen
- Maximum Working Pressure: 21 MPa (3,045 psid)
  (In Aluminum)

---

**MATERIALS**

- Body ................. 303 Stainless Steel
- Pin .................... 303 Stainless Steel
- Screen ............... 316 Stainless Steel

---

**INSTALLATION PROCEDURE**

Insert the IMH orifice into a drilled installation hole. Seal and lock in place by driving in the screened expander pin. Surface A and B will be flush within +0.25mm (+0.010”) of each other.

---

**INSTALLATION**

- Tool Part Number..... CCRT0029354S
- Force.................... 178 Kg F (max.)
- For installation procedure see left.

---

* LOA before installation.
All dimensions in millimeters.
**2.5mm INSERT ORIFICE FOR GASES UNSCREENED - REVERSE FLOW**

**IMH ORIFICE UNSCREENED**

**INSTALLATION HOLE UNSCREENED**

* LOA before installation.

* All dimensions in millimeters.

---

**ACTUAL SIZE**

(As Installed)

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**PERFORMANCE**

- Metered Flow
- Lohm Rate Tolerance: ± 5%
- Test Fluid: Clean & Dry Nitrogen
- Maximum Working Pressure: 21 MPa (3,045 psid) (In Aluminum)

---

**MATERIALS**

- Body ................. 303 Stainless Steel
- Pin ..................... 416 Stainless Steel

---

**INSTALLATION**

- Tool Part Number..... CCRT0029354S
- Force.................... 178 Kg F (max.)
- For installation procedure see page A1.
2.5mm INSERT ORIFICE FOR GASES
UNSCREENED - FORWARD FLOW

* LOA before installation. 
All dimensions in millimeters.

**ACTUAL SIZE**

(As Installed)

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**PERFORMANCE**

Metered Flow
Lohm Rate Tolerance: ± 5%
Test Fluid: Clean & Dry Nitrogen
Maximum Working Pressure:
21 MPa (3,045 psid) (In Aluminum)

**MATERIALS**

Body .................. 303 Stainless Steel
Pin .................... 416 Stainless Steel

**INSTALLATION**

Tool Part Number..... CCRT0029354S
Force................... 178 Kg F (max.)
For installation procedure see page A1.
**5.5mm INSERT ORIFICE FOR LIQUIDS**

**SCREENED - REVERSE FLOW**

---

**IMH ORIFICE SCREENED**

**INSTALLATION HOLE SCREENED REVERSE**

* LOA before installation.
All dimensions in millimeters.

---

**ACTUAL SIZE**

(As Installed)

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**PERFORMANCE**

- Metered Flow
- Lohm Rate Tolerance: ± 5%
- Test Fluid: Distilled Water
- Maximum Working Pressure: 21 MPa (3,045 psid)

---

**MATERIALS**

- Body .......................... 303 Stainless Steel
- Pin ............................. 416 Stainless Steel
- Screen ...................... 316 Stainless Steel

---

**INSTALLATION**

- Tool Part Number..... CCRT0900120S
- Force ...................... 625 Kg F (max.)
For installation procedure see page A1.
**5.5mm INSERT ORIFICE FOR LIQUIDS**

**SCREENED - FORWARD FLOW**

---

**IMH ORIFICE SCREENED**

---

**INSTALLATION HOLE SCREENED FORWARD**

---

* LOA before installation.  
All dimensions in millimeters.

**ACTUAL SIZE**

(As Installed)

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**PERFORMANCE**

Metered Flow  
Lohm Rate Tolerance: ± 5%  
Test Fluid: Distilled Water  
Maximum Working Pressure: 21 MPa (3,045 psid)

---

**MATERIALS**

Body ................. 303 Stainless Steel  
Pin .................... 303 Stainless Steel  
Screen ............... 316 Stainless Steel

---

**INSTALLATION**

Tool Part Number..... CCRT0900120S  
Force.................... 625 Kg F (max.)  
For installation procedure see page A1.
5.5mm INSERT ORIFICE FOR LIQUIDS
UNSCREENED - REVERSE FLOW

**IMH ORIFICE UNSCREENED**

**INSTALLATION HOLE UNSCREENED**

* LOA before installation.
All dimensions in millimeters.

**ACTUAL SIZE**

(As Installed)

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**PERFORMANCE**

Metered Flow
Lohm Rate Tolerance: ± 5%

Test Fluid: Distilled Water

Maximum Working Pressure:
21 MPa (3,045 psid)

**MATERIALS**

Body ................. 303 Stainless Steel
Pin ................. 416 Stainless Steel

**INSTALLATION**

Tool Part Number..... CCRT0900120S
Force.................. 625 Kg F (max.)
For installation procedure see page A1.
**5.5mm INSERT ORIFICE FOR LIQUIDS**
**UNSCREENED - FORWARD FLOW**

**IMH ORIFICE**
**UNSCREENED**

**INSTALLATION HOLE**
**UNSCREENED**

* LOA before installation.
All dimensions in millimeters.

**ACTUAL SIZE**
(As Installed)

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**PERFORMANCE**
Metered Flow
Lohm Rate Tolerance: ± 5%
Test Fluid: Distilled Water
Maximum Working Pressure:
21 MPa (3,045 psid)

**MATERIALS**
Body ................. 303 Stainless Steel
Pin .................... 416 Stainless Steel

**INSTALLATION**
Tool Part Number..... CCRT0900120S
Force.................. 625 Kg F (max.)
For installation procedure see page A1.
5.5mm INSERT ORIFICE FOR GASES
SCREENED - REVERSE FLOW

IMH ORIFICE SCREENED

INSTALLATION HOLE SCREENED REVERSE

* LOA before installation.
All dimensions in millimeters.

Actual Size

(As Installed)

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PERFORMANCE

Metered Flow
Lohm Rate Tolerance: ± 5%
Test Fluid: Clean & Dry Nitrogen
Maximum Working Pressure: 21 MPa (3,045 psid)

MATERIALS

Body ................. 303 Stainless Steel
Pin ................. 416 Stainless Steel
Screen .............. 316 Stainless Steel

INSTALLATION

Tool Part Number..... CCRT0900120S
 Force.................... 625 Kg F (max.)
For installation procedure see page A1.
**5.5mm INSERT ORIFICE FOR GASES**
**SCREENED - FORWARD FLOW**

---

**ACTUAL SIZE**

(As Installed)

---

**IMH ORIFICE SCREENED**

**INSTALLATION HOLE SCREENED**

* LOA before installation.  
All dimensions in millimeters.

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**PERFORMANCE**

Metered Flow  
Lohm Rate Tolerance: ± 5%  
Test Fluid: Clean & Dry Nitrogen  
Maximum Working Pressure: 21 MPa (3,045 psid)

---

**MATERIALS**

Body ............... 303 Stainless Steel  
Pin ................. 303 Stainless Steel  
Screen .............. 316 Stainless Steel

---

**INSTALLATION**

Tool Part Number..... CCRT0900120S  
Force.................... 625 Kg F (max.)  
For installation procedure see page A1.
## 5.5mm INSERT ORIFICE FOR GASES
UNSCREENED - REVERSE FLOW

### IMH ORIFICE UNSCREENED

![IMH Orifice Diagram]

* LOA before installation.
All dimensions in millimeters.

### INSTALLATION HOLE UNSCREENED

![Installation Hole Diagram]

### ACTUAL SIZE

(As Installed)

### LEE PART NUMBER

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### PERFORMANCE

Metered Flow
Lohm Rate Tolerance: ± 5%

Test Fluid: Clean & Dry Nitrogen

Maximum Working Pressure: 21 MPa (3,045 psid)

### MATERIALS

Body ............... 303 Stainless Steel
Pin ................. 416 Stainless Steel

### INSTALLATION

Tool Part Number..... CCRT0900120S
Force.................. 625 Kg F (max.)
For installation procedure see page A1.
**5.5mm INSERT ORIFICE FOR GASES**

**UNSCREENED - FORWARD FLOW**

* LOA before installation.
All dimensions in millimeters.

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**ACTUAL SIZE**

(As Installed)

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**PERFORMANCE**

Metered Flow
Lohm Rate Tolerance: ± 5%

Test Fluid: Clean & Dry Nitrogen

Maximum Working Pressure:
21 MPa (3,045 psid)

**MATERIALS**

Body .................. 303 Stainless Steel
Pin ..................... 416 Stainless Steel

**INSTALLATION**

Tool Part Number..... CCRT0900120S
Force..................... 625 Kg F (max.)
For installation procedure see page A1.
8.0mm INSERT ORIFICE FOR LIQUIDS
SCREENED - REVERSE FLOW

IMH ORIFICE SCREENED

INSTALLATION HOLE SCREENED REVERSE

* LOA before installation.
All dimensions in millimeters.

ACTUAL SIZE
(As Installed)

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PERFORMANCE
Metered Flow
Lohm Rate Tolerance: ± 5%
Test Fluid: Distilled Water
Maximum Working Pressure:
21 MPa (3,045 psid)

MATERIALS
Body ................. 303 Stainless Steel
Pin .................. 416 Stainless Steel
Screen ............... 316 Stainless Steel

INSTALLATION
Tool Part Number..... CCRT0900150S
Force.................. 680 Kg F (max.)
For installation procedure see page A1.
**INSERT ORIFICES**

**8.0mm INSERT ORIFICE FOR LIQUIDS**

**SCREENED - FORWARD FLOW**

---

**IMH ORIFICE SCREENED**

**INSTALLATION HOLE SCREENED FORWARD**

* LOA before installation.

All dimensions in millimeters.

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**ACTUAL SIZE**

(As Installed)

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**PERFORMANCE**

- Metered Flow
- Lohm Rate Tolerance: ± 5%
- Test Fluid: Distilled Water
- Maximum Working Pressure: 21 MPa (3,045 psid)

**MATERIALS**

- Body ............... 303 Stainless Steel
- Pin ................. 303 Stainless Steel
- Screen .............. 316 Stainless Steel

**INSTALLATION**

- Tool Part Number..... CCRT0900150S
- Force.................... 680 Kg F (max.)
- For installation procedure see page A1.
8.0mm INSERT ORIFICE FOR LIQUIDS
UNSCREENED - REVERSE FLOW

IMH ORIFICE
UNSCREENED

INSTALLATION HOLE
UNSCREENED

* LOA before installation.  
All dimensions in millimeters.

ACTUAL SIZE
(As Installed)

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PERFORMANCE
Metered Flow
Lohm Rate Tolerance: ± 5%
Test Fluid: Distilled Water
Maximum Working Pressure: 21 MPa (3,045 psid)

MATERIALS
Body .................. 303 Stainless Steel
Pin .................... 416 Stainless Steel

INSTALLATION
Tool Part Number..... CCRT0900150S
Force.................... 680 Kg F (max.)
For installation procedure see page A1.
**8.0mm INSERT ORIFICE FOR LIQUIDS**
**UNSCREENED – FORWARD FLOW**

* LOA before installation.
*All dimensions in millimeters.*

**ACTUAL SIZE**

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**PERFORMANCE**

- Metered Flow
- Lohm Rate Tolerance: ± 5%
- Test Fluid: Distilled Water
- Maximum Working Pressure: 21 MPa (3,045 psid)

**MATERIALS**

- Body ................. 303 Stainless Steel
- Pin ................. 416 Stainless Steel

**INSTALLATION**

- Tool Part Number..... CCRT0900150S
- Force.................... 680 Kg F (max.)
- For installation procedure see page A1.
**8.0mm INSERT ORIFICE FOR GASES**

**SCREENED - REVERSE FLOW**

**IMH ORIFICE SCREENED**

**INSTALLATION HOLE SCREENED REVERSE**

* LOA before installation.

All dimensions in millimeters.

**ACTUAL SIZE**

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**PERFORMANCE**

Metered Flow
Lohm Rate Tolerance: ± 5%
Test Fluid: Clean & Dry Nitrogen
Maximum Working Pressure: 21 MPa (3,045 psid)

**MATERIALS**

Body ................. 303 Stainless Steel
Pin .................. 416 Stainless Steel
Screen ............... 316 Stainless Steel

**INSTALLATION**

Tool Part Number..... CCRT0900150S
Force .................. 680 Kg F (max.)
For installation procedure see page A1.
8.0mm INSERT ORIFICE FOR GASES
SCREENED - FORWARD FLOW

IMH ORIFICE SCREENED

INSTALLATION HOLE SCREENED FORWARD

* LOA before installation.
All dimensions in millimeters.

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</tr>
</tbody>
</table>

PERFORMANCE

Metered Flow
Lohm Rate Tolerance: ± 5%
Test Fluid: Clean & Dry Nitrogen
Maximum Working Pressure: 21 MPa (3,045 psid)

MATERIALS

Body .................. 303 Stainless Steel
Pin .................... 303 Stainless Steel
Screen ............... 316 Stainless Steel

INSTALLATION

Tool Part Number..... CCRT0900150S
Force.................. 680 Kg F (max.)
For installation procedure see page A1.
8.0mm INSERT ORIFICE FOR GASES
UNSCREENED - REVERSE FLOW

* LOA before installation.
All dimensions in millimeters.

ACTUAL SIZE
(As Installed)

<table>
<thead>
<tr>
<th>LEE PART NUMBER</th>
<th>LOHM RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>RIGR8051005S</td>
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<tr>
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<td>RIGR8051008S</td>
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<tr>
<td>RIGR8051010S</td>
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<tr>
<td>RIGR8051012S</td>
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</tr>
<tr>
<td>RIGR8051015S</td>
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</tr>
</tbody>
</table>

PERFORMANCE
Metered Flow
Lohm Rate Tolerance: ± 5%

Test Fluid: Clean & Dry Nitrogen

Maximum Working Pressure:
21 MPa (3,045 psid)

MATERIALS
Body ................. 303 Stainless Steel
Pin ................ 416 Stainless Steel

INSTALLATION
Tool Part Number..... CCRT0900150S
Force.................... 680 Kg F (max.)
For installation procedure see page A1.
**8.0mm INSERT ORIFICE FOR GASES**

**UNSCREENED - FORWARD FLOW**

---

**IMH ORIFICE UNSCREENED**

---

**INSTALLATION HOLE UNSCREENED**

---

* LOA before installation.
All dimensions in millimeters.

---

**ACTUAL SIZE**

(As Installed)

---

**LEE PART NUMBER**

<table>
<thead>
<tr>
<th>LEE PART NUMBER</th>
<th>LOHM RATE</th>
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<tr>
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<tr>
<td>RIGF8051015S</td>
<td>1,500</td>
</tr>
</tbody>
</table>

---

**PERFORMANCE**

Metered Flow
Lohm Rate Tolerance: ± 5%

Test Fluid: Clean & Dry Nitrogen

Maximum Working Pressure:
21 MPa (3,045 psid)

---

**MATERIALS**

Body ................. 303 Stainless Steel
Pin ................. 416 Stainless Steel

---

**INSTALLATION**

Tool Part Number..... CCRT0900150S
Force.................... 680 Kg F (max.)
For installation procedure see page A1.
Restrictor checks are functionally an orifice in series with a check valve, all in one package. IMH Restrictor Checks are the same size as their equivalent check valves. These valves come in forward and reverse flow directions and incorporate a screen of an appropriate filtration size for orifice diameters below 0.5mm (0.020”).

Large orifice diameters do not come with screens as standards. IMH Restrictor Checks are available in a wide range of metered lohm rates; 40,000 lohms [0.1mm (0.004”)] to 400 lohms [1.1mm (0.044”)] equivalent orifice.
Features and Benefits

- Combines hydraulic functions
  - Simplifies manifold.

- Accurate flow
  - Eliminate expensive alternative components.
  - More consistent system performance.

- Integral screened versions
  - Protects the orifice.
  - Saves space and weight.
  - Simplifies assembly.
  - Ensures reliability.

- 100% flow tested
  - Eliminates rework.
  - All parts within flow tolerance.
  - Consistent batch to batch performance.

---

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5.5mm RESTRICTOR CHECKS

- Reverse Screened .......... A53
- Reverse Unscreened .......... A54
- Forward Screened .......... A55
- Forward Unscreened .......... A56
**RESTRICTOR CHEK - SCREENED REVERSE FLOW**

**MATERIALS**

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<thead>
<tr>
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<td>CORM5521040S</td>
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<td>125</td>
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<td>CORM5521050S</td>
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</table>

**INSTRUCTION**

* LOA before installation.
  All dimensions in millimeters.

**ACTUAL SIZE**

(As Installed)

**PERFORMANCE**

- Metered Flow Lohm Rate Tolerance: ± 5%
- Leakage: 20 sccm/min. (max.) @ 172 kPa (25 psid) on air
- 1 Drop/min. (max.) on hydraulic fluid
- Maximum Working Pressure: 28 MPa (4,060 psid)
- Checked Direction
- Metered Flow Direction
- Cracking Pressure: 40 ± 30 kPa (6 ± 4.4 psid)

**MATERIALS**

- Body ............ 303 Stainless Steel
- Pin ............ 416 Stainless Steel
- Cage ............ 305 Stainless Steel
- Spring ............ 302 Stainless Steel
- Ball ............. 440C Stainless Steel
- Screen ........... 316 Stainless Steel

**INSTALLATION**

- Tool Part Number ..... CCRT0900120S
- Force ................. 625 Kg F (max.)
  For installation procedure see page A1.
**MATERIALS**

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<thead>
<tr>
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<td>1,500</td>
</tr>
<tr>
<td>CORM5501020S</td>
<td>2,000</td>
</tr>
</tbody>
</table>

**PERFORMANCE**

- Metered Flow Lohm Rate Tolerance: ± 5%
- Leakage: 20 sccm/min. (max.) @ 172 kPa (25 psid) on air
- 1 Drop/min. (max.) on hydraulic fluid
- Maximum Working Pressure:
  - 28 MPa (4,060 psid)
  - 4 MPa (580 psid)
- Metered Flow Direction
- Cracking Pressure: 40 ± 30 kPa (6 ± 4.4 psid)

**INSTALLATION**

- Tool Part Number: CCRT0900120S
- Force: 625 Kg F (max.)
- For installation procedure see page A1.

* LOA before installation.
  All dimensions in millimeters.
**MATERIALS**

- **Body**: 303 Stainless Steel
- **Pin**: 303 Stainless Steel
- **Cage**: 305 Stainless Steel
- **Spring**: 302 Stainless Steel
- **Ball**: 440C Stainless Steel
- **Screen**: 316 Stainless Steel

---

**ACTUAL SIZE**

(As Installed)

---

**FORWARD RESTRICTOR CHEK**

---

**INSTALLATION HOLE**

---

**PERFORMANCE**

- Metered Flow Lohm Rate Tolerance: ± 5%
- Leakage: 20sccm/min. (max.) @ 172 kPa (25 psid) on air
  - 1 Drop/min. (max.) on hydraulic fluid
- Maximum Working Pressure:
  - 28 MPa (4,060 psid)
  - Checked Direction
  - 4 MPa (580 psid)
  - Metered Flow Direction
- Cracking Pressure: 40 ± 30 kPa (6 ± 4.4 psid)

---

**LEE PART NUMBER**

<table>
<thead>
<tr>
<th>LEE PART NUMBER</th>
<th>LOHM RATE</th>
<th>SCREEN MICRON RATING</th>
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</thead>
<tbody>
<tr>
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<tr>
<td>COFM5521030S</td>
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</tr>
<tr>
<td>COFM5571150S</td>
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<td>75</td>
</tr>
</tbody>
</table>

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**INSTALLATION**

- **Tool Part Number**: CCRT0900120S
- **Force**: 625 Kg F (max.)

For installation procedure see page A1.
RESTRICTOR CHEK - FORWARD FLOW

**MATERIALS**

<table>
<thead>
<tr>
<th>LEE PART NUMBER</th>
<th>LOHM RATE</th>
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<tbody>
<tr>
<td>COFM5501004S</td>
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<tr>
<td>COFM5501005S</td>
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</tr>
<tr>
<td>COFM5501006S</td>
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<tr>
<td>COFM5501008S</td>
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<tr>
<td>COFM5501010S</td>
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<tr>
<td>COFM5501012S</td>
<td>1,200</td>
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<tr>
<td>COFM5501015S</td>
<td>1,500</td>
</tr>
<tr>
<td>COFM5501020S</td>
<td>2,000</td>
</tr>
</tbody>
</table>

**PERFORMANCE**

- Metered Flow Lohm Rate Tolerance: ± 5%
- Leakage: 20sccm/min. (max.) @ 172 kPa (25 psid) on air
  - 1 Drop/min. (max.) on hydraulic fluid
- Maximum Working Pressure:
  - 28 MPa (4,060 psid) Checked Direction
  - 4 MPa (580 psid) Metered Flow Direction
- Cracking Pressure: 40 ± 30 kPa (6 ± 4.4 psid)

**INSTALLATION**

Tool Part Number: CCRT0900120S
Force: 625 Kg F (max.)
For installation procedure see page A1.
Flow Controls are functionally an orifice in parallel with a check valve — all in one package. IMH Flow Controls are the same size as the equivalent IMH check valve. Flow Controls are available in two diameters; 5.5mm and 8.0mm. The 5.5mm version covers lohm rates from 2,000 lohms [0.5mm (0.020")] to 10,000 lohms [0.22mm (0.009")] equivalent orifice diameters. The 8.0mm Flow Control covers 500 lohms [0.99mm (0.039"] to 2,000 lohms [0.5mm (0.020")] equivalent orifice diameters. Both sizes are available in forward and reverse configurations.

**Reverse Flow Valve**

**Forward Flow Valve**
### Features and Benefits

- Combines hydraulic functions
  - Simplifies manifold.
- Accurate flow
  - Eliminate expensive alternative components.
  - More consistent system performance.
- 100% flow tested
  - Eliminates rework.
  - All parts within flow tolerance.
  - Consistent batch to batch performance.

### TABLE OF CONTENTS

#### 5.5mm FLOW CONTROLS
- Reverse ...................... A59
- Forward ...................... A60

#### 8.0mm FLOW CONTROLS
- Reverse ...................... A61
- Forward ...................... A62
**5.5mm FLOW CONTROL - REVERSE FLOW**

### INSTALLATION HOLE

- **FREE FLOW**
- **METERED FLOW**

---

### PERFORMANCE

**Metered Flow**
- Lohm Rate Tolerance: ± 15%
- Free Flow Lohm Rate: 250 Lohms
- Cracking Pressure: 40 ± 30 kPa (6 ± 4.4 psid)
- Maximum Working Pressure: 28 MPa (4,060 psid)
- Metered Flow Direction
- 4 MPa (580 psid)
- Free Flow Direction

---

### MATERIALS

- **Body** .................303 Stainless Steel
- **Pin** .................416 Stainless Steel
- **Cage** .................305 Stainless Steel
- **Spring** .................302 Stainless Steel
- **Ball** .................440C Stainless Steel

---

### INSTALLATION

- **Tool Part Number** ..... CCRT0900120S
- **Force** ................. 625 Kg F (max.)
- For installation procedure see page A1.
5.5mm FLOW CONTROL - FORWARD FLOW

FORWARD FLOW CONTROL

INSTALLATION HOLE

ACTUAL SIZE

FREE FLOW

METERED FLOW

* LOA before installation.
All dimensions in millimeters.

PERFORMANCE

Metered Flow
Lohm Rate Tolerance: ± 15%
Free Flow Lohm Rate: 250 Lohms
Cracking Pressure: 40 ± 30 kPa
(6 ± 4.4 psid)
Maximum Working Pressure:
28 MPa (4,060 psid)
Metered Flow Direction
4 MPa (580 psid)
Free Flow Direction

MATERIALS

Body………………303 Stainless Steel
Pin…………………416 Stainless Steel
Cage………………305 Stainless Steel
Spring……………302 Stainless Steel
Ball………………..440C Stainless Steel

INSTALLATION

Tool Part Number ..... CCRT0900120S
Force .................. 625 Kg F (max.)
For installation procedure see page A1.
**INSERT FLOW CONTROLS**

### 8.0mm FLOW CONTROL - REVERSE

#### REVERSE FLOW CONTROL

- **FREE FLOW**
- **METERED FLOW**

#### INSTALLATION HOLE

- 10.0 MIN.
- 3.0 MIN.
- 118° ± 2°
- 1.6 Ra MAX.
- Ø 0.55 MAX.
- Ø 6.5 MAX.

#### ACTUAL SIZE

(As Installed)

* LOA before installation.

All dimensions in millimeters.

#### Free Flow Curve

**ΔP vs. Flow on Water @80°F (27°C)**

![Flow Curve for 40 kPa Valve](image)

#### PERFORMANCE

- **Metered Flow Lohm Rate Tolerance:** ± 15%
- **Free Flow Lohm Rate:** 75 Lohms
- **Cracking Pressure:** 40 ± 30 kPa (6 ± 4.4 psid)
- **Maximum Working Pressure:** 28 MPa (4,060 psid)
- **Metered Flow Direction:** 4 MPa (580 psid)
- **Free Flow Direction:**

#### MATERIALS

- Body ............ 303 Stainless Steel
- Pin .............. 416 Stainless Steel
- Cage .......... 305 Stainless Steel
- Spring .......... 302 Stainless Steel
- Ball............. 440C Stainless Steel

#### INSTALLATION

- **Tool Part Number:** CCRT0900150S
- **Force:** 680 Kg F (max.)

For installation procedure see page A1.
**MATERIALS**

<table>
<thead>
<tr>
<th>LEE PART NUMBER</th>
<th>LOHM RATE</th>
</tr>
</thead>
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<tr>
<td>CFFM8001020S</td>
<td>2,000</td>
</tr>
</tbody>
</table>

**PERFORMANCE**

- Metered Flow Lohm Rate Tolerance: ± 15%
- Free Flow Lohm Rate: 75 Lohms
- Cracking Pressure: 40 ± 30 kPa
  
  \( (6 ± 4.4 \text{ psid}) \)
- Maximum Working Pressure:
  
  
  \( 28 \text{ MPa (4,060 psid)} \)
  
  \( 4 \text{ MPa (580 psid)} \)
  
  
  Free Flow Direction

**INSTALLATION**

- Tool Part Number: CCRT0900150S
- Force: 680 Kg F (max.)
- For installation procedure see page A1.
The IMH Shuttle valve is a miniature, economical and reliable solution to the problem of hydraulic isolation in manifolds. This valve features a compact, non-detented, selective design that is ideal as a signal for auxiliary functions, such as hydraulically released, spring applied brakes as well as load sensing applications.

The IMH Shuttle valve is available in two sizes; a 5.5mm 2.5 GPM model and a 8.0mm 6 GPM version. These valves are the smallest in their class, often one third the size of existing shuttle valves with comparable flow rates.

The all metal construction provides high reliability, yet leakage is drip tight. Each valve is 100% factory tested for flow and leakage to ensure consistent, long term performance.

This cartridge-style valve installs easily into a drilled hole, eliminating the need for threads or o-rings. The Lee Company does not recommend the use of coatings or surface treatments in the area of the installation hole where the Lee component is to be installed. Do not clean the insert prior to installation. The assembly is prelubricated for proper installation. To install, simply insert the shuttle valve into a drilled hole and drive the expansion pin into the valve body with a minimum of 545 KgF (1,200 lbs. force) and a maximum of 635 KgF (1,400 lbs. force). The ends of the expansion pin and insert will be flush to within ±0.25mm (±0.010") above flush of each other. The installation tool can bottom on the insert body. Lee Installation Tools are available for each valve and part numbers are listed on each page. The locking end seals Port A from Port C and retains the valve. During installation, the edge seal at the opposite end is driven into the housing, sealing Port B from Port C.

This valve is constructed entirely of stainless steel for long term, trouble free life.
Features and Benefits

- Smallest in their class
  - Minimize housing size.

- Leak tight
  - No system drift.
  - No system losses.

- Low shuttling pressure
  - Fast system response.

- All metal retention and sealing
  - No threads necessary.
  - No o-rings to fail.
**5.5mm SHUTTLE VALVE**

**SHUTTLE VALVE**

Flow Direction:
PORT A to PORT C
or PORT B to PORT C

**INSTALLATION HOLE**

ΔP vs. Flow on Water @80°F (27°C)

PERFORMANCE

Flow Rate: (A to C or B to C) 75 Lohms max. (2 GPM @50 psid)

Shuttling Pressure: 7 kPa (1 psi) maximum

Leakage: A to B or B to A, 1 Drop/min. (max.) after 2 minute wait on hydraulic fluid at 6.9-27.6 MPa (1,000 - 4,000 psid)

Maximum Working Pressure: 28 MPa (4,060 psid)

MATERIALS

Upper Body........303 Stainless Steel
Lower Body........303 Stainless Steel
Pin ..................416 Stainless Steel
Ball..................440C Stainless Steel

INSTALLATION

Tool Part Number..... CCRT0900120S
Force .................. 545 Kg F (min.)
635 Kg F (max.
For installation procedure see page A63.
**8.0mm SHUTTLE VALVE**

**SHUTTLE VALVE**

- Flow Direction: PORT A to PORT C or PORT B to PORT C
- Initial Air before installation.
- All dimensions are in millimeters.

**ACTUAL SIZE**

(As Installed)

**INSTALLATION HOLE**

- \( \phi 11.00 \) to \( 10.80 \)
- \( 6.27 \pm 0.20 \)
- \( 7.00 \) to \( 6.00 \)
- \( 118^\circ \pm 2^\circ \)
- 4.50 MIN.
- 18.0 MIN.
- 3.0 MIN.

**ΔP vs. Flow on Water @80°F (27°C)**

- Graph showing ΔP vs. Flow
- ΔP (PSI) vs. Flow (LPM)

**PERFORMANCE**

- Flow Rate: (A to C or B to C) 32 Lohms max. (6.2 GPM @ 100 psid)
- Shutting Pressure: 7 kPa (1 psi) maximum
- Leakage: A to B or B to A, 1 Drop/min. (max.) after 2 minute wait on hydraulic fluid at 6.9-27.6 MPa (1,000 - 4,000 psid)
- Maximum Working Pressure: 28 MPa (4,060 psid)

**MATERIALS**

- Upper Body: 303 Stainless Steel
- Lower Body: 303 Stainless Steel
- Pin: 416 Stainless Steel
- Ball: 440C Stainless Steel

**INSTALLATION**

- Tool Part Number: CCRT0900150S
- Force: 545 Kg F (min.)
- 635 Kg F (max.)
- For installation procedure see page A63.
IMH Screens are “last chance” safety screens designed to protect critical fluid control components against rogue contamination. They are not intended to serve as system filters. The screens are constructed of stainless steel woven wire mesh, bonded together using a proprietary process that offers superior integrity and life.

IMH Screens are available in Insert or Cartridge styles. Insert Screens feature an integral locking end, while Cartridge Screens are designed to be retained by the customer, or for 5.5 and 8mm sizes, retained by a separate locking end.

IMH Insert Style Screens use the proven Lee Insert Principle of controlled expansion during installation to lock the screen in place.

A preinstalled expander pin is simply pressed flush with the screen body, expanding the locking grooves into the wall of the installation hole to effect a seal and retain the part. The Lee Company does not recommend the use of coatings or surface treatments in the area of the installation hole where the Lee component is to be installed. Do not clean the insert prior to installation. The assembly is prelubricated for proper installation.

IMH Cartridge Screens use proprietary high strength bonded mesh to provide additional strength and integrity for applications where higher pressures could cause rupture due to the effects of clogging, possibly with catastrophic consequences. The unique design of the Lee Cartridge Screen is engineered to prevent a rupture and instead allow a gradual reduction in flow performance.
Features and Benefits

• Self retained
  – Retracts into drilled hole.
  – Easy to install.
  – No threads necessary.

• Proprietary bonded mesh
  – Superior integrity and life.

• High pressure capability
  – Won’t fail when clogged.
  – No catastrophic failure.
  – Ensures reliability.

TABLE OF CONTENTS

5.5mm
Insert Screen......................... A69

8.0mm
Insert Screen......................... A70

10.0mm
Insert Screen......................... A71

12.0mm
Insert Screen......................... A72

5.5mm
Cartridge Screen....................... A73

5.5mm
Insert Retainer......................... A74

8.0mm
Cartridge Screen....................... A75

8.0mm
Insert Retainer......................... A76

10.0mm
Cartridge Screen...................... A77-A78

12.0mm
Cartridge Screen...................... A77-A78

16.0mm
Cartridge Screen...................... A77-A78
5.5mm INSERT SAFETY SCREEN

INSERT SCREEN

INSTALLATION HOLE

ACTUAL SIZE

(As Installed)

<table>
<thead>
<tr>
<th>LEE PART NUMBER</th>
<th>MICRON RATING</th>
<th>LOHM RATE</th>
<th>MAXIMUM FLOW RATE (LPM)</th>
<th>OPEN AREA (mm²)</th>
<th>Rob NUMBER</th>
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<td>SCRM2551170S</td>
<td>170</td>
<td>180</td>
<td>21.7 (5.7 GPM)</td>
<td>2.4</td>
<td>0.43</td>
</tr>
</tbody>
</table>

MATERIALS

Body .......... 303 Stainless Steel
Pin .......... 416 Stainless Steel
Screen .......... 316 Stainless Steel

INSTALLATION

Tool Part Number ..... CCRT0901034S
Force ..................... 510 Kg F (max.)
For installation procedure see page A67.
**INSERT SAFETY SCREENS**

**8.0mm INSERT SAFETY SCREEN**

---

**INSERT SCREEN**

<table>
<thead>
<tr>
<th>Flow Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ø 7.98 ± 0.04</td>
</tr>
<tr>
<td>4.3*</td>
</tr>
<tr>
<td>3.46</td>
</tr>
</tbody>
</table>

* LOA before installation. All dimensions in millimeters.

---

**INSTALLATION HOLE**

| Ø 8.05 ± 0.10 |
| 118° ± 2°     |

---

**ACTUAL SIZE**

(As Installed)

---

<table>
<thead>
<tr>
<th>LEE PART NUMBER</th>
<th>MICRON RATING</th>
<th>LOHM RATE</th>
<th>MAXIMUM FLOW RATE (LPM)</th>
<th>OPEN AREA (mm²)</th>
<th>Rob NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCRM2803040S</td>
<td>40</td>
<td>105</td>
<td>24.6 (6.5 GPM)</td>
<td>7.0</td>
<td>0.13</td>
</tr>
<tr>
<td>SCRM2802075S</td>
<td>75</td>
<td>95</td>
<td>20.6 (5.4 GPM)</td>
<td>6.2</td>
<td>0.25</td>
</tr>
<tr>
<td>SCRM2801125S</td>
<td>125</td>
<td>105</td>
<td>24.6 (6.5 GPM)</td>
<td>5.2</td>
<td>0.46</td>
</tr>
<tr>
<td>SCRM2801170S</td>
<td>170</td>
<td>65</td>
<td>42.5 (11.2 GPM)</td>
<td>7.1</td>
<td>1.25</td>
</tr>
</tbody>
</table>

---

**MATERIALS**

Body .......... 303 Stainless Steel
Pin ............. 416 Stainless Steel
Screen .......... 316 Stainless Steel

---

**INSTALLATION**

Tool Part Number ..... CCRT0901036S
Force .................. 510 Kg F (max.)
For installation procedure see page A67.
**MATERIALS**

Body ............ 303 Stainless Steel  
Pin ............... 416 Stainless Steel  
Screen .......... 316 Stainless Steel  

**INSTALLATION**

Tool Part Number ..... CCRT0901035S
Force .................. 510 Kg F (max.)
For installation procedure see page A67.
# 12.0mm INSERT SAFETY SCREEN

**MATERIALS**
- Body ............ 303 Stainless Steel
- Pin ............... 416 Stainless Steel
- Screen .......... 316 Stainless Steel

**INSERT SCREEN**
- Flow Direction: 0.05 A
- Ra: 1.6 MAX.
- Ø 12.00 ± 0.04
- Ø 12.05 ± 0.10
- 118° ± 2°

**INSTALLATION HOLE**
- Maximum Flow Rate (LPM)
- Open Area (mm²)
- Rob Number

<table>
<thead>
<tr>
<th>LEE PART NUMBER</th>
<th>MICRON RATING</th>
<th>LOHM RATE</th>
<th>MAXIMUM FLOW RATE (LPM)</th>
<th>OPEN AREA (mm²)</th>
<th>Rob NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCRM2123040S</td>
<td>40</td>
<td>45</td>
<td>30.7 (8.1 GPM)</td>
<td>19.6</td>
<td>0.37</td>
</tr>
<tr>
<td>SCRM2122075S</td>
<td>75</td>
<td>40</td>
<td>34.6 (9.1 GPM)</td>
<td>17.2</td>
<td>0.69</td>
</tr>
<tr>
<td>SCRM2121125S</td>
<td>125</td>
<td>45</td>
<td>38.9 (10.3 GPM)</td>
<td>14.5</td>
<td>1.28</td>
</tr>
<tr>
<td>SCRM2121170S</td>
<td>170</td>
<td>30</td>
<td>41.2 (10.9 GPM)</td>
<td>19.7</td>
<td>3.47</td>
</tr>
</tbody>
</table>

**ACTUAL SIZE**

(As Installed)

* LOA before installation.
All dimensions in millimeters.
The 5.5mm Cartridge Screen is designed to slip into a drilled flat bottom hole and be retained by a secondary means. The 5.5mm Insert Screen Retainer shown on the following page is available for this purpose.

<table>
<thead>
<tr>
<th>LEE PART NUMBER</th>
<th>MICRON RATING</th>
<th>LOHM RATE</th>
<th>OPEN AREA (mm²)</th>
<th>Rob NUMBER</th>
<th>MIN. BURST PRESSURE (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCRM7551040S</td>
<td>40</td>
<td>275</td>
<td>3.2</td>
<td>0.06</td>
<td>24 (3,500 psi)</td>
</tr>
<tr>
<td>SCRM7551075S</td>
<td>75</td>
<td>200</td>
<td>2.5</td>
<td>0.10</td>
<td>24 (3,500 psi)</td>
</tr>
<tr>
<td>SCRM7551125S</td>
<td>125</td>
<td>275</td>
<td>1.6</td>
<td>0.14</td>
<td>24 (3,500 psi)</td>
</tr>
<tr>
<td>SCRM7551170S</td>
<td>170</td>
<td>165</td>
<td>1.8</td>
<td>0.33</td>
<td>24 (3,500 psi)</td>
</tr>
</tbody>
</table>

All dimensions in millimeters.

Body .......... 305 Stainless Steel
Pintal ........ 17-7 Stainless Steel
Screen ........ 316 Stainless Steel
**5.5mm INSERT - SCREEN RETAINER**

For use in retaining the 5.5mm Cartridge Screen

---

**SCREEN RETAINER**

**INSTALLATION HOLE**

* LOA before installation. 
All dimensions in millimeters.

---

**LEE PART NUMBER**

SCRR5510001S

Screen and Retainer sold separately.

---

**MATERIALS**

Body .......... 303 Stainless Steel
Pin .......... 416 Stainless Steel

---

**INSTALLATION**

Tool Part Number .......... CCRT0900120S
Force ......................... 662 Kg F (max.)

To install, insert the 5.5mm Cartridge Screen into the installation hole as shown. Then insert the Screen Retainer into the installation hole and drive the expander pin flush to within 0.25mm (0.010") above flush of the retainer. The installation tool can bottom on the retainer body with no consequence. A Lee Installation tool is available, see part number listed above.
The 8.0mm Cartridge Screen is designed to slip into a drilled flat bottom hole and be retained by a secondary means. The 8.0mm Insert Screen Retainer shown on the following page is available for this purpose.

### MATERIALS

<table>
<thead>
<tr>
<th>Body</th>
<th>305 Stainless Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pintal</td>
<td>17-7 Stainless Steel</td>
</tr>
<tr>
<td>Screen</td>
<td>316 Stainless Steel</td>
</tr>
</tbody>
</table>
To install, insert the 8.0mm Cartridge Screen into the installation hole as shown. Then insert the Screen Retainer into the installation hole and drive the expander pin flush to within 0.25mm (0.010") above flush of the retainer. The installation tool can bottom on the retainer body with no consequence. A Lee Installation tool is available, see part number listed above.
All dimensions in millimeters.

**INSTALLATION**

The Cartridge Screen is designed to slip into a drilled, flat bottom hole and be retained by a secondary means.

**MATERIALS**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Body</td>
<td>305 Stainless Steel</td>
</tr>
<tr>
<td>Pintal</td>
<td>17-7 Stainless Steel</td>
</tr>
<tr>
<td>Screen</td>
<td>316 Stainless Steel</td>
</tr>
</tbody>
</table>
### 10mm CARTRIDGE SCREEN

<table>
<thead>
<tr>
<th>LEE PART NUMBER</th>
<th>MICRON RATING</th>
<th>LOHM RATE</th>
<th>OPEN AREA (mm²)</th>
<th>Rob NUMBER</th>
<th>MIN. BURST PRESSURE (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCRM7101040S</td>
<td>40</td>
<td>70</td>
<td>11.6</td>
<td>0.22</td>
<td>24 (3,500 psi)</td>
</tr>
<tr>
<td>SCRM7101075S</td>
<td>75</td>
<td>60</td>
<td>9.6</td>
<td>0.39</td>
<td>24 (3,500 psi)</td>
</tr>
<tr>
<td>SCRM7101125S</td>
<td>125</td>
<td>65</td>
<td>7.4</td>
<td>0.65</td>
<td>24 (3,500 psi)</td>
</tr>
<tr>
<td>SCRM7101170S</td>
<td>170</td>
<td>45</td>
<td>8.7</td>
<td>1.53</td>
<td>24 (3,500 psi)</td>
</tr>
<tr>
<td>SCRM7101300S</td>
<td>300</td>
<td>35</td>
<td>10.0</td>
<td>6.75</td>
<td>24 (3,500 psi)</td>
</tr>
</tbody>
</table>

### 12mm CARTRIDGE SCREEN

<table>
<thead>
<tr>
<th>LEE PART NUMBER</th>
<th>MICRON RATING</th>
<th>LOHM RATE</th>
<th>OPEN AREA (mm²)</th>
<th>Rob NUMBER</th>
<th>MIN. BURST PRESSURE (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCRM7121040S</td>
<td>40</td>
<td>45</td>
<td>18.1</td>
<td>0.34</td>
<td>24 (3,500 psi)</td>
</tr>
<tr>
<td>SCRM7121075S</td>
<td>75</td>
<td>35</td>
<td>14.9</td>
<td>0.60</td>
<td>24 (3,500 psi)</td>
</tr>
<tr>
<td>SCRM7121125S</td>
<td>125</td>
<td>55</td>
<td>11.6</td>
<td>1.02</td>
<td>24 (3,500 psi)</td>
</tr>
<tr>
<td>SCRM7121170S</td>
<td>170</td>
<td>35</td>
<td>14.3</td>
<td>2.52</td>
<td>24 (3,500 psi)</td>
</tr>
<tr>
<td>SCRM7121300S</td>
<td>300</td>
<td>25</td>
<td>17.0</td>
<td>11.44</td>
<td>24 (3,500 psi)</td>
</tr>
</tbody>
</table>

### 16mm CARTRIDGE SCREEN

<table>
<thead>
<tr>
<th>LEE PART NUMBER</th>
<th>MICRON RATING</th>
<th>LOHM RATE</th>
<th>OPEN AREA (mm²)</th>
<th>Rob NUMBER</th>
<th>MIN. BURST PRESSURE (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCRM7161040S</td>
<td>40</td>
<td>30</td>
<td>34</td>
<td>0.64</td>
<td>24 (3,500 psi)</td>
</tr>
<tr>
<td>SCRM7161075S</td>
<td>75</td>
<td>20</td>
<td>29</td>
<td>1.16</td>
<td>24 (3,500 psi)</td>
</tr>
<tr>
<td>SCRM7161125S</td>
<td>125</td>
<td>30</td>
<td>23</td>
<td>2.05</td>
<td>24 (3,500 psi)</td>
</tr>
<tr>
<td>SCRM7161170S</td>
<td>170</td>
<td>20</td>
<td>28</td>
<td>5.06</td>
<td>24 (3,500 psi)</td>
</tr>
<tr>
<td>SCRM7161300S</td>
<td>300</td>
<td>15</td>
<td>35</td>
<td>23.5</td>
<td>24 (3,500 psi)</td>
</tr>
</tbody>
</table>
The Lee Company has supplied over 100 million Lee Plugs® to the aerospace industry since 1948. Virtually every military and commercial aircraft in flight today contains Lee Plugs® in hydraulic, fuel, and lube system manifolds. The IMH Division based its commercial Lee Betaplug® designs on the same reliable, field-proven controlled expansion principle.

The Lee Betaplug is a pre-assembled, one-piece, tapered expansion plug specifically engineered to seal fluid passages in metal castings and plastic housings leak-tight, without the use of threads or sealants. Controlled expansion during installation causes the lands and grooves on the O.D. of the plug body to bite into the wall of the fluid passage, creating a leak-tight seal and assuring retention. The unique tapered design eliminates the need for tight manufacturing tolerances, and allows the designer to minimize the wall thickness required around the plug, even for brittle housing materials. **Note: Betaplugs are not recommended for use above 275°F (135°C).**

**LEE BETAPLUG ADVANTAGE**

**KNOWN BOSS STRESS**

Conventional, cylindrical shaped expansion plugs require additional expansion for the clearance between the plug O.D. and the installation hole.

The matching tapers of the Betaplug and its installation hole create a perfect fit, eliminating the need for additional expansion. Since the Betaplug’s expansion is precisely controlled by the size of the tapered pin, the amount of expansion and any resulting boss stress is completely predictable.

The installation of Lee Betaplugs, whether performed manually or automatically, is very easy and economical. First, the preassembled Betaplug is inserted into the tapered installation hole narrow end first. The pin is then driven into the plug using the recommended Lee Company Installation/Staking Tool until the pin is below flush and the plug is staked. The installation tool is designed to install the pin below flush while staking over the back edge of the plug.
For 6000 Series Betaplugs the pin should be installed 0.38 to 0.46mm (0.015" to 0.018") below flush. The Short Betaplug pin should be installed 0.50 to 0.80mm (0.020" to 0.031) below flush.

Lee Installation/Staking Tools are available for each Betaplug and part numbers are listed in each section. The tool contains a centering feature which ensures proper tool alignment during installation. All Betaplug pins are coated with a wax that produces a thin, solid lubricating film that reduces friction, allowing the pin to be driven to its correct position relative to the plug. Do not clean prior to installation.

The installation force required to drive the pin into the Betaplug is a function of boss material, installation hole and boss geometry, and plug size. A boss made of a stronger material or having a larger wall thickness will require a greater installation force than one made of a weaker material or having thinner walls. Typical installation forces for A380 die-cast aluminum are listed for each Betaplug. See Tooling Table in each section.

Available Designs
The 6000 Series Betaplug is designed for high pressure systems (up to 7,000 psi), and is available in 4, 5, 6, 7 and 8 mm diameters.

**MATERIALS**
- Pin ............ 6061 Aluminum
- Plug .......... 6061/6262 Aluminum

The Short Betaplug is designed for low pressure systems, up to 500 psi, and is available in 7, 9, 11, 13 and 16 mm diameters.

**MATERIALS**
- Pin & Plug ........ 6061 Aluminum
### 6000 SERIES BETAPLUG

<table>
<thead>
<tr>
<th>Diameter</th>
<th>BETAPLUG</th>
<th>MAXIMUM PASSAGE DIAMETER</th>
</tr>
</thead>
<tbody>
<tr>
<td>4mm</td>
<td><img src="image1.png" alt="Diagram" /></td>
<td><img src="image2.png" alt="Diagram" /></td>
</tr>
<tr>
<td>5mm</td>
<td><img src="image3.png" alt="Diagram" /></td>
<td><img src="image4.png" alt="Diagram" /></td>
</tr>
<tr>
<td>6mm</td>
<td><img src="image5.png" alt="Diagram" /></td>
<td><img src="image6.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>

#### Actual Size

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Actual Size (As Installed)</th>
<th>LEE PART NUMBER</th>
<th>Burst Pressure †</th>
</tr>
</thead>
<tbody>
<tr>
<td>4mm</td>
<td><img src="image7.png" alt="Image" /></td>
<td>PLBA0402604S</td>
<td>483 Bar (7,000 psi)</td>
</tr>
<tr>
<td>5mm</td>
<td><img src="image8.png" alt="Image" /></td>
<td>PLBA0502604S</td>
<td>483 Bar (7,000 psi)</td>
</tr>
<tr>
<td>6mm</td>
<td><img src="image9.png" alt="Image" /></td>
<td>PLBA0602604S</td>
<td>483 Bar (7,000 psi)</td>
</tr>
</tbody>
</table>

* LOA before installation. All dimensions in millimeters.
† Typical burst pressure for A380 die-cast aluminum
**6000 SERIES BETAPLUG (cont.)**

### 7mm BETAPLUG

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ø</td>
<td>11.69*</td>
</tr>
<tr>
<td>ø</td>
<td>9.65</td>
</tr>
<tr>
<td>ø</td>
<td>8.13</td>
</tr>
<tr>
<td>ø</td>
<td>7.15</td>
</tr>
<tr>
<td>ø</td>
<td>7.09</td>
</tr>
<tr>
<td>ø</td>
<td>3.56</td>
</tr>
</tbody>
</table>

**MAXIMUM PASSAGE DIAMETER**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ø</td>
<td>6.5 MAX.</td>
</tr>
</tbody>
</table>

### ACTUAL SIZE

(As Installed)

**LEE PART NUMBER** | **BURST PRESSURE†**
---|---
PLBA0703604S | 276 Bar (4,000 psi)

### 8mm BETAPLUG

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ø</td>
<td>13.08*</td>
</tr>
<tr>
<td>ø</td>
<td>11.18</td>
</tr>
<tr>
<td>ø</td>
<td>9.14</td>
</tr>
<tr>
<td>ø</td>
<td>8.04</td>
</tr>
<tr>
<td>ø</td>
<td>7.98</td>
</tr>
<tr>
<td>ø</td>
<td>4.06</td>
</tr>
</tbody>
</table>

**MAXIMUM PASSAGE DIAMETER**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ø</td>
<td>7.3 MAX.</td>
</tr>
</tbody>
</table>

### ACTUAL SIZE

(As Installed)

**LEE PART NUMBER** | **BURST PRESSURE†**
---|---
PLBA0803604S | 276 Bar (4,000 psi)

* LOA before installation. All dimensions in millimeters.
† Typical burst pressure for A380 die-cast aluminum
The installation hole for a 6000 Series Lee Betaplug has an included taper angle, Beta, of 4.3°, which matches the tapered outside diameter of the Betaplug. This included draft angle of 4.3° is very easy to achieve with a core pin in a die-cast or molded part or to machine using a tapered tool.

A tolerance of ±0.3° on the taper angle of 4.3° is specified to guarantee that the Betaplug’s rated performance is achieved. If the taper angles are out of tolerance, the plug will either wedge first at the top or at the bottom, reducing sealing burst pressure. Tapered reamers are available for each size Betaplug. See the tooling table for applicable part numbers.

The Lee Company recommends that the Betaplug be installed below the surface of the housing to ensure maximum plug retention capability. The use of coatings or surface treatments in the area of the installation hole where the Betaplug is to be installed is not recommended.

### Gage Dimensions and Maximum Passage Diameters (mm)

<table>
<thead>
<tr>
<th>Beta-Plug Size</th>
<th>Top Gage Dia., D1</th>
<th>Bottom Gage Dia., D2</th>
<th>Max. Passage Dia., D3</th>
<th>Min. Opening, D4</th>
<th>Min. Wall Thickness, D5</th>
<th>Gage Length, L1</th>
<th>Min. Gage Depth, L2</th>
<th>Min. Taper Depth, L3*</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>4.07</td>
<td>3.68</td>
<td>3.60</td>
<td>4.16</td>
<td>1.40</td>
<td>4.88-5.57</td>
<td>1.12</td>
<td>7.54</td>
</tr>
<tr>
<td>5</td>
<td>5.08</td>
<td>4.70</td>
<td>4.50</td>
<td>5.19</td>
<td>1.80</td>
<td>4.75-5.43</td>
<td>1.38</td>
<td>8.59</td>
</tr>
<tr>
<td>6</td>
<td>6.10</td>
<td>5.60</td>
<td>5.50</td>
<td>6.21</td>
<td>2.20</td>
<td>6.25-7.14</td>
<td>1.38</td>
<td>10.06</td>
</tr>
<tr>
<td>7</td>
<td>7.11</td>
<td>6.58</td>
<td>6.50</td>
<td>7.23</td>
<td>2.50</td>
<td>6.63-7.57</td>
<td>1.50</td>
<td>10.26</td>
</tr>
<tr>
<td>8</td>
<td>8.00</td>
<td>7.37</td>
<td>7.30</td>
<td>8.13</td>
<td>2.80</td>
<td>7.87-9.00</td>
<td>1.63</td>
<td>11.41</td>
</tr>
</tbody>
</table>

* Depth of tapered hole (L3) from depth of minimum diameter (D4).
All dimensions are in millimeters.
<table>
<thead>
<tr>
<th>BETAPlug Size</th>
<th>Installation/Staking Tool Part Number</th>
<th>Tapered Reamer Part Number</th>
<th>Typical Installation Force (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>PLBT0470030S</td>
<td>PLBT0470020S</td>
<td>2.9 (650 lbf)</td>
</tr>
<tr>
<td>5</td>
<td>PLBT0570030S</td>
<td>PLBT0570020S</td>
<td>2.4 (550 lbf)</td>
</tr>
<tr>
<td>6</td>
<td>PLBT0670030S</td>
<td>PLBT0670020S</td>
<td>2.6 (600 lbf)</td>
</tr>
<tr>
<td>7</td>
<td>PLBT0770030S</td>
<td>PLBT0770020S</td>
<td>4.0 (900 lbf)</td>
</tr>
<tr>
<td>8</td>
<td>PLBT0870030S</td>
<td>PLBT0870020S</td>
<td>4.4 (1,000 lbf)</td>
</tr>
</tbody>
</table>
**SHORT BETAPLUG**

**MAXIMUM PASSAGE DIAMETER**

### 7mm BETAPLUG

- **Actual Size (As Installed):**
  - Ø 7.01
  - Ø 3.30

### 9mm BETAPLUG

- **Actual Size (As Installed):**
  - Ø 9.01
  - Ø 4.00

### 11mm BETAPLUG

- **Actual Size (As Installed):**
  - Ø 11.03
  - Ø 5.00

**LEE PART NUMBER | RATED PRESSURE †**

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>PRESSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLBA0702610S</td>
<td>35 Bar (500 psi)</td>
</tr>
<tr>
<td>PLBA0903610S</td>
<td>35 Bar (500 psi)</td>
</tr>
<tr>
<td>PLBA1103610S</td>
<td>35 Bar (500 psi)</td>
</tr>
</tbody>
</table>

* LOA before installation. *All dimensions in millimeters.

† Rated pressures may be higher depending upon specific application requirements. Contact your Lee Sales Engineer for higher pressure requirements.
SHORT BETAPLUG (cont.)

13mm BETAPLUG

**MAXIMUM PASSAGE DIAMETER**

- **11.20** (8.56)
- **7.10**
- **(Ø 13.03) (Ø 6.55) (90°)**
- **(0.075 TAPER/MM)**

**ACTUAL SIZE**

(As Installed)

<table>
<thead>
<tr>
<th>LEE PART NUMBER</th>
<th>RATED PRESSURE †</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLBA1304610S</td>
<td>35 Bar (500 psi)</td>
</tr>
</tbody>
</table>

16mm BETAPLUG

**MAXIMUM PASSAGE DIAMETER**

- **11.17** (8.97)
- **7.10**
- **(Ø 16.08) (Ø 7.85) (90°)**
- **(0.075 TAPER/MM)**

**ACTUAL SIZE**

(As Installed)

<table>
<thead>
<tr>
<th>LEE PART NUMBER</th>
<th>RATED PRESSURE †</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLBA1604610S</td>
<td>35 Bar (500 psi)</td>
</tr>
</tbody>
</table>

* LOA before installation. All dimensions in millimeters.
† Rated pressures may be higher depending upon specific application requirements. Contact your Lee Sales Engineer for higher pressure requirements.
The Short Betaplug has been qualified to work in generously tolerated installation holes. The taper of the hole can range anywhere from 4°-5°, giving the designer flexibility in satisfying specific application requirements. Tapered Reamers are available for each size Short Betaplug. See the tooling table for applicable part numbers.

The Lee Company recommends that the Short Betaplug be installed flush or below the surface of the housing to ensure optimum performance. The use of coatings or surface treatments in the area of the installation hole where the Short Betaplug is to be installed is not recommended.

### GAGE DIMENSIONS AND MAXIMUM PASSAGE DIAMETERS (mm)

<table>
<thead>
<tr>
<th>BETA-PLUG SIZE</th>
<th>TOP GAGE DIA., D1</th>
<th>BOTTOM GAGE DIA., D2</th>
<th>MAX. PASSAGE DIA., D3</th>
<th>MIN. OPENING, D4</th>
<th>MIN. WALL THICKNESS, D5</th>
<th>GAGE LENGTH, L1</th>
<th>MIN. TAPER DEPTH, L3*</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>7.01</td>
<td>6.69</td>
<td>6.50</td>
<td>7.16</td>
<td>2.45</td>
<td>3.66-4.58</td>
<td>10.00</td>
</tr>
<tr>
<td>9</td>
<td>9.01</td>
<td>8.69</td>
<td>8.38</td>
<td>9.16</td>
<td>3.15</td>
<td>3.66-4.58</td>
<td>12.00</td>
</tr>
<tr>
<td>11</td>
<td>11.03</td>
<td>10.71</td>
<td>10.39</td>
<td>11.18</td>
<td>3.85</td>
<td>3.66-4.58</td>
<td>12.00</td>
</tr>
<tr>
<td>13</td>
<td>13.03</td>
<td>12.71</td>
<td>12.40</td>
<td>13.18</td>
<td>4.55</td>
<td>3.66-4.58</td>
<td>12.00</td>
</tr>
<tr>
<td>16</td>
<td>16.08</td>
<td>15.76</td>
<td>15.39</td>
<td>16.23</td>
<td>5.60</td>
<td>3.66-4.58</td>
<td>12.00</td>
</tr>
</tbody>
</table>

* Depth of tapered hole (L3) from depth of minimum diameter (D4).
All dimensions are in millimeters.
<table>
<thead>
<tr>
<th>BETAPLUG SIZE</th>
<th>INSTALLATION/STAKING TOOL PART NUMBER</th>
<th>TAPERED REAMER PART NUMBER</th>
<th>TAPERED REAMER, ROUGH FINISH PART NUMBER</th>
<th>TYPICAL INSTALLATION FORCE (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>PLBT0070901S</td>
<td>PLBT0700012S</td>
<td>PLBT0700014S</td>
<td>4.9 (1,100 lbf)</td>
</tr>
<tr>
<td>9</td>
<td>PLBT0090901S</td>
<td>PLBT0900012S</td>
<td>PLBT0900014S</td>
<td>4.9 (1,100 lbf)</td>
</tr>
<tr>
<td>11</td>
<td>PLBT0110901S</td>
<td>PLBT1100012S</td>
<td>PLBT1100014S</td>
<td>4.9 (1,100 lbf)</td>
</tr>
<tr>
<td>13</td>
<td>PLBT0130901S</td>
<td>PLBT1300012S</td>
<td>PLBT1300014S</td>
<td>6.2 (1,400 lbf)</td>
</tr>
<tr>
<td>16</td>
<td>PLBT0160901S</td>
<td>PLBT1600012S</td>
<td>PLBT1600014S</td>
<td>6.2 (1,400 lbf)</td>
</tr>
</tbody>
</table>
The Industrial Microhydraulics Group offers a line of products intended for installation into plastic manifolds or fittings. A series of smoothly curved lands allow the part to be pressed in while the plastic flows into the adjacent grooves. Some plastics with a lot of elongation, such as Polypropylene, Nylon, Acetal, Polyethylene and PEEK, cold flow into the grooves effecting retention and a seal.

Other plastics, such as acrylic and polycarbonate, are rigid and must be heat flowed into the hole. The IMH Group can offer advice on the best methods of installation for each product and plastic. We offer products already installed in plastic fittings, equipment to install our products, as well as the service of installing them for you.
Many of the insert products from Section I, such as check valves, relief valves, orifices, restrictor check valves and safety screens, are offered in the plastic installation configuration. They contain many of the same features and offer the same benefits:

**Features and Benefits**

- **Miniature Size**
  - Allows designers to save space and weight.

- **100% Testing**
  - Eliminates need for system rework.

- **Stainless Steel Construction**
  - Compatible with most fluids.

- **Rugged, Durable Design**
  - Provides high reliability and long life.

- **Low Leakage Valve Seats**
  - More efficient system performance.

- **Highly Accurate Orifices**
  - Provides more consistent system performance.
IMH Checks and Relief Valves for plastic installation have the same internal design as the inserts in Section I. A high quality metal to metal seat provides low leakage and highly repeatable cracking pressure. Their all stainless steel design provides compatibility with a wide range of fluids and gases. Some models are available with a ceramic ball as standard. These valves come in three diameters (2.5, 5.5 and 8.0mm) with corresponding flow capabilities. The 2.5mm valve is the smallest cartridge style valve available and is so small it fits in many common plastic fittings (see “Products in Plastic Fittings” section, pages B39-B46).
Features and Benefits

- Metal to metal seating
  - Provides high reliability.
  - Repeatable crack.
- Press-in design
  - Simple installation.
- Leak tight
  - Efficient system performance.
- Guided ball design
  - Fast response.
  - Low hysteresis.
- Ceramic ball versions
  - Compatible with aggressive fluids.
- 100% tested
  - Eliminates rework.

TABLE OF CONTENTS

Check Valves

2.5mm Check Valve ............... B5
  with Ceramic Ball ............... B6

5.5mm Check Valve ............... B7
  with Ceramic Ball ............... B8

316L Check Valve ............... B9

8.0mm Check Valve ............... B10
  with Ceramic Ball ............... B11

Relief Valves

2.5mm Relief Valve ............... B12
  with Ceramic Ball ............... B13

5.5mm Relief Valve ............... B14
  with Ceramic Ball ............... B15

316L Relief Valve ............... B16

8.0mm Relief Valve ............... B17
  with Ceramic Ball ............... B18

Features
- Metal to metal seating
- Press-in design
- Leak tight
- Guided ball design
- Ceramic ball versions
- 100% tested
**PERFORMANCE**

- **Lohm Rate**: 750 Lohms
- **Leakage**: 10 sccm/min. (max.)@500 kPa (72.5 psid) on air
  - 1 Drop/min. (max.) on water

**MATERIALS**

- **Body**: 303 Stainless Steel
- **Ball Stop**: 303 Stainless Steel
- **Spring**: 302 Stainless Steel
- **Ball**: 440C Stainless Steel

**INSTALLATION**

To install, simply press the valve into a plastic installation hole until the valve is flush minimum with the top of the installation hole. The valve can be installed in either direction, providing forward or reverse flow capabilities.
**PERFORMANCE**

Lohm Rate: 750 Lohms  
Leakage: 10 sccm/min. (max.)@500 kPa (72.5 psid) on air  
1 Drop/min. (max.) on water

**MATERIALS**

Body...........303 Stainless Steel  
Ball Stop .......303 Stainless Steel  
Spring .........302 Stainless Steel  
Ball.............Ceramic

**INSTALLATION**

Tool Part Number .....CCRT0024277S  
To install, simply press the valve into a plastic installation hole until the valve is flush minimum with the top of the installation hole. The valve can be installed in either direction, providing forward or reverse flow capabilities.
5.5mm CHECK VALVE
for PLASTIC INSTALLATION

PERFORMANCE
Lohm Rate: 250 Lohms
Leakage: 20 sccm/min. (max.)@172 kPa (25 psid) on air
1 Drop/min. (max.) on water

MATERIALS
Body........... 303 Stainless Steel
Cage .......... 305 Stainless Steel
Spring ......... 302 Stainless Steel
Ball............. 440C Stainless Steel

INSTALLATION
Tool Part Number ..... CCRT0900170S
To install, simply press the valve into a plastic installation hole until the valve is flush minimum with the top of the installation hole. The valve can be installed in either direction, providing forward or reverse flow capabilities. See page B27.
5.5mm CHECK VALVE - CERAMIC BALL for PLASTIC INSTALLATION

**CHEK VALVE**

![Diagram of CHEK VALVE with dimensions]

**ACTUAL SIZE**

(As Installed)

All dimensions in millimeters.

**ΔP vs. Flow on Water @80°F (27°C)**

![Graph showing ΔP vs. Flow on Water]

**PERFORMANCE**

- **Lohm Rate:** 250 Lohms
- **Leakage:** 20 sccm/min. (max.)@172 kPa (25 psid) on air
- 1 Drop/min. (max.) on water

**MATERIALS**

- **Body:** 303 Stainless Steel
- **Cage:** 305 Stainless Steel
- **Spring:** 302 Stainless Steel
- **Ball:** Ceramic

**INSTALLATION**

Tool Part Number .....CCRT0900170S

To install, simply press the valve into a plastic installation hole until the valve is flush minimum with the top of the installation hole. The valve can be installed in either direction, providing forward or reverse flow capabilities. See page B27.
5.5mm CHECK VALVE - MEDICAL GRADE 316L for PLASTIC INSTALLATION

**PERFORMANCE**
- Lohm Rate: 250 Lohms
- Leakage: 20 sccm/min. (max.) @ 172 kPa (25 psid) on air
- 1 Drop/min. (max.) on water

**MATERIALS**
- Body: 316L Stainless Steel
- Cage: 316L Stainless Steel
- Spring: 316L Stainless Steel
- Ball: Ceramic

**INSTALLATION**
Tool Part Number: CCRT0900170S
To install, simply press the valve into a plastic installation hole until the valve is flush minimum with the top of the installation hole. The valve can be installed in either direction, providing forward or reverse flow capabilities. See page B27.
8.0mm CHECK VALVE for PLASTIC INSTALLATION

CHECK VALVE

INSTALLATION HOLE

ACTUAL SIZE

(As Installed)

All dimensions in millimeters.

∆P vs. Flow on Water @80°F (27°C)

PERFORMANCE

Lohm Rate: 75 Lohms
Leakage: 20 sccm/min. (max.) @ 172 kPa (25 psid) on air
1 Drop/min. (max.) on water

MATERIALS

Body...........303 Stainless Steel
Cage .........305 Stainless Steel
Spring .........302 Stainless Steel
Ball.............440C Stainless Steel

INSTALLATION

Tool Part Number ..... CCRT0900180S
To install, simply press the valve into a plastic installation hole until the valve is flush minimum with the top of the installation hole. The valve can be installed in either direction, providing forward or reverse flow capabilities. See page B27.
**8.0mm CHECK VALVE - CERAMIC BALL**

**for PLASTIC INSTALLATION**

### CHEK VALVE

**INSTALLATION HOLE**

<table>
<thead>
<tr>
<th>LEE PART NO.</th>
<th>CRACKING PRESSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCP8080000S</td>
<td>0 kPa (No Spring)</td>
</tr>
<tr>
<td>CCP8080007S</td>
<td>7 ± 5 kPa (1 ± 0.7 psid)</td>
</tr>
<tr>
<td>CCP8080014S</td>
<td>14 ± 5 kPa (2 ± 0.7 psid)</td>
</tr>
<tr>
<td>CCP8080040S</td>
<td>40 ± 30 kPa (6 ± 4.4 psid)</td>
</tr>
<tr>
<td>CCP8080069S</td>
<td>69 ± 17.3 kPa (10 ± 2.5 psid)</td>
</tr>
</tbody>
</table>

**PERFORMANCE**

- Lohm Rate: 75 Lohms
- Leakage: 20 sccm/min. (max.)@ 172 kPa (25 psid) on air
- 1 Drop/min. (max.) on water

**MATERIALS**

- Body ............ 303 Stainless Steel
- Cage ............ 305 Stainless Steel
- Spring ......... 302 Stainless Steel
- Ball ............ Ceramic

**INSTALLATION**

To install, simply press the valve into a plastic installation hole until the valve is flush minimum with the top of the installation hole. The valve can be installed in either direction, providing forward or reverse flow capabilities. See page B27.

**ACTUAL SIZE**

(As Installed)

All dimensions in millimeters.


### PERFORMANCE

- **Lohm Rate:** 750 Lohms
- **Leakage:** 10 sccm/min. (max.) @ 500 kPa (72.5 psid) on air
  1 Drop/min. (max.) on water
- **Cracking Pressure Tolerance:** ± 15%

### MATERIALS

- **Body:** 303 Stainless Steel
- **Ball Stop:** 303 Stainless Steel
- **Spring:** 302 Stainless Steel
- **Ball:** 440C Stainless Steel

### INSTALLATION

To install, simply press the valve into a plastic installation hole until the valve is flush minimum with the top of the installation hole. The valve can be installed in either direction, providing forward or reverse flow capabilities.

### ∆P vs. Flow on Water @ 80°F (27°C)

<table>
<thead>
<tr>
<th>Flow Curve for 40 kPa Valve</th>
</tr>
</thead>
<tbody>
<tr>
<td>∆P (kPa)</td>
</tr>
<tr>
<td>Flow (LPM)</td>
</tr>
<tr>
<td>∆P (PSI)</td>
</tr>
</tbody>
</table>

### INSTALLATION HOLE

- **MATERIALS:**
  - **Body:** 303 Stainless Steel
  - **Ball Stop:** 303 Stainless Steel
  - **Spring:** 302 Stainless Steel
  - **Ball:** 440C Stainless Steel

### LEE PART NO. CRACKING PRESSURE

- CCPI2510100S 100 kPa (14.5 psid)
- CCPI2510150S 150 kPa (21.8 psid)
- CCPI2510200S 200 kPa (29 psid)
- CCPI2510250S 250 kPa (36.6 psid)
- CCPI2510300S 300 kPa (43.5 psid)
- CCPI2510345S 345 kPa (50 psid)
**PERFORMANCE**

- **Lohm Rate:** 750 Lohms
- **Leakage:** 10 sccm/min. (max.)@500 kPa (72.5 psid) on air
  1 Drop/min. (max.) on water
- **Cracking Pressure Tolerance:** ± 15%

**MATERIALS**

- **Body:** 303 Stainless Steel
- **Ball Stop:** 303 Stainless Steel
- **Spring:** 302 Stainless Steel
- **Ball:** Ceramic

**INSTALLATION**

To install, simply press the valve into a plastic installation hole until the valve is flush minimum with the top of the installation hole. The valve can be installed in either direction, providing forward or reverse flow capabilities.
5.5mm RELIEF VALVE
for PLASTIC INSTALLATION

RELIEF VALVE

INSTALLATION HOLE

ACTUAL SIZE
(As Installed)

All dimensions in millimeters.

<table>
<thead>
<tr>
<th>LEE PART NO.</th>
<th>CRACKING PRESSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCPI5510100S</td>
<td>100 kPa (14.5 psid)</td>
</tr>
<tr>
<td>CCPI5510150S</td>
<td>150 kPa (21.8 psid)</td>
</tr>
<tr>
<td>CCPI5510200S</td>
<td>200 kPa (29 psid)</td>
</tr>
<tr>
<td>CCPI5510250S</td>
<td>250 kPa (36.6 psid)</td>
</tr>
<tr>
<td>CCPI5510300S</td>
<td>300 kPa (43.5 psid)</td>
</tr>
<tr>
<td>CCPI5510350S</td>
<td>350 kPa (50.8 psid)</td>
</tr>
<tr>
<td>CCPI5510400S</td>
<td>400 kPa (58 psid)</td>
</tr>
<tr>
<td>CCPI5510500S</td>
<td>500 kPa (72.5 psid)</td>
</tr>
<tr>
<td>CCPI5510550S</td>
<td>550 kPa (79.8 psid)</td>
</tr>
<tr>
<td>CCPI5510625S</td>
<td>625 kPa (90.6 psid)</td>
</tr>
</tbody>
</table>

PERFORMANCE
Lohm Rate: 250 Lohms
Leakage: 20 sccm/min. (max.) @ 172 kPa (25 psid) on air
1 Drop/min. (max.) on water
Cracking Pressure Tolerance: ± 15%

MATERIALS
Body......... 303 Stainless Steel
Cage .......... 305 Stainless Steel
Spring ......... 302 Stainless Steel
Ball........... 440C Stainless Steel

INSTALLATION
Tool Part Number ..... CCRT0900170S
To install, simply press the valve into a plastic installation hole until the valve is flush minimum with the top of the installation hole. The valve can be installed in either direction, providing forward or reverse flow capabilities. See page B27.
**5.5mm RELIEF VALVE - CERAMIC BALL for PLASTIC INSTALLATION**

### RELIEF VALVE

- **Actual Size:**
  - Ø 5.46 ± 0.03
  - Ø 5.32 ± 0.04

### INSTALLATION HOLE

- **7.31 MIN**

### Flow Curve for 40 kPa Valve

#### ΔP vs. Flow on Water @80°F (27°C)

<table>
<thead>
<tr>
<th>Flow (GPM)</th>
<th>ΔP (kPa)</th>
<th>ΔP (PSI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>100</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>200</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>300</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>400</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

### PERFORMANCE

- **Lohm Rate:** 250 Lohms
- **Leakage:** 20 sccm/min. (max.)@172 kPa (25 psid) on air
  - 1 Drop/min. (max.) on water
- **Cracking Pressure Tolerance:** ± 15%

### MATERIALS

- **Body:** 303 Stainless Steel
- **Cage:** 305 Stainless Steel
- **Spring:** 302 Stainless Steel
- **Ball:** Ceramic

### INSTALLATION

- **Tool Part Number:** CCRT0900170S
- **To install:** Simply press the valve into a plastic installation hole until the valve is flush minimum with the top of the installation hole. The valve can be installed in either direction, providing forward or reverse flow capabilities. [See page B27.]
**5.5mm RELIEF VALVE - MEDICAL GRADE 316L**

**for PLASTIC INSTALLATION**

**PERFORMANCE**

- Lohm Rate: 250 Lohms
- Leakage: 20 sccm/min. (max.) @ 172 kPa (25 psid) on air
- 1 Drop/min. (max.) on water
- Cracking Pressure Tolerance: ± 15%

**MATERIALS**

- Body: 316L Stainless Steel
- Cage: 316L Stainless Steel
- Spring: 316L Stainless Steel
- Ball: Ceramic

**INSTALLATION**

To install, simply press the valve into a plastic installation hole until the valve is flush minimum with the top of the installation hole. The valve can be installed in either direction, providing forward or reverse flow capabilities. See page B27.
8.0mm RELIEF VALVE
for PLASTIC INSTALLATION

**RELIEF VALVE**

**INSTALLATION HOLE**

- **ACTUAL SIZE**
  - (As Installed)
  - All dimensions in millimeters.

- **∆P vs. Flow on Water @80°F (27°C)**
  - Flow Curve for 40 kPa Valve

- **PERFORMANCE**
  - Lohm Rate: 75 Lohms
  - Leakage: 20 sccm/min. (max.) @ 172 kPa (25 psid) on air
  - 1 Drop/min. (max.) on water
  - Cracking Pressure Tolerance: ± 15%

- **MATERIALS**
  - Body: 303 Stainless Steel
  - Cage: 305 Stainless Steel
  - Spring: 302 Stainless Steel
  - Ball: 440C Stainless Steel

- **INSTALLATION**
  - Tool Part Number: CCRT0900180S
  - To install, simply press the valve into a plastic installation hole until the valve is flush minimum with the top of the installation hole. The valve can be installed in either direction, providing forward or reverse flow capabilities. See page B27.
8.0mm RELIEF VALVE - CERAMIC BALL for PLASTIC INSTALLATION

<table>
<thead>
<tr>
<th>LEE PART NO.</th>
<th>CRACKING PRESSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCPI8080100S</td>
<td>100 kPa (14.5 psid)</td>
</tr>
<tr>
<td>CCPI8080150S</td>
<td>150 kPa (21.8 psid)</td>
</tr>
<tr>
<td>CCPI8080200S</td>
<td>200 kPa (29 psid)</td>
</tr>
<tr>
<td>CCPI8080250S</td>
<td>250 kPa (36.6 psid)</td>
</tr>
<tr>
<td>CCPI8080300S</td>
<td>300 kPa (43.5 psid)</td>
</tr>
<tr>
<td>CCPI8080350S</td>
<td>350 kPa (50.8 psid)</td>
</tr>
<tr>
<td>CCPI8080400S</td>
<td>400 kPa (58 psid)</td>
</tr>
<tr>
<td>CCPI8080500S</td>
<td>500 kPa (72.5 psid)</td>
</tr>
</tbody>
</table>

PERFORMANCE

Lohm Rate: 75 Lohms
Leakage: 20 sccm/min. (max.) @ 172 kPa (25 psid) on air
1 Drop/min. (max.) on water
Cracking Pressure Tolerance: ±15%

MATERIALS

Body............ 303 Stainless Steel
Cage .......... 305 Stainless Steel
Spring ......... 302 Stainless Steel
Ball............. Ceramic

INSTALLATION

Tool Part Number ..... CCRT0900180S

To install, simply press the valve into a plastic installation hole until the valve is flush minimum with the top of the installation hole. The valve can be installed in either direction, providing forward or reverse flow capabilities. See page B27.
IMH Orifices for plastic are economical, reliable, highly accurate miniature restrictors. These orifices are 100% flow tested to ensure that every part is within ±5% of its nominal flow rate (tighter flow tolerances available as special orders). Tight flow tolerances are only possible if entrance and exit conditions are closely controlled. This provides far more accuracy than an orifice specified by hole tolerance. An ordinary hole held to a very tight hole tolerance will not result in a tight flow tolerance. IMH orifices are so consistent because they are produced in high volume by automated processes.

Installation is simple. Press or heat flow the orifice into a plastic hole, narrow end first, until the orifice is flush minimum with the top of the installation hole. Pressing or heat flowing the restrictors into the manifold or fitting provides retention and creates a leak tight seal.

Orifices are available in Brass, 303 and 316 Stainless Steel. Brass orifices are available in gas versions only and are often used for oxygen service. Stainless steel orifices come in gas and liquid versions and will not change flow rate over time due either to corrosion or erosion. Gas orifices are tested on clean dry nitrogen and liquid orifices on distilled water. Great care is taken to ensure the accuracy of the automated test systems. To further increase accuracy, orifices are tested in the direction of use. Simply refer to the diagram illustrating forward and reverse flow.
Features and Benefits

- Accurate flow
  - Eliminate expensive alternative components.
  - More consistent system performance.
- Press-in design
  - Easy installation.
  - Maintains flow accuracy.
- 100% flow tested
  - All parts within flow tolerance.
  - Consistent batch to batch performance.
- Various material choices
  - Design flexibility.

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- 303 Stainless Steel............ B21
- 316 Stainless Steel............ B22

2.5mm ORIFICES FOR GASES
- 303 Stainless Steel............ B23
- 316 Stainless Steel............ B24
- Brass.............................. B25

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PERFORMANCE

Metered Flow
Lohm Rate Tolerance: ± 5%

Test Fluid: Distilled Water

MATERIALS

Body............... 303 Stainless Steel

INSTALLATION

Tool Part Number ..... CCRT0029354S

For installation procedure see page B19.

For companion 2.5mm Safety Screen see page B35.
2.5mm ORIFICE FOR LIQUIDS
316 STAINLESS STEEL for PLASTIC INSTALLATION

All dimensions in millimeters.

<table>
<thead>
<tr>
<th>LEE PART NO.</th>
<th>METERED FLOW DIRECTION</th>
<th>LOHM RATE</th>
</tr>
</thead>
<tbody>
<tr>
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<td>FORWARD</td>
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PERFORMANCE
Metered Flow
Lohm Rate Tolerance: ± 5%
Test Fluid: Distilled Water

MATERIALS
Body.................316 Stainless Steel

INSTALLATION
Tool Part Number ..... CCRT0029354S
For installation procedure see page B19.
For companion 2.5mm Safety Screen see page B35.
### Performance

<table>
<thead>
<tr>
<th>Metered Flow Rate</th>
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<tr>
<td>Reverse</td>
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</table>

Lohm Rate Tolerance: ± 5%

Test Fluid: Clean & Dry Nitrogen

### Installation

**Tool Part Number** CCRT0029354S

- For installation procedure see page B19.
- For companion 2.5mm Safety Screen see page B35.

### Materials

Body .................... 303 Stainless Steel

### Materials

- 2.5mm ORIFICE FOR GASES
- 303 STAINLESS STEEL for PLASTIC INSTALLATION

---

**Lee Part No.**

<table>
<thead>
<tr>
<th>Metered Flow Direction</th>
<th>Lohm Rate</th>
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<td>Forward</td>
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</tr>
<tr>
<td>Reverse</td>
<td>600</td>
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</table>

---

**IMH Orifice**

- **Installation Hole**
  - Actual Size: (As Installed)
  - Diameter: 3.81 min.

---

**Actual Size**

- Diameter: 3.30
- Diameter: 2.54
- Diameter: 2.34
- Diameter: 2.26

---

All dimensions in millimeters.
2.5mm ORIFICE FOR GASES
316 STAINLESS STEEL for PLASTIC INSTALLATION

**IMH ORIFICE**

```
3.30

Ø 2.54

DIRECTION OF INSTALLATION
```

**INSTALLATION HOLE**

```
METERED FLOW
FORWARD

METERED FLOW
REVERSE

3.81 MIN.

Ø 2.34
Ø 2.26
```

**PERFORMANCE**

- Metered Flow
- Lohm Rate Tolerance: ± 5%
- Test Fluid: Clean & Dry Nitrogen

**MATERIALS**

- Body: 316 Stainless Steel

**INSTALLATION**

- Tool Part Number ..... CCRT0029354S
- For installation procedure see page B19.

For companion 2.5mm Safety Screen see page B35.

All dimensions in millimeters.

### LEE PART NO.

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2.5mm ORIFICE FOR GASES
BRASS for PLASTIC INSTALLATION

IMH ORIFICE

INSTALLATION HOLE

All dimensions in millimeters.

<table>
<thead>
<tr>
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<th>LOHM RATE</th>
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</table>

Performance

Metered Flow
Lohm Rate Tolerance: ± 5%
Test Fluid: Clean & Dry Nitrogen

Materials

Body.......................... Brass C3600

Installation

Tool Part Number ..... CCRT0029354S
For installation procedure see page B19.

For companion 2.5mm Safety Screen see page B35.
Restrictor Checks are functionally an orifice in series with a check valve, all in one compact package. Flow controls are functionally an orifice in parallel with a check valve, all in one package. Both come in a wide variety of metered lohm rates (orifices sizes).

Where screening is necessary, companion screens for plastic are available in four different micron ratings (see pages B36-B37).

To install, simply press or heat flow the valve into a plastic installation hole until the valve is flush minimum with the top of the installation hole. The valve can be installed in either direction, providing forward or reverse flow capabilities. Lee installation tools are available for each product and part numbers are listed on each page.
Features and Benefits

• Combines hydraulic functions
  – Simplifies manifold.

• Accurate flow
  – Eliminate expensive alternative components.
  – More consistent system performance.

• 100% flow tested
  – Eliminates rework.
  – All parts within flow tolerance.
  – Consistent batch to batch performance.

• Press-in Design
  – Simple installation.
5.5mm FLOW CONTROL
for PLASTIC INSTALLATION

FLOW CONTROL

ACTUAL SIZE

(As Installed)

INSTALLATION HOLE

Free Flow Curve

∆P vs. Flow on Water @80°F (27°C)

PERFORMANCE

Metered Flow
Lohm Rate Tolerance: ± 15%
Free Flow Lohm Rate: 250 Lohms
Cracking Pressure: 40 ± 30 kPa
(6 ± 4.4 psid)

MATERIALS

Body.................303 Stainless Steel
Cage.................305 Stainless Steel
Spring..............302 Stainless Steel
Ball...............440C Stainless Steel

INSTALLATION

Tool Part Number ..... CCRT0900170S
For installation procedure see page B27.
PERFORMANCE

Metered Flow
Lohm Rate Tolerance: ± 15%
Free Flow Lohm Rate: 75 Lohms
Cracking Pressure: 40 ± 30 kPa
(6 ± 4.4 psid)

MATERIALS

Body .............. 303 Stainless Steel
Cage .............. 305 Stainless Steel
Spring ............ 302 Stainless Steel
Ball ............... 440C Stainless Steel

INSTALLATION

Tool Part Number ..... CCRT0900180S
For installation procedure see page B27.
**PERFORMANCE**

Metered Flow
Lohm Rate Tolerance: ± 5%

Leakage:
- 20 sccm/min. (max.)@172 kPa (25 psid) on air
- 1 Drop/min. (max.) on water

Cracking Pressure: 40 ± 30 kPa (6 ± 4.4 psid)

**MATERIALS**

- Body........... 303 Stainless Steel
- Cage ........... 305 Stainless Steel
- Spring ......... 302 Stainless Steel
- Ball............. 440C Stainless Steel

**INSTALLATION**

Tool Part Number ..... CCRT0900170S
For installation procedure see page B27.

---

**5.5mm RESTRICTOR CHEK** for PLASTIC INSTALLATION

**ACTUAL SIZE**

(As Installed)

All dimensions in millimeters.

---

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</thead>
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<td>COPM5501015S</td>
<td>1500</td>
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<tr>
<td>COPM5501020S</td>
<td>2000</td>
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</table>
IMH Screens are "last chance" safety screens designed to protect critical fluid control components against rogue contamination. They are not intended to serve as system filters. The screens are constructed of stainless steel woven wire mesh, bonded together using a proprietary process that offers superior integrity and life.

IMH Safety Screens for plastic are designed to be companion parts to other products in this section or used as stand alone components.
Features and Benefits

• Press-in design
  – Easy to install.

• Proprietary bonded mesh
  – Superior integrity and life.

• Various diameters
  – Design flexibility.

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5.5mm Safety Screen ........ B36
8.0mm Safety Screen ........ B37
Notes............................... B38
2.5mm SAFETY SCREEN for PLASTIC INSTALLATION

SCREEN

1.31 ± 0.15
Ø 2.54 ± 0.05
Ø 2.39

INSTALLATION HOLE

1.50 MIN.

Ø 2.36
2.26

Flow Direction

All dimensions in millimeters.

ACTUAL SIZE

optic

(As Installed)

MATERIALS

Body..............303 Stainless Steel
Screen..............316 Stainless Steel

INSTALLATION

Tool Part Number .....CCRT0029354S

To install, simply press the screen into a plastic installation hole, narrow end first, until the screen is flush minimum with the top of the installation hole.

<table>
<thead>
<tr>
<th>LEE PART NUMBER</th>
<th>MICRON RATING</th>
<th>LOHM RATE</th>
<th>OPEN AREA (mm²)</th>
<th>Rob#</th>
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SAFETY SCREENS FOR PLASTIC

5.5mm SAFETY SCREEN for PLASTIC INSTALLATION

<table>
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<tr>
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<th>INSTALLATION HOLE</th>
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<tr>
<td>2.3</td>
<td>2.5 MIN.</td>
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<tr>
<td>Ø 5.46 ± 0.05</td>
<td>Ø 5.32 ± 0.04</td>
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</table>

Flow Direction

All dimensions in millimeters.

ACTUAL SIZE

(As Installed)

MATERIALS

| Body | 303 Stainless Steel |
| Screen | 316 Stainless Steel |

INSTALLATION

Tool Part Number: CCRT0900170S

To install, simply press the screen into a plastic installation hole until the screen is flush minimum with the top of the installation hole. The screen can be installed in either direction.

<table>
<thead>
<tr>
<th>LEE PART NUMBER</th>
<th>MICRON RATING</th>
<th>LOHM RATE</th>
<th>OPEN AREA (mm²)</th>
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<td>2.8</td>
<td>0.49</td>
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</table>
8.0mm SAFETY SCREEN for PLASTIC INSTALLATION

All dimensions in millimeters.

**MATERIALS**

<table>
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<tr>
<th>Body</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Screen</td>
<td>316 Stainless Steel</td>
</tr>
</tbody>
</table>

**INSTALLATION**

Tool Part Number ..... CCRT0900180S

To install, simply press the screen into a plastic installation hole until the screen is flush minimum with the top of the installation hole. The screen can be installed in either direction.

<table>
<thead>
<tr>
<th>LEE PART NUMBER</th>
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</table>
The Lee Company IMH Group offers our highly accurate Orifice preinstalled into a male to female luer adaptor and features an integral safety screen to protect the orifice from contamination. Ideal for medical applications, the orifice and screen are 300 Series stainless steel and the fitting is made of medical grade polypropylene. Designed for both liquid and gas applications, the orifices are 100% flow tested on either distilled water or nitrogen to ensure that each part is within ±5% of its nominal flow rate. This provides far more accuracy than orifices specified by hole tolerance.

Orifices of very high lohm rates (very small hole diameters) are now available in a barb to barb union as standard. Lohm rates of as high as five million lohms, equivalent to as small as a 0.001mm (0.0004") diameter orifice, come flow tested to tolerances of ±5%. This incredible accuracy is simply not available anywhere else. These orifices are protected by a 4 micron screen. The orifice and screen are 300 Series stainless steel and the fitting is medical grade polypropylene. This product is intended for gas applications only.

The IMH Group also offers a series of Luer Tee fittings with a relief valve in the branch of the Tee. These are particularly useful for a syringe driven system where a maximum force is required. One version uses a 2.5mm relief valve and another uses a 5.5mm model for higher flow. A third version has a 2.5mm relief valve in the branch and a check valve in the downstream branch to prevent backflow as well as over pressure protection. The check valve has a cracking pressure of 4 kPa and the relief valves range from 100 to 300 kPa. As with all IMH valves, cracking pressure is highly repeatable and valve seat leakage is very low.
All of the high quality fittings used by IMH are made by Value Plastics, Inc. (www.valueplastics.com.) IMH products for plastics can be installed in a wide variety of fitting configurations and materials other than those shown as standard in this handbook. For more information on other materials or to discuss alternate fitting configurations please contact a Lee Sales Engineer.

**Features and Benefits**

- Preassembled
  - Ready to use.
- Numerous configurations
  - Design flexibility.
- Integral safety screens
  - Blocks rogue contamination.
  - Ensures reliability.
- 100% tested
  - Eliminates rework.
  - All parts within performance tolerance.
  - Consistent batch to batch performance.

---

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</tr>
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</table>
GAS ORIFICE - LEE IMH SCREENED ORIFICE
IN MALE TO FEMALE LUER

**MATERIALS**
- Fitting ............... Polypropylene - Natural
- Orifice ............... 303 Stainless Steel
- Screen Body .......... 303 Stainless Steel
- Screen ............... 316 Stainless Steel

**PERFORMANCE**
- Metered Flow
- Lohm Rate Tolerance: ± 5%
- Screen Size: 40 Micron
- Test Fluid: Clean & Dry Nitrogen

**Lee Part No.** | **Lohm Rate**
--- | ---
RESM1505000S | 5,000
RESM1505500S | 5,500
RESM1506000S | 6,000
RESM1506500S | 6,500
RESM1507000S | 7,000
RESM1507500S | 7,500
RESM1508000S | 8,000
RESM1508500S | 8,500
RESM1509000S | 9,000
RESM1509500S | 9,500
RESM1510000S | 10,000
RESM1515000S | 15,000
RESM1520000S | 20,000
RESM1525000S | 25,000
RESM1530000S | 30,000
RESM1535000S | 35,000
RESM1540000S | 40,000
RESM1545000S | 45,000

All dimensions in millimeters.
LIQUID ORIFICE – LEE IMH SCREENED ORIFICE IN MALE TO FEMALE LUER

**MATERIALS**

- Fitting.............Polypropylene - Natural
- Orifice.............303 Stainless Steel
- Screen Body...303 Stainless Steel
- Screen.............316 Stainless Steel

**LEE PART NO.** | **LOHM RATE**
--- | ---
RESM0505000S | 5,000
RESM0505500S | 5,500
RESM0506000S | 6,000
RESM0506500S | 6,500
RESM0507000S | 7,000
RESM0507500S | 7,500
RESM0508000S | 8,000
RESM0508500S | 8,500
RESM0509000S | 9,000
RESM0509500S | 9,500
RESM0510000S | 10,000
RESM0515000S | 15,000
RESM0520000S | 20,000
RESM0525000S | 25,000
RESM0530000S | 30,000
RESM0535000S | 35,000
RESM0540000S | 40,000
RESM0545000S | 45,000

**PERFORMANCE**

- Metered Flow
- Lohm Rate Tolerance: ± 5%
- Screen Size: 40 Micron
- Test Fluid: Distilled Water

---

**ACTUAL SIZE**

(As Installed)

All dimensions in millimeters.
### MATERIALS

- **Fitting**: Polypropylene - Blue
- **Orifice**: 303 Stainless Steel
- **Screen Body**: 303 Stainless Steel
- **Screen**: 316 Stainless Steel

### PERFORMANCE

- **Metered Flow**
  - Lohm Rate Tolerance: ± 5%
- **Screen Size**: 4 Micron
- **Test Fluid**: Clean & Dry Nitrogen

### LEE PART NUMBER

<table>
<thead>
<tr>
<th>LEE PART NUMBER</th>
<th>LOHM RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>RHGV1530060S</td>
<td>60,000</td>
</tr>
<tr>
<td>RHGV1530075S</td>
<td>75,000</td>
</tr>
<tr>
<td>RHGV1530100S</td>
<td>100,000</td>
</tr>
<tr>
<td>RHGV1530250S</td>
<td>250,000</td>
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<tr>
<td>RHGV1530500S</td>
<td>500,000</td>
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<tr>
<td>RHGV1530750S</td>
<td>750,000</td>
</tr>
<tr>
<td>RHGV1531000S</td>
<td>1,000,000</td>
</tr>
<tr>
<td>RHGV1532000S</td>
<td>2,000,000</td>
</tr>
<tr>
<td>RHGV1533000S</td>
<td>3,000,000</td>
</tr>
<tr>
<td>RHGV1534000S</td>
<td>4,000,000</td>
</tr>
<tr>
<td>RHGV1535000S</td>
<td>5,000,000</td>
</tr>
</tbody>
</table>

**ACTUAL SIZE**

(As Installed)

*All dimensions in millimeters.*
2.5mm RELIEF VALVE IN Luer TEE

**PERFORMANCE**

- Relief Valve Lohm Rate: 750 Lohms
- Leakage: 1 Drop/min. (max.) on water
- Cracking Pressure Tolerance: ± 15%

**MATERIALS**

- Fitting.............. Polypropylene - Blue
- Relief Valve
  - Body .......... 303 Stainless Steel
  - Ball Stop .... 303 Stainless Steel
  - Spring ......... 302 Stainless Steel
  - Ball ............ 440C Stainless Steel

<table>
<thead>
<tr>
<th>LEE PART NUMBER</th>
<th>CRACKING PRESSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCPF0100100S</td>
<td>100 kPa (14.5 psid)</td>
</tr>
<tr>
<td>CCPF0100200S</td>
<td>200 kPa (29 psid)</td>
</tr>
<tr>
<td>CCPF0100300S</td>
<td>300 kPa (43.5 psid)</td>
</tr>
</tbody>
</table>

All dimensions in millimeters.
5.5mm RELIEF VALVE IN LUER TEE

**ACTUAL SIZE**

(As Installed)

**PERFORMANCE**

Relief Valve Lohm Rate: 250 Lohms  
Leakage: 1 Drop/min. (max.) on water  
Cracking Pressure Tolerance: ± 15%

<table>
<thead>
<tr>
<th>LEE PART NUMBER</th>
<th>CRACKING PRESSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCPF0300100S</td>
<td>100 kPa (14.5 psid)</td>
</tr>
<tr>
<td>CCPF0300200S</td>
<td>200 kPa (29 psid)</td>
</tr>
<tr>
<td>CCPF0300300S</td>
<td>300 kPa (43.5 psid)</td>
</tr>
<tr>
<td>CCPF0300400S</td>
<td>400 kPa (58 psid)</td>
</tr>
<tr>
<td>CCPF0300500S</td>
<td>500 kPa (72.5 psid)</td>
</tr>
</tbody>
</table>

**MATERIALS**

Fitting.........Polypropylene - Blue  
Relief Valve  
- Body ..........303 Stainless Steel  
- Cage ..........305 Stainless Steel  
- Spring .........302 Stainless Steel  
- Ball ...........440C Stainless Steel

*All dimensions in millimeters.*
PERFORMANCE

- Relief Valve Lohm Rate: 750 Lohms
- Relief Valve Cracking Pressure Tolerance: ± 15%
- Relief Valve Leakage: 1 Drop/min. (max.) on water
- Check Valve Lohm Rate: 750 Lohms
- Check Valve Cracking Pressure: 4 ± 3 kPa (0.6 ± 0.4 psid)
- Check Valve Leakage: 1 Drop/min. (max.) on water

MATERIALS

- Fitting: Polypropylene - Blue
- Relief and Check Valve Body: 303 Stainless Steel
- Ball Stop: 303 Stainless Steel
- Spring: 302 Stainless Steel
- Ball: 440C Stainless Steel

<table>
<thead>
<tr>
<th>LEE PART NUMBER</th>
<th>CRACKING PRESSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCPF0200100S</td>
<td>100 kPa (14.5 psid)</td>
</tr>
<tr>
<td>CCPF0200200S</td>
<td>200 kPa (29 psid)</td>
</tr>
<tr>
<td>CCPF0200300S</td>
<td>300 kPa (43.5 psid)</td>
</tr>
</tbody>
</table>
The Engineering Reference Section of the IMH Handbook is a handy compilation of facts that every hydraulics engineer can use. It starts with a comprehensive discussion of Lohm Laws which make every hydraulic and pneumatic calculation easy. It includes formulas for comparing the effectiveness of different mesh size safety screens called ROB numbers, and finally, extensive reference material including standards, conversion factors, graphic symbols and definitions.

**LOHM LAWS – DEFINITION**

Every engineer will be interested in our simple system of defining the fluid resistance of Lee hydraulic components.

Just as the OHM is used in the electrical industry, we find that we can use a liquid OHM or “Lohm” to good advantage on all hydraulic computations.

When using the Lohm system, you can forget about coefficients of discharge and dimensional tolerances on drilled holes. These factors are automatically compensated for in the Lohm calculations, and confirmed by testing each component to establish flow tolerances. The resistance to flow of any fluid component can be expressed in Lohms.

The Lohm has been selected so that a 1 Lohm restriction will permit a flow of 100 gallons per minute of water with a pressure drop of 25 psi at a temperature of 80° F.

The graph on page C3 relates Lohms to hole diameter in inches and millimeters.

**LOHM SYSTEM SLIDE RULE**

The Lee Company offers a specially designed Hydraulic and Pneumatic Flow Calculator to help in the transition to the Lohm System. This handy, free slide rule can be used to solve basic Lohm calculations.
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- Momentum Forces ........ C21
- Water Hammer ............... C22
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- Momentum Forces –
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LIQUID FLOW

The Lohm has been selected so that a 1 Lohm restriction will permit a flow of 100 gallons per minute of water with a pressure drop of 25 psi at a temperature of 80°F.

\[ I = \text{Flow rate (gallons per minute).} \]
\[ H = \text{Differential pressure (psi).} \]
\[ L = \text{Lohms, a measure of resistance to liquid flow. It includes all density, viscosity, Reynolds number, coefficient of discharge & area units.} \]

\[ L = 20 \frac{\sqrt{H}}{I} \quad \text{and} \quad I = 20 \frac{\sqrt{H}}{L} \]

\[ H = \frac{I^2 \times L^2}{400} \]

When testing on water at 25 psi $\Delta P$, $\sqrt{H} = 5$ and the above formulas simplify as follows:

\[ L = \frac{100}{I} \quad \text{and} \quad I = \frac{100}{L} \]

Some useful relationships:

1. 1000 Lohms will permit a flow of 50 lb/hr water at 25 psi $\Delta P$.

2. Flow Coefficient, $C_v = \frac{20}{L}$

3. \[ L = \frac{0.76}{d^2} \quad L = \frac{0.527}{C_d A} \]
   \[ d = \text{Orifice diameter (inches)} \]
   \[ C_d = \text{Coefficient of discharge} \]
   \[ A = \text{Orifice area (inches)}^2 \]

4. For metric units \[ L = \frac{490}{d^2} \]
   where \(d\) = orifice diameter in millimeters
LIQUID FLOW - EXAMPLES

Problem 1. What restriction will permit a flow of 1 gallon of water per hour at 50 psi ∆P?

\[ I = \frac{1}{60} = 0.0167 \text{ GPM} \]

\[ L = \frac{20 \sqrt{H}}{I} = \frac{20 \sqrt{50}}{0.0167} = 8500 \text{ Lohms} \]

Problem 2. An orifice with a hole diameter of .012" flows 18 lb/hr of water at 100 psi ∆P. How many Lohms?

\[ I = \frac{18}{60 \times 8.345} = 0.036 \text{ GPM} \]

\[ L = \frac{20 \sqrt{H}}{I} = \frac{20 \sqrt{100}}{0.036} = 5500 \text{ Lohms} \]

Problem 3. What ∆P will be required to flow 20 GPH of water through a 2000 Lohm orifice?

\[ I = \frac{20}{60} = 0.333 \text{ GPM} \]

\[ H = \frac{I^2 \times L^2}{400} = \frac{0.333^2 \times 2000^2}{400} = \frac{0.111 \times 4,000,000}{400} = 1110 \text{ psi } \Delta P \]

Problem 4. What water flow will result from a restriction of 500 Lohms and a ∆P of 500 psi?

\[ I = \frac{20 \sqrt{H}}{L} = \frac{20 \sqrt{500}}{500} = 0.894 \text{ GPM} \]

NOTE: For special flow requirements, The Lee Company can determine the required Lohm rating.
LIQUID FLOW - TWO FORMULAS
FOR COMBINATIONS OF RESTRICTORS

PARALLEL FLOW, the total Lohm rating is:

$$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \ldots + \frac{1}{L_N}$$

Please note that this relationship is identical to the electrical equation.
EXAMPLE: Parallel flow

L1 = 2000 Lohms
L2 = 3000 Lohms
L3 = 5000 Lohms

$$\frac{1}{L_T} = \frac{1}{2000} + \frac{1}{3000} + \frac{1}{5000} = 0.00103$$

and therefore

$$L_T = 970$$

SERIES FLOW, the total Lohm rating is:

$$L_T = \sqrt{L_1^2 + L_2^2 + L_3^2 + \ldots + L_N^2}$$

Please note that this relationship is not the same as in electrical problems. The difference is due to the non-linearity of

$$H = \frac{I^2 L^2}{400}$$

EXAMPLE: Series flow:

L1 = 2000 Lohms
L2 = 3000 Lohms
L3 = 5000 Lohms

$$L_T = \sqrt{2000^2 + 3000^2 + 5000^2} = 6160$$

When L1 = L2 = L3 , then L_T = L_N

N = Number of equal resistors in series

For passageway size: $D_T = D / N^{1/4}$

$D_T$ = Diameter of a single equivalent orifice, with a Lohm rate = $L_T$

D = Diameter of the actual orifices, each with a Lohm rate = $L_1$
One of the reasons for using two restrictors in series is to allow fine tuning of a total resistance value. If $L_1$ is known and is more than 90% of $L_T$, then $L_2$ may vary by ±5% without altering the value of $L_T$ by more than ±1%, even though the value of $L_2$ may be as high as 40% of $L_T$. This effect becomes even more pronounced as $L_1$ approaches $L_T$.

To determine the intermediate pressure between two resistances in series, the following formulas may be used.

$$\Delta P_1 = \frac{P_T}{1 + (L_2/L_1)^2}$$

$$\Delta P_2 = \frac{P_T}{1 + (L_1/L_2)^2}$$

$$\left(\frac{L_1}{L_2}\right)^2 = \frac{P_1}{P_2}$$
**LIQUID FLOW - FLOW FORMULA**

The following formulas are presented to extend the use of the Lohm laws to many different liquids, operating over a wide range of pressure conditions.

**NOMENCLATURE**

\[ \begin{align*}
L & = \text{Lohms} \\
H & = \text{Differential pressure} \\
I & = \text{Liquid flow rate: Volumetric} \\
S & = \text{Specific gravity* (see pages C15 – C16)} \\
V & = \text{Viscosity compensation factor** (see page C12)} \\
w & = \text{Liquid flow rate: Gravimetric} \\
K & = \text{Units Constant – Liquid (see page C9)}
\end{align*} \]

*\[S = 1.0 \text{ for water at 80°F.}\]*

**\[V = 1.0 \text{ for water at 80°F.}\]**

**LIQUID FLOW**

These formulas introduce compensation factors for liquid density and viscosity. They are applicable to any liquid of known properties, with minimum restrictions on pressure levels or temperature.

The units constant (K) eliminates the need to convert pressure and flow parameters to special units.

**Volumetric Flow Units**

\[ L = \frac{KV}{I} \sqrt{\frac{H}{S}} \]

**Gravimetric Flow Units**

\[ L = \frac{KV}{w} \sqrt{HS} \]
LIQUID FLOW – UNITS CONSTANT K

Volumetric Flow Units

\[ L = \frac{KV}{I} \sqrt{\frac{H}{S}} \]

### VOLUMETRIC FLOW UNITS

<table>
<thead>
<tr>
<th>Flow Units</th>
<th>Pressure Units</th>
<th>( \text{psi} )</th>
<th>bar</th>
<th>kPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPM</td>
<td>20</td>
<td>76.2</td>
<td>7.62</td>
<td></td>
</tr>
<tr>
<td>L/min</td>
<td>75.7</td>
<td>288</td>
<td>28.8</td>
<td></td>
</tr>
<tr>
<td>ml/min</td>
<td>75700</td>
<td>288000</td>
<td>28800</td>
<td></td>
</tr>
<tr>
<td>in(^3)/min</td>
<td>4620</td>
<td>17600</td>
<td>1760</td>
<td></td>
</tr>
</tbody>
</table>

Gravimetric Flow Units

\[ L = \frac{KV}{\sqrt{w}} \sqrt{HS} \]

### GRAVIMETRIC FLOW UNITS

<table>
<thead>
<tr>
<th>Flow Units</th>
<th>Pressure Units</th>
<th>( \text{psi} )</th>
<th>bar</th>
<th>kPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPH</td>
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<td>38100</td>
<td>3810</td>
<td></td>
</tr>
<tr>
<td>gm/min</td>
<td>75700</td>
<td>288000</td>
<td>28800</td>
<td></td>
</tr>
</tbody>
</table>
LIQUID FLOW CALCULATIONS - EXAMPLES

Problem 1. An orifice is required to flow 0.15 GPM of MIL-H-83282 hydraulic fluid at 80°F and 100 psi ∆P. What restriction is required?

Solution:
1. Read specific gravity; $S = 0.84$ from chart on page C15.
2. Read viscosity; $\nu = 21$cs. From chart on page C13.
3. Use viscosity and $\Delta P$ to determine viscosity compensation factor $V = 0.95$ from graph on page C12.
4. Select units constant, $K = 20$ from table on page C9.

\[
\frac{L}{I} = \frac{KV}{T} \sqrt{\frac{H}{S}} = \frac{20 \times 0.95}{0.15} \sqrt{\frac{100}{0.84}} = 1380 \text{ Lohms}
\]

Problem 2. What pressure drop will result from a flow of 5 PPH of SAE #10 lubricating oil at 20°F, flowing through a 1000 Lohm orifice?

Solution:
1. Read specific gravity and viscosity.
   $S = 0.90$, $\nu = 600$cs.
2. Use knowledge of system to assume solution.
   $H = 50$ psid.
3. Use assumed $\Delta P$ to determine $V = 0.18$
4. Select units constant, $K = 10,000$ from table on page C9.
5. Compute trial $\Delta P$.

\[
H = \frac{w^2 L^2}{S K^2 V^2} = \frac{5^2 \times (1000)^2}{0.90 \times (10,000)^2 \times 0.18^2} = 8.6 \text{ psid}
\]

6. Make trials as required to find correct solution.
$H = 26 \text{ psid}$. 

LIQUID FLOW - EXAMPLES

Problem 3. A Safety Screen is required to flow 775 lb/hr of diesel fuel @ 80°F with a maximum pressure drop of 5 psid. What is the maximum Lohm rate allowed for the Safety Screen?

Solution:
1. Find specific gravity; \( S = 0.87 \) from curve on page C15.
2. Find viscosity; \( \nu = 3.1 \text{cs} \) from curve on page C13.
3. Use \( \nu \) and \( \Delta P \) to determine viscosity compensation factor, \( V = 0.87 \) from curve on page C12.
4. Select units constant, \( K = 10,000 \) from table on page C9.

\[
L = \frac{KV}{w} \sqrt{\frac{HS}{775}} = \frac{10000(0.87)}{775} \sqrt{5(0.87)} = 23 \text{ Lohms Maximum}
\]
VISCOSITY COMPENSATION FACTOR
FOR SINGLE ORIFICE

\[ \Delta P: \text{PSI} \quad \text{or} \quad \text{kPa} \]
VISCOSITIES OF TYPICAL FLUIDS vs TEMPERATURE
VISCOSITIES OF TYPICAL FLUIDS vs TEMPERATURE
SPECIFIC GRAVITY OF TYPICAL FLUIDS vs TEMPERATURE
SPECIFIC GRAVITY OF TYPICAL FLUIDS vs TEMPERATURE

(SPECIFIC GRAVITY (WITH RESPECT TO H2O AT 60°F))

TEMPERATURE °F

120 140 160 180 200 220 240 260 280 300
Whenever there is flow through an orifice, there is a power consumption (or loss) which is a function of the pressure drop and the flow rate. The following data is useful in calculating the hydraulic power requirements of a system.

\[
H.P. = \frac{H \times I}{1714} \quad \text{When } H = \text{ psi } \Delta P \quad I = \text{ GPM flow rate}
\]

The hydraulic power can also be expressed in another convenient form.

\[
H.P. = \frac{0.0117 H^{3/2}}{L} \quad \text{or} \quad 0.0117 \frac{H^{\sqrt{H}}}{L}
\]

Since 1 H.P. = 746 watts, the above formula can be:

\[
\text{Watts} = \frac{8.70 H^{3/2}}{L} \quad \text{or} \quad 8.70 \frac{H^{\sqrt{H}}}{L}
\]

The nomogram on the opposite page shows this relationship.

**EXAMPLE:**

A Lee IMH Chek Valve with 400 Lohms will flow 0.35 GPM at 50 psid. At those conditions, what horsepower is lost?

\[
H.P. = \frac{H \times I}{1714} = \frac{50 \times 0.35}{1714}
\]

\[
H.P. = 0.010
\]
NOMOGRAM FOR HYDRAULIC POWER

\[
W = 8.70 \frac{H^{3/2}}{L}
\]

\[
HP = 0.117 \frac{H^{3/2}}{L}
\]

EXAMPLE

\[H \quad \text{(PSI)} \quad HP \quad \text{(HORSEPOWER)} \quad W \quad \text{(WATTS)} \quad L \quad \text{(LOHMS)}\]
TEMPERATURE RISE IN HYDRAULIC FLUIDS

Hydraulic fluid heats when flowing through a restriction as the pressure energy upstream of the restriction is converted into thermal energy.

\[ \Delta T = \frac{0.003 \ (\Delta P)}{(S) \ (c)} \]

<table>
<thead>
<tr>
<th>FLUID</th>
<th>c~BTU/ lb./ °F*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>1.00</td>
</tr>
<tr>
<td>JP-4</td>
<td>0.50</td>
</tr>
<tr>
<td>MIL-H-5606</td>
<td>0.47</td>
</tr>
<tr>
<td>MIL-H-83282</td>
<td>0.50</td>
</tr>
<tr>
<td>Skydrol 500 B-4</td>
<td>0.39</td>
</tr>
<tr>
<td>Silicone 100cs</td>
<td>0.35</td>
</tr>
<tr>
<td>Gasoline</td>
<td>0.50</td>
</tr>
</tbody>
</table>

\( \Delta T = \text{Temp. rise in °F} \)
\( \Delta P = \text{Pressure drop in psi} \)
\( S = \text{Specific gravity} \)
\( c = \text{Specific heat} \)

*Specific Heat at 100°F.

EXAMPLE:

If a Lee orifice is flowing MIL-H-83282 at 120°F and 2500 psid, the temperature rise across the Lee orifice is computed as follows:

For MIL-H-83282 at 120°F, S = 0.82, c = 0.50

\[ \Delta T = \frac{(0.003) \ (2500)}{(0.82) \ (0.50)} = 18.3°F \]
1. Connect c to S
2. From point on reference line, connect P and extend to T.
MOMENTUM FORCES

The momentum Lohm Laws give the designer simple formulas to determine the forces caused by changes in velocity (either speed or direction) of a liquid.

\[
F = \frac{SI^2L}{400} \quad F = \frac{H}{L} \quad F = \frac{I\sqrt{HS}}{20}
\]

- \(F\) = Force in lbs.
- \(H\) = psid
- \(I\) = GPM
- \(S\) = Spec. gravity

These forces are produced by locally high (or low) pressure gradients, and should be added to the forces produced by the static pressure. It is often useful to sketch these pressure gradients to determine the direction of the momentum forces.

EXAMPLE: Where a liquid changes direction.

\[
F_{\text{momentum}} = \frac{H}{L} = \frac{990}{600} = 1.7 \text{ lbf}
\]

The momentum force of 1.6 lbs. in this example must be added to the force produced by static pressure on the plate (of 0.1 in.\(^2\) x 10 psi = 1 lb.) to give the total force on the plate.

EXAMPLE: Where a liquid changes speed.

\[
F_{\text{momentum}} = \frac{SI^2L}{400} = \frac{1 \times 2^2 \times 100}{400} = 1 \text{ lbf}
\]

The momentum force of 1lb. in this example must be subtracted from the force produced by static pressure on the plate (of 0.1 x [3000-2900] = 10 lb.) to give the total force on the piston.
WATER HAMMER

A brief pressure spike, commonly called water hammer, occurs when a high velocity fluid is suddenly stopped. It is often brought on by the fast closing of a valve somewhere in the system. The hydraulic system designer can approximate the magnitude of the pressure spike with the following formula that assumes a “hard” system with non-compliant fluid passages, and will, therefore, yield a worst case value for the peak pressure.

\[ \Delta P = \frac{I}{2D^2} \sqrt{S \cdot B} \]

- \( \Delta P \) = Pressure rise caused by water hammer effects (psi)
- \( I \) = Flow rate (GPM)
- \( S \) = Specific gravity, see pages C15 – C16.
- \( B \) = Bulk modulus (psi)
- \( D \) = Inside diameter of fluid passageway upstream of the Lee component (in.)

**EXAMPLE:** An IMH component is flowing 1 GPM of MIL-H-83282 at 80°F with 4000 psi upstream and 3500 psi downstream. The component is being fed through a 0.15 in. dia. passage upstream. If a valve is suddenly shut downstream of the component, the pressure spike will be:

\[ \Delta P = \frac{1}{20 (0.15)^2} \sqrt{0.84 \cdot (300,000)} = 1,100 \text{ psi} \]

The maximum upstream pressure would then be:
(4000 psi steady state) + (1100 psi spike) = 5100 psi total
BULK MODULUS

Bulk Modulus is a measure of the resistance of a fluid to compression. It is defined as the ratio of pressure stress to volumetric strain. The value of bulk modulus equals the pressure change $x$ 100 required to cause a one percent change in volume.

$$B = - \frac{\Delta P}{\Delta V} \times V$$

EXAMPLE:

MIL-H-83282 oil has a bulk modulus of $3.0 \times 10^5$ psi. Thus, a pressure increase of 3000 psi will reduce its volume by 1.0%.

When the value of $B$ is known (see reference table on next page), it is easy to calculate the effect of any pressure change on volume, or of any volume change on pressure.

$$\Delta V = - \frac{V}{B} \times \Delta P \quad \text{or} \quad \Delta P = - \frac{B}{V} \times \Delta V$$

COEFFICIENT OF THERMAL EXPANSION

The Coefficient of Cubical Thermal Expansion is the change in volume per unit volume caused by a change in temperature of 1°F.

$$\Delta V = V \times \gamma \times \Delta T$$

EXAMPLE:

MIL-H-83282 oil has a coefficient of cubical thermal expansion of 0.00046/°F. Thus a temperature rise of 100°F will increase its volume by 4.6%.

The bulk modulus and the coefficient of cubical thermal expansion can be used together to compute the pressure rise in a closed system subjected to an increasing temperature.

Pressure Rise: $$\Delta P = B \times \gamma \times \Delta T$$
**BULK MODULUS**

**EXAMPLE:**

MIL-H-83282 oil at 0 psi is heated from 70°F to 120°F in a closed, constant volume system containing 100 cu. in.

\[ \Delta P = 3.0 \times 10^5 \times 0.00046 \times 50 = 6900 \text{ psi} \]

This is the same \( \Delta P \) which would be caused by adding 2.3 cubic inches of oil with no temperature change. It is also apparent that a constant system pressure could be maintained by bleeding off 2.3 cubic inches of oil while increasing the temperature by 50°F.

**REFERENCE TABLE**

<table>
<thead>
<tr>
<th>FLUID</th>
<th>( B_{\text{ref.}} )</th>
<th>( \gamma )</th>
<th>FLASH POINT*</th>
<th>POUR POINT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Units psi</td>
<td>( \Delta V/V/\degree F )</td>
<td>( \degree F, \min. )</td>
<td>( \degree F, \max. )</td>
</tr>
<tr>
<td>Gasoline</td>
<td>150 000</td>
<td>0.00072</td>
<td>-50°</td>
<td>-75°</td>
</tr>
<tr>
<td>JP-4</td>
<td>200 000</td>
<td>0.00057</td>
<td>0°</td>
<td>-76°</td>
</tr>
<tr>
<td>MIL-H-5606</td>
<td>260 000</td>
<td>0.00046</td>
<td>200°</td>
<td>-75°</td>
</tr>
<tr>
<td>MIL-H-83282</td>
<td>300 000</td>
<td>0.00046</td>
<td>400°</td>
<td>-65°</td>
</tr>
<tr>
<td>MIL-H-6083</td>
<td>260 000</td>
<td>0.00044</td>
<td>200°</td>
<td>-75°</td>
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<tr>
<td>SKYDROL 500B-4</td>
<td>340 000</td>
<td>0.00047</td>
<td>340°</td>
<td>-80°</td>
</tr>
<tr>
<td>Silicone 100cs</td>
<td>150 000</td>
<td>0.00054</td>
<td>575°</td>
<td>-65°</td>
</tr>
<tr>
<td>Water</td>
<td>310 000</td>
<td>0.00021</td>
<td>—</td>
<td>+32°</td>
</tr>
</tbody>
</table>

\( B_{\text{ref.}} = \) Tangent adiabatic bulk modulus psi stated at 100°F, 2500 psi and no entrained air. A reference point.

\( \gamma = \) Coefficient of cubical thermal expansion/°F at 100°F

\( \Delta P = \) Pressure rise, psi

\( \Delta T = \) Temperature rise, °F

\( P_1, P_2 = \) Initial and final pressures, psi

*Flash point is the lowest temperature at which sufficient combustible vapor is driven off a fuel to flash when ignited in the presence of air.*
BULK MODULUS (ACTUAL)

The previous examples used a constant bulk modulus for simplicity. In actual use, the bulk modulus is affected by the working pressure, temperature and percent of entrained air. Use the next 3 graphs to find the effect of these variables, and you will get a close approximation of actual conditions. The actual bulk modulus, $B$, of a fluid is the value in the table on page C24 as $B_{\text{ref.}}$ modified for the effect of pressure, temperature and percent of entrained air.

The actual bulk modulus $B = E_P \times E_T \times E_A \times B_{\text{ref.}}$

EXAMPLE:
500 psi, 60°F, 2% entrained air, MIL-H-83282.
Actual $B = 0.91 \times 1.10 \times 0.8 \times 300,000 = 240,000$ psi

EXAMPLE:
Actual $B = 0.98 \times 0.86 \times 0.98 \times 300,000 = 248,000$ psi

With the corrected bulk moduli for the two end points of a thermal problem, an average bulk modulus can be selected for calculation purposes. We would use 244,000 psi for $B$. 
BULK MODULUS

WORKING PRESSURE
The effect of working pressure on bulk modulus for hydrocarbon fluids.

TEMPERATURE
The effect of temperature on bulk modulus for hydrocarbon fluids.
The effect of entrained air on bulk modulus in hydrocarbon and other fluids for different working pressures.

To simplify the calculations of thermal problems with entrained air, these curves show the average effect on a 230,000 psi bulk modulus for pressure points fairly close together. If a wide change in pressure is encountered in a problem, it would be more accurate to break the changes down into two or more steps, depending on the accuracy desired.

An accurate one step formula for this relationship follows:

(Note that pressure is in units of psia.)

\[ E_A = \frac{1}{0.147 \frac{B_{ref}}{P_1} \times \frac{x}{\% \text{ air} + 1}} \times \frac{P_1 \times P_2}{14.7} \]
CAVITATION

Liquid flowing through any orifice will cavitate whenever its velocity causes the pressure in the throat of the orifice to drop below the vapor pressure of the flowing liquid. Even though there may be a high supply pressure and a high back pressure on the orifice, if the velocity is high enough there will be a subsequent lowering of the pressure in the throat of the orifice and the possibility of cavitation.

The effects of cavitation are choked flow and erosion – both of which are undesirable. To prevent cavitation, the throat pressure must be maintained, either by:

1. Applying sufficiently high back pressure, or
2. Reducing the velocity of the liquid as it flows through a restrictor.
The Lohm Laws extend the definition of Lohms for gas flow at any pressure and temperature, and with any gas. The formulas work well for all gases because they are corrected for the specific gas, and for the flow region and incompressibility of low pressure gases.

A 100 Lohm restriction will permit a flow of 250 standard liters per minute of nitrogen at a temperature of 59°F, and an upstream pressure of 90 psia discharging to atmosphere.

\[
L = \frac{K}{Q} \quad \text{(Sonic region)} \quad \text{i.e. } P_1/P_2 \geq 1.9
\]

\[
L = \frac{2Kf_T\sqrt{\Delta P}P_2}{Q} \quad \text{(Subsonic region)} \quad \text{i.e. } P_1/P_2 < 1.9
\]

**NOMENCLATURE**

- \(L\) = Lohms
- \(K\) = Units Constant – Gas (see page C31)
- \(f_T\) = Temperature correction factor (see page C30)
- \(P_1\) = Upstream absolute pressure
- \(P_2\) = Downstream absolute pressure
- \(Q\) = Gas flow rate
- \(\Delta P\) = \(P_1 - P_2\)

1. Compute the \(P_1/P_2\) pressure ratio.
2. Select the correct formula for the flow region.
3. Look up the value of “\(K\)” for the gas.
4. Determine the temperature correction factor, “\(f_T\)”.
5. Use the formula to solve for the unknown.
EXAMPLE: What restriction will permit a flow of 1.00 std L/min. of nitrogen at 90°F, with supply pressure at 5 psig, discharging to atmosphere?

\[ K = 276 \text{ (see page C31)} \]
\[ T_1 = 90^\circ F, \quad f_T = 0.98 \text{ (see below)} \]
\[ P_1 = 5.0 + 14.7 = 19.7 \text{ psia, } P_2 = 14.7 \text{ psia} \]
\[ P_1 / P_2 = 19.7/14.7 = 1.34 \text{ (subsonic)} \]
\[ \Delta P = 5.0 \text{ psid} \]
\[ Q = 1.00 \text{ std L/min.} \]
\[ L = \frac{2(276)0.98 \sqrt{5.0(14.7)}}{1.00} = 4640 \text{ Lohms} \]

**TEMPERATURE CORRECTION FACTOR**  
\[ f_T = \sqrt{\frac{530}{T^\circ F + 460}} \]

\[ f_T = 1.0 @ \text{ room temperature (70°F)} \]
GAS FLOW - UNITS CONSTANT “K”

To eliminate the need to convert pressure and flow parameters into specific units such as “psia” and “std L/min.,” the table below lists values of the Units Constant “K,” which is used in the Gas Flow Lohm Formulas:

\[
\text{Lohms} = \frac{K f_T P_1}{Q} \quad \text{(Sonic: } P_1 / P_2 \geq 1.9)\
\]

\[
\text{Lohms} = \frac{2K f_T \sqrt{\Delta P} P_2}{Q} \quad \text{(Subsonic: } P_1 / P_2 < 1.9)\
\]

<table>
<thead>
<tr>
<th>VOLUMETRIC FLOW UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abs. Pres</strong></td>
</tr>
<tr>
<td><strong>Flow</strong></td>
</tr>
<tr>
<td>H₂</td>
</tr>
<tr>
<td>He</td>
</tr>
<tr>
<td>Neon</td>
</tr>
<tr>
<td>Nat. Gas</td>
</tr>
<tr>
<td>N₂</td>
</tr>
<tr>
<td>CO</td>
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<td>Air</td>
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<td>Ethane</td>
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<tr>
<td>O₂</td>
</tr>
<tr>
<td>Argon</td>
</tr>
<tr>
<td>CO₂</td>
</tr>
<tr>
<td>N₂O</td>
</tr>
<tr>
<td>SO₂</td>
</tr>
<tr>
<td>Freon-12</td>
</tr>
</tbody>
</table>
GAS FLOW - UNITS CONSTANT “K”

Lohms = \frac{K f_T P_1}{Q} \quad \text{(Sonic)}

Lohms = \frac{2 K f_T \sqrt{\Delta P} P_2}{Q} \quad \text{(Subsonic)}

<table>
<thead>
<tr>
<th>Abs. Pres</th>
<th>psia</th>
<th>lbm/s</th>
<th>kg/min</th>
<th>bar</th>
<th>kPa</th>
<th>mm.Hg</th>
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</thead>
<tbody>
<tr>
<td>Flow</td>
<td>PPH</td>
<td>kg/min</td>
<td>kg/min</td>
<td>kg/min</td>
<td>gm/min</td>
<td></td>
</tr>
<tr>
<td>H₂</td>
<td>11.6</td>
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<td>0.0876</td>
<td>168</td>
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<tr>
<td>He</td>
<td>17.3</td>
<td>0.00479</td>
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<td>250</td>
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<td>0.0189</td>
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<tr>
<td>Neon</td>
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<td>0.293</td>
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<td>0.0425</td>
</tr>
<tr>
<td>Nat. Gas</td>
<td>34.8</td>
<td>0.00966</td>
<td>0.263</td>
<td>505</td>
<td>3.82</td>
<td>0.0382</td>
</tr>
<tr>
<td>N₂</td>
<td>43.2</td>
<td>0.0120</td>
<td>0.326</td>
<td>626</td>
<td>4.73</td>
<td>0.0473</td>
</tr>
<tr>
<td>CO</td>
<td>43.0</td>
<td>0.0119</td>
<td>0.325</td>
<td>623</td>
<td>4.71</td>
<td>0.0471</td>
</tr>
<tr>
<td>Air</td>
<td>43.8</td>
<td>0.0122</td>
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<td>4.81</td>
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<td>Ethane</td>
<td>42.2</td>
<td>0.0117</td>
<td>0.319</td>
<td>611</td>
<td>4.62</td>
<td>0.0462</td>
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<tr>
<td>O₂</td>
<td>46.0</td>
<td>0.0128</td>
<td>0.348</td>
<td>667</td>
<td>5.04</td>
<td>0.0504</td>
</tr>
<tr>
<td>Argon</td>
<td>54.6</td>
<td>0.0152</td>
<td>0.413</td>
<td>792</td>
<td>5.99</td>
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<tr>
<td>CO₂</td>
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<td>0.396</td>
<td>759</td>
<td>5.74</td>
<td>0.0574</td>
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<tr>
<td>N₂O</td>
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<td>0.0146</td>
<td>0.398</td>
<td>764</td>
<td>5.77</td>
<td>0.0577</td>
</tr>
<tr>
<td>SO₂</td>
<td>63.0</td>
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<td>0.476</td>
<td>914</td>
<td>6.91</td>
<td>0.0691</td>
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<tr>
<td>Freon-12</td>
<td>83.2</td>
<td>0.0231</td>
<td>0.629</td>
<td>1210</td>
<td>9.12</td>
<td>0.0912</td>
</tr>
</tbody>
</table>
When selecting components for use in a gas system, certain factors must be considered which arise only because of the compressibility of the gaseous medium. The nature of gas compressibility is defined by the following two rules.

**Boyle's Law** – The pressure and specific volume of a gas are inversely proportional to each other under conditions of constant temperature.

**Charles' Law** – The pressure and temperature of a gas are directly proportional to each other when the volume is held constant, and the volume and temperature are directly proportional when the pressure is held constant.

Thus, a gas will expand to fill any container, and pressure and temperature will adjust to values consistent with the above rules. Gas flowing through valves and restrictors will be subject to an increasing specific volume as pressure drops take place, and temperatures will change as determined by the Joule-Thompson effect.

The combination of the above rules forms the basis for the “Equation of State” for perfect gases. This allows either pressure, temperature, or volume to be calculated for a known quantity of gas when the other two variables are known.

\[
p V = m R T
\]

(See page C51 for values of the Gas Constant, \(R\))

In general, the following comments apply to gas flow.

1. Gas flow at high pressure ratios \(P_1/P_2 > 1.9\) is directly proportional to the upstream absolute pressure (see page C29).

2. Gas flow at moderate pressure ratios \(P_1/P_2 < 1.9\) is proportional to the downstream absolute pressure, and to the pressure differential (see page C29).
GAS FLOW CHARACTERISTICS

3. Gas flow at low pressure ratios \( (P_1/P_2 < 1.1) \) is proportional to the pressure differential, similar to hydraulic flow.

4. When restrictions appear in series, the most downstream restrictor dominates in the determination of flow rate.

5. When the absolute pressure ratio across a restrictor is above 1.9, the gas velocity will reach the speed of sound (sonic flow) in the restrictor throat. When restrictors appear in series the overall pressure ratio must be higher to achieve sonic flow.

6. When equal restrictors appear in series, sonic flow can only occur in the most downstream restrictor.

7. Velocity of the gas stream cannot exceed the speed of sound in either a constant area duct, or a converging section.

**The Rule of Forbidden Signals:**

“The effect of pressure changes produced by a body moving at a speed faster than the speed of sound cannot reach points ahead of the body.”

This rule can be applied to pneumatic flow restrictors where the body is not moving, but the flow velocity relative to the body can reach, or exceed, the speed of sound. Whenever the downstream pressure is low enough to produce Mach 1 at the restrictor throat, any effect of changes in the downstream pressure cannot reach points upstream of the throat. Thus, flow rate will be independent of downstream pressure. This situation applies to a single orifice restrictor flowing air when the overall pressure ratio exceeds 1.89/1.

**GAS FLOW**

**ABSOLUTE PRESSURE MEASUREMENT**

Gas flow is a function of upstream absolute pressure, and of the ratio of upstream to downstream pressures. Lohm testing done at The Lee Company is performed at an upstream pressure which is high enough so that downstream pressure does not affect the flow rate. To accurately determine the upstream absolute pressure, it is necessary to measure atmospheric pressure with a suitable barometer. This measurement will normally be in units of in. Hg, while the gauge pressure reading is in units of psig. Thus, the barometer reading must be converted to psia, and added to the gauge reading to get the value of pressure in psia.

\[
\text{Pres. (psia)} = \text{Pres. (psig)} + 0.4912 \times \text{Pres. (in. Hg)}
\]

**EXAMPLE:** What single-orifice restriction will permit a flow of 2.00 std L/min. of nitrogen at 70°F, with supply pressure at 10 psig, discharging to an atmospheric pressure of 29.5 in. Hg?

\[
\begin{align*}
K &= 276 \text{ (see page C31)} \\
T_1 &= 70^\circ F, \ f_r = 1.00 \text{ (see page C30)} \\
P_2 &= 0.4912 \times 29.5 = 14.5 \text{ psia} \\
P_1 &= 10.0 + 14.5 = 24.5 \text{ psia} \\
P_1/P_2 &= 24.5/14.5 = 1.69 \text{ (subsonic)} \\
\Delta P &= 24.5 - 14.5 = 10.0 \text{ psid} \\
Q &= 2.00 \text{ std L/min.}
\end{align*}
\]

\[
L = \frac{2 \times 276 \times 1.0 \times \sqrt{10.0 \times (14.5)}}{2.00} = 3320 \text{ Lohms}
\]
GAS FLOW
ACFM TO SCFM CONVERSION

It is frequently convenient to express gas flow in terms of flow at standard conditions. This is useful for calculation purposes, or for application to flow measuring instruments.

\[
\text{SCFM} = \text{ACFM} \left( \frac{P}{14.7} \right) \left( \frac{519}{T} \right)
\]

UNITS:

- \( T \) = Gas temperature, °R = 460 + °F
- \( P \) = Gas pressure, psia
- \( \text{ACFM} \) = Gas flow, actual cubic feet/minute
- \( \text{SCFM} \) = Gas flow, standard cubic feet/minute

EXAMPLE: What is SCFM corresponding to 0.032 ACFM at 300 psia and at 240°F?

SOLUTION:

\[
\text{SCFM} = 0.032 \left( \frac{300}{14.7} \right) \left( \frac{519}{700} \right) = 0.48
\]
When multiple orifices appear in series or when a restrictor has several stages, there is a non-uniform distribution of the overall pressure drop through the restrictor. See page C39 for additional discussion of series gas flow.

The effect of the above flow behavior is that the gas flow rate of a multi-orifice device is higher than would be expected from a single-orifice device of the same lohm rate, and at the same pressure conditions. This characteristic is reflected in the flow factor, “f_M”, which reaches a maximum value of 1.3 at a pressure ratio of 3/1. See the graph on page C38 for values of “f_M” at any pressure ratio for multi-orifice restrictors.

\[
\text{Lohms} = \frac{K f_T f_M P_1}{Q} \quad \text{(Sonic region)}
\]

**EXAMPLE:** What multi-orifice restriction will permit a flow of 0.5 std L/min. of hydrogen at 70°F, with supply pressure at 40 psig, discharging to atmosphere?

\[
\begin{align*}
K &= 1030 \quad \text{(see page C31)} \\
T_1 &= 70^\circ F, \quad f_T = 1.0 \quad \text{(see page C30)} \\
P_1 &= 40.0 + 14.7 = 54.7 \text{ psia} \\
P_2 &= 14.7 \text{ psia} \\
P_1/P_2 &= 54.7 / 14.7 = 3.72 \\
f_M &= 1.30 \quad \text{(see page C38)} \\
Q &= 0.50 \text{ std L/min} \\
L &= \frac{1030 \times 1.0 \times 1.30 \times 54.7}{0.50} = 146,000 \text{ Lohms}
\end{align*}
\]
GAS FLOW
FLOW FACTOR “fM” (MULTI-ORIFICE)

Sonic flow:

for \( \frac{P_1}{P_2} > 3 \), use \( f_M = 1.3 \)
GAS FLOW SERIES

When gas flow passes through orifices in series, the pressure drops are not evenly distributed. This is caused by the compressibility of the gas, and generally results in higher pressure drops at the downstream orifices. Thus, it becomes difficult to calculate the intermediate pressure between series restrictors flowing gas without using a trial and error process. To simplify this calculation, the chart on the following page may be used when the Lohm rates of the applicable restrictors are known.

TWO RESTRICTORS

The chart on the adjacent page solves for the absolute pressure between two orifices as a percentage of the supply pressure. To solve a problem, simply follow the graph line corresponding to the Lohm ratio, \( \frac{L_1}{L_2} \), until it crosses the overall pressure ratio, \( \frac{P_1}{P_3} \). Then read horizontally across to the left hand scale to obtain the value of \( P_2 \) as a percentage of the upstream absolute pressure, \( P_1 \).

**EXAMPLE:** Find the intermediate pressure between two restrictors with an upstream pressure 72 psia, exhausting to atmosphere at 14.7 psia.

\[
L_1 = 2000 \text{ Lo.} \quad L_2 = 500 \text{ Lo.}
\]

Calculate the Lohm ratio: \( \frac{L_1}{L_2} = \frac{2000}{500} = 4.0 \)

Calculate the overall pressure ratio: \( \frac{P_1}{P_3} = \frac{72.0}{14.7} = 4.9 \)

Read 28% from left hand scale of graph.

The upstream pressure is known, thus:

\[
P_2 = 0.28 \times 72.0 = 20 \text{ psia}
\]
TWO RESTRICTORS – GENERAL

The following will allow solutions to be obtained for 2 restrictor problems even when Lohm or pressure ratios are off – scale:

1. When Lohm ratio is less than 0.1, then $P_2 = P_1$.
2. When Lohm ratio is less than 8.0, then solution for pressure ratio greater than 10, is the same as at 10.
3. When Lohm ratio is greater than 1.5, then solution at high values of pressure ratio is such that ratio $P_2 / P_1$ is equal to the reciprocal of the Lohm ratio.
The following formulas provide solutions to series gas flow problems which must be solved with more precision than can be obtained by use of the graph on page C40. In each case, the graph may be used to determine whether or not each restrictor has a high enough pressure ratio (i.e. $P_1 / P_2 \geq 1.9$) to be in the sonic region.

1.) $L_1$ and $L_2$ are both sonic ($L_1 > L_2$):

$$P_2 = P_1 \times \frac{L_2}{L_1}$$

2.) $L_1$ is subsonic, and $L_2$ is sonic ($L_1 \neq L_2$):

$$P_2 = \frac{4P_1L_2^2}{L_1^2 + 4L_2^2}$$

3.) $L_1$ is subsonic, and $L_2$ is sonic ($L_1 = L_2$):

$$P_2 = 0.8 \times P_1$$

4.) $L_1$ is sonic, and $L_2$ is subsonic ($L_1 > L_2$):

$$P_2 = P_3 + \frac{P_1^2L_2^2}{4P_3L_1^2}$$

5.) $L_1$ is subsonic, and $L_2$ is subsonic ($L_1 \neq L_2$):

$$P_2 = \frac{1}{2} \left[ P_1 - A + \sqrt{(P_1 - A)^2 + 4P_3A} \right], \quad A = P_3 \left( \frac{L_1}{L_2} \right)^2$$

6.) $L_1$ is subsonic, and $L_2$ is subsonic ($L_1 = L_2$):

$$P_2 = \frac{\Delta P_{1-3} + \sqrt{\Delta P_{1-3}^2 + 4P_3^2}}{2}$$
EXAMPLE: Find the intermediate pressure in the example problem on page C39 with more precision.

\[ L_1 = 2000 \text{ Lo.}, \quad L_2 = 500 \text{ Lo.} \]

\[ P_1 = 72 \text{ psia}, \quad P_2 = 20 \text{ psia}, \quad P_3 = 14.7 \text{ psia} \]

\[ \frac{P_1}{P_2} = \frac{72}{20} = 3.60 \quad \text{(Sonic)} \]

\[ \frac{P_2}{P_3} = \frac{20}{14.7} = 1.36 \quad \text{(Subsonic)} \]

\[ P_2 = P_3 + \frac{P_1^2 L_2^2}{4 P_3 L_1^2} = 14.7 + \frac{72^2 \times 500^2}{4 \times 14.7 \times 2000^2} = 20.2 \text{ psia} \]

EXAMPLE: Find the intermediate pressure between two restrictors with an upstream pressure of 30 psia, exhausting to atmosphere at 14.7 psia.

\[ L_1 = 1500 \text{ Lo.}, \quad L_2 = 1500 \text{ Lo.} \]

Use solution procedure from page C39 to determine approximate value of intermediate pressure, \( P_2 \):

\[ \frac{L_1}{L_2} = \frac{1500}{1500} = 1.0, \quad \frac{P_1}{P_3} = \frac{30.0}{14.7} = 2.04 \]

\[ P_2 = 0.81 \times 30.0 = 24 \text{ psia. (approx.)} \]

\[ \frac{P_1}{P_2} = \frac{30.0}{24.0} = 1.25, \quad \frac{P_2}{P_3} = \frac{24.0}{14.7} = 1.63 \]

(L1 and L2 are both subsonic)

\[ P_2 = \Delta P_{1-3} + \sqrt{\frac{\Delta P_{1-3}^2 + 4 P_3^2}{2}} = 15.3 + \sqrt{15.3^2 + 4 \times 14.7^2} \]

\[ P_2 = 24.2 \text{ psia} \]
GAS FLOW PARALLEL

For parallel flow, the total Lohm rating is:

\[ \frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \ldots + \frac{1}{L_N} \]

Note that this relationship is identical to that for hydraulic flow, and to the electrical equation.

EXAMPLE:

\[ \frac{1}{L_T} = \frac{1}{2000} + \frac{1}{3000} + \frac{1}{5000} = 0.00103 \]

Therefore, \( L_T = 970 \) Lohms
MOMENTUM FORCES - GAS FLOW

When a flowing stream of gas is subject to a change in velocity (either speed or direction), forces arise which are the reaction to the change in momentum of the stream. This is particularly important in valve design where the position of a moving element may be affected.

The direction in which the momentum force acts is always opposite to the acceleration which is imparted to the flow stream. The magnitude of the force may be calculated by using the momentum Lohm Laws which apply to air at near room temperature.

\[
F = \frac{0.4 \times P_1}{L} \quad F = \frac{\text{SLPM}}{700} \quad \text{(sonic flow)}
\]

EXAMPLE: Where a gas changes direction.

\[
F = \frac{0.4 \times P_1}{L} = \frac{0.4 \times 1000}{2000} = 0.2 \text{ lbf.}
\]

The momentum force of 0.2 lbs. in this example must be added to the force produced by static pressure on the plate (0.1 in.\(^2\) x 10 psi = 1 lb.) to give the total force on the plate.

EXAMPLE: Where a gas changes speed.

\[
F = \frac{\text{SLPM}}{700} = \frac{35}{700} = 0.05 \text{ lbf.}
\]

The momentum force of 0.05 lb. in this example must be subtracted from the force produced by static pressure on the plate (0.1 in.\(^2\) x [100-50] = 5 lb.) to give the total force on the piston.
TRANSIENT GAS FLOW

This type of flow normally concerns the charging of a volume through a fixed resistance such as an orifice. Use of the Lohm system simplifies the calculation of the time required to blow down or charge up a vessel.

The first step is to calculate system time constant, $\tau$, which takes into consideration the type of gas, pressure–vessel volume, absolute temperature, and flow resistance. The time constant is given by:

$$\tau = \frac{4 \, f \, T \, V \, L}{K}$$

Note: Select $K$ from the appropriate “psia” column of the Volumetric Flow Table on page C31. Keep the units of pressure vessel volume ($V$) consistent with the volumetric flow units.

The larger the value of $\tau$, the more sluggish the system.

Once $\tau$ has been calculated, the ratio of upstream pressure to downstream pressure for both the initial and final conditions must be computed. Then, from the pressure–ratio graph, initial and final values for $N$ can be found. $N$ is the number of system time constants required for the system to reach equilibrium.

If the final condition is equilibrium, where upstream and downstream pressures are equal, the final pressure ratio is 1 and the final value of $N$ is 0. With these values, the time for the system to blow down or charge up can be calculated from:

$$t = \tau (N_i - N_f) \quad t = \text{Time (sec.)}$$
TRANSIENT GAS FLOW

NOMENCLATURE

K = Units correction factor
L = Flow resistance, (Lohms)
N_i = Initial number of system time constants
N_f = Final number of system time constants
P_1 = Upstream gas pressure
P_2 = Downstream gas pressure
f_T = Temperature factor
t = Time to charge up or blow down a pressure vessel (sec.)
V = Pressure vessel volume
\( \tau \) = System time constant (sec.)
TEMPERATURE CHANGE IN GAS FLOW

When a gas flows through an orifice it is subject to a throttling process. This results in the gas temperature changing to an extent determined by the pressure drop. Many of the common gasses will be chilled by throttling, although some gasses will increase in temperature.

A positive Joule–Thomson coefficient, which is a function of both temperature and pressure, will produce cooling of the gas. This is only the case at below the “inversion” temperature. At the inversion temperature, the Joule–Thomson coefficient is zero, so no heating or cooling occurs.

The following graph allows downstream temperature to be found when starting from an upstream pressure of 4500 psia; 750 psia for CO₂. Solutions may be obtained for other upstream pressures by shifting the graph lines vertically to pass through the zero “temp. change” line at the appropriate pressure. The graph works for a wide range of initial temperatures, but is most accurate when the initial temperature is close to 70°F.

The graph is entered on the zero “temp. change” line at the point corresponding to the actual upstream pressure. Then the graph line, or a parallel line, for the applicable gas, is followed to the right. When the value of the downstream pressure (read on the X-axis) is reached, the temperature change can be read on the Y-axis.

Note that actual downstream temperature will not normally be as extreme as calculated due to heat transfer to or from the piping.
TEMPERATURE CHANGE IN GAS FLOW

EXAMPLE:
A Lee IMH orifice is used in a 4500 psia helium gas system to obtain a pressure drop down to 300 psia starting with an upstream temperature of 80°F. What downstream gas temperature will result?

Enter the graph at the 4500 psia point and follow the helium line to a pressure of 300 psia. Then read the temperature change on the left hand scale. This value is +30°F; thus, the calculated downstream temperature is 110°F.
PNEUMATIC POWER

A gas flowing through an orifice is throttled (causing turbulence and heating), and expanded (causing cooling). Thus, it is subject to energy conversions which reduce the amount of energy available to do work. The rate at which available energy is lost can be termed the pneumatic power, which is a function of the pressures, Lohm rate of the orifice, and the flow. For nitrogen, the relationship is shown on the accompanying graph.

When the flow rate and pressure ratio is known, the resulting power consumption can be determined from the graph. If flow is not known, it can be readily calculated from the Lohm rate using the gas Lohm Law. Simply enter the graph at the appropriate pressure ratio (X-axis), and read vertically to the line corresponding to the applicable flow rate. The resulting power may then be read horizontally across on the Y-axis. Note that pressure ratio is the ratio of the absolute pressures.

For more precise calculations, or to extend the range of the pneumatic power graph, the following formula may be used for nitrogen or air.

\[
HP = \frac{2.2}{L} \frac{P_1}{P_2} \left[ \frac{(P_1/P_2)^{1/4} - 1}{P_1} \right]
\]

Note that due to compressor inefficiencies, more power will be needed to compress the gas than will be expended when it flows through an orifice.
EXAMPLE:

For a 500 Lohm orifice flowing nitrogen at 750 psia exhausting to 75 psia, the flow can be easily calculated from the gas Lohm Law.

\[
Q = \frac{270 \cdot P_1}{L} = \frac{270 \times (750)}{500} = 405 \text{ std L/min.}
\]

Next, determine the pressure ratio, \( P_1/P_2 \), which in this example is 750/75 = 10. Then, from the graph:

Pneumatic power = 2.5 HP
# GAS PROPERTIES

<table>
<thead>
<tr>
<th>Gas</th>
<th>k</th>
<th>R</th>
<th>Density</th>
<th>c\textsubscript{P}</th>
<th>c\textsubscript{V}</th>
</tr>
</thead>
<tbody>
<tr>
<td>H\textsubscript{2}</td>
<td>1.40</td>
<td>766.6</td>
<td>0.00532</td>
<td>0.000188</td>
<td>3.420</td>
</tr>
<tr>
<td>He</td>
<td>1.66</td>
<td>386.1</td>
<td>0.01056</td>
<td>0.000373</td>
<td>1.250</td>
</tr>
<tr>
<td>Neon</td>
<td>1.66</td>
<td>76.6</td>
<td>0.0533</td>
<td>0.00188</td>
<td>0.248</td>
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<td>Nat. Gas</td>
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<td>0.00182</td>
<td>0.560</td>
</tr>
<tr>
<td>N\textsubscript{2}</td>
<td>1.40</td>
<td>55.2</td>
<td>0.0739</td>
<td>0.00261</td>
<td>0.247</td>
</tr>
<tr>
<td>CO</td>
<td>1.41</td>
<td>55.2</td>
<td>0.0739</td>
<td>0.00261</td>
<td>0.243</td>
</tr>
<tr>
<td>Air</td>
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<td>53.3</td>
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<td>0.00270</td>
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<td>Ethane</td>
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<td>51.4</td>
<td>0.0793</td>
<td>0.00280</td>
<td>0.386</td>
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<td>0.0845</td>
<td>0.00298</td>
<td>0.217</td>
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<td>Argon</td>
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<td>0.00372</td>
<td>0.124</td>
</tr>
<tr>
<td>CO\textsubscript{2}</td>
<td>1.28</td>
<td>35.1</td>
<td>0.1162</td>
<td>0.00410</td>
<td>0.205</td>
</tr>
<tr>
<td>N\textsubscript{2}O</td>
<td>1.26</td>
<td>35.1</td>
<td>0.1162</td>
<td>0.00410</td>
<td>0.221</td>
</tr>
<tr>
<td>SO\textsubscript{2}</td>
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<td>24.1</td>
<td>0.1691</td>
<td>0.00597</td>
<td>0.154</td>
</tr>
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<td>Freon-12</td>
<td>1.13</td>
<td>12.8</td>
<td>0.319</td>
<td>0.01127</td>
<td>0.145</td>
</tr>
</tbody>
</table>

*values at 68°F and 14.7 psia

\[ c\textsubscript{P} = \text{Specific heat at constant pressure} \]
\[ c\textsubscript{V} = \text{Specific heat at constant volume} \]
\[ k = \text{Ratio of specific heats}, \quad \frac{c\textsubscript{P}}{c\textsubscript{V}} \]
\[ R = \text{Gas Constant}, \quad \frac{R}{\text{Molecular. Wt.}} \]
The ROB Number, a system of rating the relative resistance to blockage of safety screens, has been developed to minimize the guesswork and expensive testing formerly involved in selecting a screen.

The ROB Number was conceived to aid system designers in choosing the optimum screen for their conditions relative to other screen options available. The ROB Number is not used to predict absolute screen life.

The ROB Number system is based on a few assumptions.

- The same contamination level applies for all screen options.
- Fluid contamination level is not affected by having a safety screen in the system.
- When particles block holes, the manner in which they block different size holes is essentially the same.
- Particle distribution follows a log - log² distribution.
**Rob NUMBER DEFINITION**

A fluid contamination level per MIL-STD-1246 Class 200 was chosen as the basis of comparison with the Rob Number defined as;

\[
\text{Rob} = \frac{N}{63.25n}
\]

where  
\[n = 10 \cdot (4.9029 - 0.926 \log_2 d)\]
\[d = \text{hole size (µ)}\]
\[N = \# \text{ of holes in a screen}\]

A master screen of Rob = 1 is therefore defined as having 1000 holes all 100 µ in size.

The following tables give the Rob Number for single holes of a given diameter. To determine the Rob Number for a screen, multiply the single hole value by the number of holes in the screen.

**Screen Rob # = Single orifice Rob # x # of holes.**

The screen safety factor is defined as the ratio of the screen Rob Number to the Rob Number of the orifice it is protecting. You should choose a screen to provide the highest practical safety factor.

**Rob NUMBER EXAMPLE**

**EXAMPLE:** Which safety screen would be the better choice to protect a 0.030 diameter orifice: A 0.008 hole size screen with 850 holes, or a 0.015 hole size screen with 450 holes?

**SOLUTION:** From the table on page C54, we find that a single orifice of 0.030 diameter has a Rob Number of 9.71.

Again using the table for 0.008 and 0.015 holes and multiplying by the respective number of holes gives the following results:

<table>
<thead>
<tr>
<th>HOLE SIZE</th>
<th># OF HOLES</th>
<th>Rob NUMBER</th>
<th>SAFETY FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>(in)</td>
<td>(µ)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orifice 0.030</td>
<td>762</td>
<td>1</td>
<td>9.7</td>
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<tr>
<td>Screen 1 0.008</td>
<td>203</td>
<td>850</td>
<td>14.4</td>
</tr>
<tr>
<td>Screen 2 0.015</td>
<td>381</td>
<td>450</td>
<td>131</td>
</tr>
</tbody>
</table>

The results show screen 2 to be the better choice.
## Single Orifice Rob Numbers

<table>
<thead>
<tr>
<th>HOLE SIZE</th>
<th>SINGLE ORIFICE ROB #</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inch</strong></td>
<td><strong>Micron</strong></td>
</tr>
<tr>
<td>0.0010</td>
<td>25</td>
</tr>
<tr>
<td>0.0015</td>
<td>38</td>
</tr>
<tr>
<td>0.0020</td>
<td>51</td>
</tr>
<tr>
<td>0.0025</td>
<td>64</td>
</tr>
<tr>
<td>0.0030</td>
<td>76</td>
</tr>
<tr>
<td>0.0035</td>
<td>89</td>
</tr>
<tr>
<td>0.0040</td>
<td>102</td>
</tr>
<tr>
<td>0.0045</td>
<td>114</td>
</tr>
<tr>
<td>0.0050</td>
<td>127</td>
</tr>
<tr>
<td>0.0055</td>
<td>140</td>
</tr>
<tr>
<td>0.0060</td>
<td>152</td>
</tr>
<tr>
<td>0.0065</td>
<td>165</td>
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<tr>
<td>0.0070</td>
<td>178</td>
</tr>
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<td>0.0075</td>
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<td>0.0090</td>
<td>229</td>
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<td>0.0095</td>
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<td>0.010</td>
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<td>0.011</td>
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<td>0.012</td>
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<td>0.013</td>
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<td>0.014</td>
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<tr>
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</table>
# Single Orifice Rob Numbers

<table>
<thead>
<tr>
<th>Hole Size</th>
<th>Inch</th>
<th>Micron</th>
<th>Rob #</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.052</td>
<td>0.052</td>
<td>1321</td>
<td>207</td>
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<tr>
<td>0.053</td>
<td>0.053</td>
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<td>231</td>
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<tr>
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<td>0.054</td>
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<td>257</td>
</tr>
<tr>
<td>0.055</td>
<td>0.055</td>
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<tr>
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<td>1651</td>
<td>765</td>
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<tr>
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<td>0.067</td>
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<tr>
<td>0.068</td>
<td>0.068</td>
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<td>0.069</td>
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<td>1094</td>
</tr>
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<td>0.070</td>
<td>1780</td>
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</tr>
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<td>0.071</td>
<td>0.071</td>
<td>1800</td>
<td>1.3E + 03</td>
</tr>
<tr>
<td>0.072</td>
<td>0.072</td>
<td>1830</td>
<td>1.4E + 03</td>
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<td>0.073</td>
<td>0.073</td>
<td>1850</td>
<td>1.5E + 03</td>
</tr>
<tr>
<td>0.074</td>
<td>0.074</td>
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</tr>
<tr>
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<td>0.075</td>
<td>1910</td>
<td>1.8E + 03</td>
</tr>
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<td>0.076</td>
<td>1930</td>
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</tr>
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</tr>
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<td>2.9E + 03</td>
</tr>
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</table>
**CONTAMINATION LEVEL CORRELATION**

Fluid contamination can be described by a number of techniques:

- **The Gravimetric Method:** The contaminant level is expressed as the mass of contaminant per unit volume of fluid.
- **Parts Per Million:** The degree of contamination is based on mass or volume per million units (e.g. gms/10^6 gms).

The above techniques describe bulk or total contamination but give little information regarding size of contaminant. For example, unless the size and density of the contaminating particles is known, no conclusions may be drawn relative to numbers of particles.

Other techniques look at numbers of particles, describing contamination in terms of its size and concentration. These may be an interval concentration, for example the number of contaminant particles (per unit volume) between 5 and 15 µ in size. Additionally, contamination may be expressed as a cumulative concentration. In this case contamination levels are described by the total number of particles per unit volume above a given size. For example, the number of particles above 25 µ in size per 100 mL.

Most commonly used cleanliness specifications are based on numbers of particles rather than gravimetric techniques. However, particle distributions which were determined to be representative of service distributions (e.g. NAS 1638 distributions) correlate reasonably with those obtained gravimetrically with AC test dust. The table on page C57 (from An Encyclopedia of Fluid Contamination Control by E.C. Fitch) provides a correlation of some different cleanliness specifications.

<table>
<thead>
<tr>
<th>NAS* 1638</th>
<th>Number of Particles per 100 mL Micron Range</th>
<th>ISO 4406</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class</td>
<td>5-15 µ</td>
<td>15-25 µ</td>
</tr>
<tr>
<td>00</td>
<td>125</td>
<td>22</td>
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<tr>
<td>2</td>
<td>1K</td>
<td>178</td>
</tr>
<tr>
<td>3</td>
<td>2K</td>
<td>356</td>
</tr>
<tr>
<td>4</td>
<td>4K</td>
<td>712</td>
</tr>
<tr>
<td>5</td>
<td>8K</td>
<td>1425</td>
</tr>
<tr>
<td>6</td>
<td>16K</td>
<td>2.8K</td>
</tr>
<tr>
<td>7</td>
<td>32K</td>
<td>5.7K</td>
</tr>
<tr>
<td>8</td>
<td>64K</td>
<td>11.4K</td>
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<tr>
<td>9</td>
<td>128K</td>
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<tr>
<td>10</td>
<td>256K</td>
<td>45.6K</td>
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<tr>
<td>11</td>
<td>512K</td>
<td>91.2K</td>
</tr>
<tr>
<td>12</td>
<td>1M</td>
<td>182K</td>
</tr>
</tbody>
</table>

- SAE standard AS 4059 also applies. This lists fluid particulate contamination cumulatively for 5 ranges for contamination classes from 000 to 12.
  - >2 µ  • >5 µ  • >15 µ  • >25 µ  • >50 µ
# Contamination Level Correlation

<table>
<thead>
<tr>
<th>ISO 4406 Code</th>
<th>Particles Per mL &gt;10 µ</th>
<th>ACFTD Gravimetric, Level mg/L</th>
<th>MIL-STD 1246 Level</th>
<th>NAS 1638 Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>26/23</td>
<td>140 000</td>
<td>1000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25/23</td>
<td>85 000</td>
<td>1000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23/20</td>
<td>14 000</td>
<td>100</td>
<td>700</td>
<td>12</td>
</tr>
<tr>
<td>21/18</td>
<td>4 500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20/18</td>
<td>2 400</td>
<td></td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>20/17</td>
<td>2 300</td>
<td></td>
<td></td>
<td>11</td>
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<tr>
<td>20/16</td>
<td>1 400</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19/16</td>
<td>1 200</td>
<td></td>
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<td>10</td>
</tr>
<tr>
<td>18/15</td>
<td>580</td>
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<td>9</td>
</tr>
<tr>
<td>17/14</td>
<td>280</td>
<td>300</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>16/13</td>
<td>140</td>
<td>1</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>15/12</td>
<td>70</td>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>14/12</td>
<td>40</td>
<td>200</td>
<td></td>
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</tr>
<tr>
<td>14/11</td>
<td>35</td>
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<td>5</td>
<td></td>
</tr>
<tr>
<td>13/10</td>
<td>14</td>
<td>.1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>12/9</td>
<td>9</td>
<td></td>
<td>3</td>
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</tr>
<tr>
<td>18/8</td>
<td>5</td>
<td></td>
<td>2</td>
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<td>10/8</td>
<td>3</td>
<td>100</td>
<td></td>
<td></td>
</tr>
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<td>10/7</td>
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<td>1</td>
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<tr>
<td>10/6</td>
<td>1.4</td>
<td>.01</td>
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<td>9/6</td>
<td>1.2</td>
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<td>0</td>
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</tr>
<tr>
<td>8/5</td>
<td>0.6</td>
<td></td>
<td>00</td>
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<tr>
<td>7/5</td>
<td>0.3</td>
<td>50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6/3</td>
<td>0.14</td>
<td>.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5/2</td>
<td>0.04</td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2/8</td>
<td>0.01</td>
<td>10</td>
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<td></td>
</tr>
</tbody>
</table>
## PARTICLE SIZE COMPARISON

### SIZES OF FAMILIAR OBJECTS

<table>
<thead>
<tr>
<th>SUBSTANCE</th>
<th>MICRONS</th>
<th>INCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain of Table Salt</td>
<td>100</td>
<td>0.0039</td>
</tr>
<tr>
<td>Human Hair</td>
<td>70</td>
<td>0.0016</td>
</tr>
<tr>
<td>Lower Limit of Visibility</td>
<td>40</td>
<td>0.0016</td>
</tr>
<tr>
<td>White Blood Cells</td>
<td>25</td>
<td>0.0010</td>
</tr>
<tr>
<td>Talcum Powder</td>
<td>10</td>
<td>0.0004</td>
</tr>
<tr>
<td>Red Blood Cells</td>
<td>8</td>
<td>0.0003</td>
</tr>
<tr>
<td>Bacteria (Average)</td>
<td>2</td>
<td>0.00008</td>
</tr>
</tbody>
</table>

### SCREEN SIZES

<table>
<thead>
<tr>
<th>U.S. SIEVE NO.</th>
<th>OPENING IN INCHES</th>
<th>OPENING IN MICRONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>0.0117</td>
<td>297</td>
</tr>
<tr>
<td>60</td>
<td>0.0090</td>
<td>228</td>
</tr>
<tr>
<td>70</td>
<td>0.0083</td>
<td>210</td>
</tr>
<tr>
<td>100</td>
<td>0.0059</td>
<td>149</td>
</tr>
<tr>
<td>140</td>
<td>0.0041</td>
<td>105</td>
</tr>
<tr>
<td>200</td>
<td>0.0029</td>
<td>74</td>
</tr>
<tr>
<td>270</td>
<td>0.0021</td>
<td>53</td>
</tr>
<tr>
<td>325</td>
<td>0.0017</td>
<td>44</td>
</tr>
<tr>
<td>Paper</td>
<td>0.00039</td>
<td>10</td>
</tr>
<tr>
<td>Paper</td>
<td>0.00019</td>
<td>5</td>
</tr>
</tbody>
</table>
CLOGGING

As a safety screen accumulates particles, the pressure drop will slowly increase until the screen is almost fully clogged. Then the pressure drop increases dramatically. For example, consider a clean safety screen in a 3000 psi hydraulic system. At its normal flow rate the screen pressure drop is 6 psi. That same screen will see a pressure drop of only 150 psi when 80% clogged. However, at 95% clogged, the differential pressure jumps to 2500 psi. This phenomenon is represented by the following formula:

\[
\Delta P = \frac{\Delta P_0}{(1- \% \text{ clogged})^2}
\]

Where \( \Delta P_0 \) is the pressure drop across the screen when it is clean.
PRIMARY STANDARDS*

**Meter**  
Length equal to 1,650,763.73 wavelengths in vacuum of the radiation corresponding to the transition between the levels 2 p₁₀ and 5 d₅ of the krypton-86 atom.

**Kilogram**  
Mass equal to the mass of the international prototype of the kilogram. This is a particular cylinder of platinum-iridium alloy which is preserved in a vault at Sevres, France by the International Bureau of Weights and Measures.

**Second**  
Time duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom.

DERIVED STANDARD

**Newton**  
Force which gives to a mass of 1 kilogram an acceleration of 1 meter per sec. per sec.

EXACT CONVERSIONS*

| 1 pascal | = 1 newton/meter² |
| 1 atmosphere | = 101 325 pascals |
| 1 bar | = 100 000 pascals |
| 1 centipoise | = 0.001 newton-second/meter² |
| 1 centistoke | = 1 x 10⁻⁶ meter²/second |
| 1 fluid ounce (U.S.) | = 2.95735295625 x 10⁻⁵ meter³ |
| 1 foot | = 0.3048 meter |
| 1 gallon (U.S.) | = 3.785411784 x 10⁻³ meter³ |
| 1 gram | = 0.001 kilogram |
| 1 inch | = 0.0254 meter |
| 1 kilogram force | = 9.80665 newtons |
| 1 liter | = 0.001 meter³ |
| 1 micron | = 1 x 10⁻⁶ meter |
| 1 milliliter | = 1 x 10⁻⁶ meter³ |
| 1 ounce mass (avdp) | = 0.028349523125 kilogram |
| 1 pound force (avdp) | = 4.4482216152605 newtons |
| 1 pound mass (avdp) | = 0.45359237 kilogram |

*Exact by National Bureau of Standards definition

DERIVED CONVERSIONS:

| 1 foot of H₂O at 4°C | = 2988.98 pascals |
| 1 gram/centimeter³ | = 1 000 kilograms/meter³ |
| 1 inch of H₂O at 4°C | = 249.082 pascals |
| 1 inch of Hg at 0°C | = 3386.389 pascals |
| 1 poundF/inch² | = 6894.7572 pascals |
| 1 poundw/inch³ | = 27,679.905 Kilograms/meter³ |
| 1 quart (U.S.) | = 9.4635295 x 10⁻⁴ meter³ |
| 1 drop | = 50 microliters |
| 1 bar | = 14.503774 poundF/inch² |
## CONVERSION FACTORS

### VOLUME

<table>
<thead>
<tr>
<th>To Convert</th>
<th>FT.³</th>
<th>IN.³</th>
<th>GAL. (U.S.)</th>
<th>QUART (U.S.)</th>
<th>FL. OZ. (U.S.)</th>
<th>liter</th>
<th>mL</th>
<th>m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>FT.³</td>
<td>—</td>
<td>1728</td>
<td>7.481</td>
<td>29.92</td>
<td>957.5</td>
<td>28.32</td>
<td>2.832 x 10⁴</td>
<td>2.832 x 10⁴</td>
</tr>
<tr>
<td>IN.³</td>
<td>5.787 x 10⁻⁴</td>
<td>—</td>
<td>4.329 x 10⁻³</td>
<td>1.732 x 10⁻²</td>
<td>0.5541</td>
<td>1.639 x 10⁻²</td>
<td>16.39 x 10⁻⁵</td>
<td></td>
</tr>
<tr>
<td>GAL. (U.S.)</td>
<td>0.1337</td>
<td>231.0</td>
<td>—</td>
<td>4.000</td>
<td>128.0</td>
<td>3.785</td>
<td>3785</td>
<td>3.785 x 10⁻³</td>
</tr>
<tr>
<td>QUART (U.S.)</td>
<td>3.342 x 10⁻²</td>
<td>57.75</td>
<td>0.2500</td>
<td>—</td>
<td>32.00</td>
<td>0.9464</td>
<td>946.4</td>
<td>9.464 x 10⁻⁴</td>
</tr>
<tr>
<td>FL. OZ. (U.S.)</td>
<td>1.044 x 10⁻³</td>
<td>1.805</td>
<td>7.813 x 10⁻³</td>
<td>3.125 x 10⁻²</td>
<td>—</td>
<td>2.957 x 10⁻²</td>
<td>29.57</td>
<td>2.957 x 10⁻³</td>
</tr>
<tr>
<td>liter</td>
<td>3.531 x 10⁻²</td>
<td>61.02</td>
<td>0.2642</td>
<td>1.057</td>
<td>33.81</td>
<td>—</td>
<td>1000</td>
<td>1.000 x 10⁻³</td>
</tr>
<tr>
<td>mL</td>
<td>3.531 x 10⁻⁵</td>
<td>6.102</td>
<td>2.642 x 10⁻⁴</td>
<td>1.057 x 10⁻³</td>
<td>3.381 x 10⁻²</td>
<td>1.000 x 10⁻³</td>
<td>—</td>
<td>1.000 x 10⁻⁶</td>
</tr>
<tr>
<td>m³</td>
<td>35.31</td>
<td>6.102 x 10⁴</td>
<td>264.2</td>
<td>1057</td>
<td>3.381 x 10⁴</td>
<td>1000</td>
<td>1.000</td>
<td>—</td>
</tr>
</tbody>
</table>

Multiply by

### MASS

<table>
<thead>
<tr>
<th>To Convert</th>
<th>LBₘ (avdp)</th>
<th>OZₘ (avdp)</th>
<th>SLUG</th>
<th>gram</th>
<th>kgₘ</th>
</tr>
</thead>
<tbody>
<tr>
<td>LBₘ (avdp)</td>
<td>—</td>
<td>16.00</td>
<td>3.108 x 10⁻²</td>
<td>453.6</td>
<td>0.4536</td>
</tr>
<tr>
<td>OZₘ (avdp)</td>
<td>6.250 x 10⁻²</td>
<td>—</td>
<td>1.943 x 10⁻³</td>
<td>28.35</td>
<td>2.835 x 10⁻²</td>
</tr>
<tr>
<td>SLUG</td>
<td>32.17</td>
<td>514.8</td>
<td>—</td>
<td>1.459 x 10⁴</td>
<td>14.59</td>
</tr>
<tr>
<td>gram</td>
<td>2.205 x 10⁻³</td>
<td>3.527 x 10⁻²</td>
<td>6.852 x 10⁻⁵</td>
<td>—</td>
<td>1.000 x 10⁻³</td>
</tr>
<tr>
<td>kgₘ</td>
<td>2.205</td>
<td>35.27</td>
<td>6.852 x 10⁻²</td>
<td>1000</td>
<td>—</td>
</tr>
</tbody>
</table>

Multiply by
### Conversion Factors

#### Pressure

<table>
<thead>
<tr>
<th></th>
<th>LB. IN.²</th>
<th>IN. HG at 0°C</th>
<th>IN. H₂O at 4°C</th>
<th>FT. H₂O at 4°C</th>
<th>ATM</th>
<th>kgF/cm²</th>
<th>kgF/m²</th>
<th>kPa</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LB. IN.²</strong></td>
<td>—</td>
<td>2.036</td>
<td>27.68</td>
<td>2.307</td>
<td>6.805 x 10⁻²</td>
<td>7.031 x 10⁻²</td>
<td>703.1</td>
<td>6.895</td>
</tr>
<tr>
<td><strong>IN. HG at 0°C</strong></td>
<td>0.4912</td>
<td>—</td>
<td>13.60</td>
<td>1.133</td>
<td>3.342 x 10⁻²</td>
<td>3.453 x 10⁻²</td>
<td>345.3</td>
<td>3.386</td>
</tr>
<tr>
<td><strong>IN. H₂O at 4°C</strong></td>
<td>3.613 x 10⁻²</td>
<td>7.355 x 10⁻²</td>
<td>—</td>
<td>8.333 x 10⁻²</td>
<td>2.458 x 10⁻³</td>
<td>2.540 x 10⁻³</td>
<td>25.40</td>
<td>0.2491</td>
</tr>
<tr>
<td><strong>FT. H₂O at 4°C</strong></td>
<td>0.4335</td>
<td>0.8826</td>
<td>12.00</td>
<td>—</td>
<td>2.950 x 10⁻²</td>
<td>3.048 x 10⁻²</td>
<td>304.8</td>
<td>2.989</td>
</tr>
<tr>
<td><strong>ATM</strong></td>
<td>14.70</td>
<td>29.92</td>
<td>406.8</td>
<td>33.90</td>
<td>—</td>
<td>1.033 x 10⁴</td>
<td>101.3</td>
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</tr>
<tr>
<td><strong>kgF/cm²</strong></td>
<td>14.22</td>
<td>28.96</td>
<td>393.7</td>
<td>32.81</td>
<td>0.9678</td>
<td>—</td>
<td>1.000 x 10⁴</td>
<td>98.07</td>
</tr>
<tr>
<td><strong>kgF/m²</strong></td>
<td>1.422 x 10⁻³</td>
<td>2.896 x 10⁻³</td>
<td>3.937 x 10⁻³</td>
<td>3.281 x 10⁻³</td>
<td>9.678 x 10⁻⁵</td>
<td>1.000 x 10⁻⁴</td>
<td>—</td>
<td>9.807 x 10⁻³</td>
</tr>
<tr>
<td><strong>kPa</strong></td>
<td>0.1450</td>
<td>0.2953</td>
<td>4.015</td>
<td>0.3346</td>
<td>9.869 x 10⁻³</td>
<td>1.020 x 10⁻²</td>
<td>102.0</td>
<td>—</td>
</tr>
</tbody>
</table>

Multiply by ___
CONVERSION FACTORS - VOLUME TO MASS
WATER AT 39.2°F (4°C)

<table>
<thead>
<tr>
<th>VOLUME</th>
<th>MASS</th>
<th>Into</th>
<th>To Convert</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LBM (avdp)</td>
<td>OZM (avdp)</td>
<td>SLUG</td>
</tr>
<tr>
<td>FT.³</td>
<td>62.43</td>
<td>998.8</td>
<td>1.940</td>
</tr>
<tr>
<td>IN.³</td>
<td>3.613 x 10⁻²</td>
<td>0.578</td>
<td>1.123 x 10⁻³</td>
</tr>
<tr>
<td>GAL. (U.S.)</td>
<td>8.345</td>
<td>133.5</td>
<td>0.2594</td>
</tr>
<tr>
<td>QT. (U.S.)</td>
<td>2.086</td>
<td>33.38</td>
<td>6.484 x 10⁻²</td>
</tr>
<tr>
<td>FL. OZ. (U.S.)</td>
<td>6.520 x 10⁻²</td>
<td>1.043</td>
<td>2.026 x 10⁻³</td>
</tr>
<tr>
<td>liter</td>
<td>2.205</td>
<td>35.27</td>
<td>6.852 x 10⁻²</td>
</tr>
<tr>
<td>mL</td>
<td>2.205 x 10⁻³</td>
<td>3.527 x 10⁻²</td>
<td>6.852 x 10⁻⁵</td>
</tr>
<tr>
<td>m³</td>
<td>2205</td>
<td>3.527 x 10⁴</td>
<td>68.52</td>
</tr>
</tbody>
</table>

Multiply by

NOTE: For application of these factors to fluids with specific gravity other than 1.0, these factors must be multiplied by the actual specific gravity.

EXAMPLE:
Problem: Determine flow rate in lb./hr. which is equivalent to 430 mL/min. Fluid is MIL-H-5606, S.G. is 0.84.

Solution:
\[
\frac{\text{lb}}{\text{hr}} = 430 \frac{\text{mL}}{\text{min}} \times 0.84 \times 2.20 \times 10^{-3} \frac{\text{lb}}{\text{mL}} \times \frac{60 \text{ min}}{1 \text{ hr}} = 47.8
\]
### CONVERSION FACTORS - MASS TO VOLUME

#### WATER AT 39.2°F (4°C)

<table>
<thead>
<tr>
<th>Volume Unit</th>
<th>LBm (avdp)</th>
<th>Ozm (avdp)</th>
<th>Slug</th>
<th>gram</th>
<th>kgm</th>
</tr>
</thead>
<tbody>
<tr>
<td>FT³</td>
<td>1.602 x 10⁻²</td>
<td>1.001 x 10⁻³</td>
<td>0.5154</td>
<td>3.532 x 10⁻⁵</td>
<td>3.532 x 10⁻²</td>
</tr>
<tr>
<td>IN³</td>
<td>27.68</td>
<td>1.730</td>
<td>890.6</td>
<td>6.103 x 10⁻²</td>
<td>61.03</td>
</tr>
<tr>
<td>GAL(U.S.)</td>
<td>0.1198</td>
<td>7.489 x 10⁻³</td>
<td>3.855</td>
<td>2.642 x 10⁻⁴</td>
<td>0.2642</td>
</tr>
<tr>
<td>QT(U.S.)</td>
<td>0.4793</td>
<td>2.996 x 10⁻²</td>
<td>15.42</td>
<td>9.464 x 10⁻⁴</td>
<td>0.9464</td>
</tr>
<tr>
<td>FL OZ(U.S.)</td>
<td>15.34</td>
<td>0.9586</td>
<td>493.5</td>
<td>3.381 x 10⁻²</td>
<td>33.81</td>
</tr>
<tr>
<td>liter</td>
<td>0.4536</td>
<td>2.835 x 10⁻²</td>
<td>14.59</td>
<td>1.000 x 10⁻³</td>
<td>1.000</td>
</tr>
<tr>
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<td>453.6</td>
<td>28.35</td>
<td>1.459 x 10⁴</td>
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<tr>
<td>m³</td>
<td>4.536 x 10⁻⁴</td>
<td>2.835 x 10⁻⁵</td>
<td>1.459 x 10⁻²</td>
<td>1.000 x 10⁻⁶</td>
<td>1.000 x 10⁻³</td>
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</table>

Multiply by

#### NOTE:
For application of these factors to fluids with specific gravity other than 1.0, these factors must be divided by the actual specific gravity.

#### EXAMPLE:

**Problem:** Determine volume in gallons which would be occupied by 3.0kg of sea water, S.G. is 1.02.

**Solution:**

\[
\text{GAL.} = \frac{3.0 \text{ kg}}{1.02 \text{ kg}} \times 0.2642 \text{ GAL} = 0.777 \text{ GAL.}
\]
TEMPERATURE CONVERSION

°F = °C \left( \frac{9}{5} \right) + 32

°C = \left( °F - 32 \right) \left( \frac{5}{9} \right)

°R = °F + 460

°K = °C + 273

°K = °R \left( \frac{5}{9} \right)
Viscosity Conversion

Kinematic viscosity (ft²/sec)

Saybolt Universal seconds (SSU)

Saybolt Furol seconds (SSF)

Engler (degrees)

Redwood No.1 (seconds)

Kinematic viscosity (centistokes)
TORQUE CONVERSION CHART

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CONNECT HORIZONTALLY
PRESSURE CONVERSION CHART

NOTE:

*1 torr = 1 mm Hg = 0.535 inch H₂O

**1 bar = 1.02 kg/cm² = 14.5 PSI

1 PSI = 6.895 kPa = 0.07031 kg/cm²

CONNECT HORIZONTALLY
### Graphic Symbols for Hydraulics and Pneumatics

<table>
<thead>
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<th>Symbol</th>
<th>Description</th>
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<td><img src="image2.png" alt="Symbol" /></td>
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<tr>
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<td>Flexible Hose</td>
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<td>Pilot Operated</td>
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GRAPHIC SYMBOLS
FOR HYDRAULICS AND PNEUMATICS

HYDRO-PNEUMATIC ACCUMULATOR

HEAT EXCHANGER

SPRING ENERGIZED ACCUMULATOR

GAS STORAGE (BOTTLE)

DOUBLE ACTING CYLINDER

SINGLE ACTING WITH SPRING RETURN

FILTER OR SCREEN

FILTER, WITH REMOVABLE ELEMENT

DOUBLE ENDED CYLINDER

PRESSURE INTENSIFIER
GRAPHIC SYMBOLS
FOR HYDRAULICS AND PNEUMATICS

- Fixed-Displacement Pump
- Variable-Displacement Pump
- Hand Pump
- Motor-Driven Pump
- Ram Air Turbine
- Fixed-Displacement Bi-Directional Hydraulic Motor
- Power Transfer Unit
- Bi-Directional Pneumatic Motor
- Screened Two-Way Restrictor
- Screened One-Way Restrictor
- Pressure Compensated Flow Control
GRAPHIC SYMBOLS FOR HYDRAULICS AND PNEUMATICS

- **CHECK VALVE**

- **PILOT TO OPEN CHECK VALVE**

- **PILOT TO CLOSE CHECK VALVE**

- **QUICK DISCONNECT**

- **SPRING BIASED SHUTTLE VALVE**

- **RELIEF VALVE**

- **PRESSURE REDUCING VALVE**

- **2-PORT, 2 POSITION SHUT-OFF VALVE**

- **3-PORT, 2 POSITION MECHANICALLY-OPERATED VALVE**

- **4-PORT, 3 POSITION SELECTOR VALVE**

- **ELECTROHYDRAULIC SERVOVALVE**

- **PRESSURE SWITCH**

- **PRESSURE TRANSDUCER**

- **ΔP INDICATOR**
DEFINITIONS OF VISCOSITY

- **Absolute Viscosity** is the ratio of the shear stress in a fluid to the rate of shearing strain.

- **Unit of absolute viscosity** in the metric system: poise and centipoise;
  
  \[ 1 \text{ poise} = 1 \text{ gm}/(\text{cm})(\text{sec.}) \]
  
  \[ 1 \text{ centipoise} = 1/100 \text{ poise} \]

- **Unit of absolute viscosity** in the English system:
  
  \[ 1 \text{ slug}/(\text{ft.})(\text{sec.}) = 478.8 \text{ poise} \]

- **Kinematic Viscosity** is the absolute viscosity ÷ density.

- **Unit of kinematic viscosity** in the metric system (and commonly used in the countries using the English system): stoke and centistoke;

  \[ 1 \text{ stoke} = 1 \text{ poise/density (gm/ml)} \]
  
  \[ 1 \text{ centistoke} = 1/100 \text{ stoke} \]

- **Other units of kinematic viscosity;** In the English system, the most practical unit for making calculations is ft.\(^2\)/sec.;

  \[ 1 \text{ ft.}^2/\text{sec.} = 92903 \text{ centistokes} \]
  
  \[ 1 \text{ centistoke} = 1/076 \times 10^{-5} \text{ ft.}^2/\text{sec.} \]

- **Saybolt Universal Seconds**, SSU, is the kinematic viscosity as determined by the time in seconds required for 60 cc of fluid to flow through a standard orifice.

- **Saybolt-Furol**, SSF, utilizes a larger orifice and is used for very viscous fluids. Time of efflux is approx. 1/10 that of Universal.

- **Engler** degrees are obtained by dividing the outflow time of a specified amount of fluid through a specified orifice by the outflow time of water at 68°F. The method is used predominantly in European countries.

- **Viscosity Index** is an empirical number indicating the effect of temperature change on viscosity. Fluids with the same viscosity at a given temperature do not necessarily have the same viscosity index.

- **SAE Viscosity Numbers** are a means of classifying crankcase lubricating oils in terms of viscosity. Other factors are not considered.

NOTE: See page C66 for conversions.
POLICY FOR SPECIALLY FABRICATED PARTS

The Lee Company offers a wide range of off-the-shelf catalog components to help designers find the solutions to their problems. Should you need a non-standard component, The Lee Company will be pleased to design products not listed in this handbook. We have the capability to design and manufacture variations to the components listed in this handbook on a prototype basis and for future production.

A unique part number would be assigned to the design. The subsequent purchase of this part number would be reserved for the originator exclusively.

If a Production Preparation Charge (PPC) is necessary to partially offset the non-recurring costs of design, manufacturing, testing or tooling, the design of this special part will be the property of The Lee Company.

PROPRIETARY RIGHTS

The Lee Company retains all proprietary rights and the exclusive right to manufacture the products shown in this handbook, as well as any specially designed products. Unlimited rights, as described in DAR 7-104.9(b), are not transferred to the buyer.

U.S. EXPORT COMPLIANCE

Buyer and (The Lee Company) shall comply with the laws and regulations of the United States of America (USA) relating to exports and foreign transactions, including, but not limited to, the International Traffic in Arms Regulations (ITAR) (22 C.F.R. Parts 120-130), the Arms Export Control Act (22 U.S.C. 2778), the Export Administration Regulation (EAR) (15 C.F.R. Parts 730-774) and the Export Administration Act of 1979, as amended (50 U.S.C. 2401 et seq). Buyer hereby agrees to hold The Lee Company harmless due to buyer's breach of such obligation.

A list of Export Classification Codes for standard Lee Company IMH products is available on our IMH website at www.leeimh.com, or you may contact The Lee Company directly.
PATENTS • TRADEMARKS • COPYRIGHTS

1. Throughout the text of this handbook, The Lee Company has referred to these hydraulic products by their trade names and trade marks. Many of these devices are covered by U.S.A. and foreign Patents – issued, pending, or applied for.

2. Permission is hereby granted to use, copy and reproduce the general engineering material, including nomograms, tables and formulas, with the only restriction being to give credit to The Lee Company if the material is published or republished.

3. It is the clear intent of The Lee Company to encourage all members of the engineering profession to use the Lohm System, whether they are customers or competitors or others who could benefit from its use. Credit to The Lee Company must be stated in all publications.

WARRANTY

The Lee Company is proud to warrant that all items described in this handbook are free from defect in design, workmanship and materials and that they conform to any applicable specifications, drawings, or approved samples.

Our products will only operate as well as the systems in which they are installed. We therefore expect the buyers of our products to be responsible for the proper design and fabrication of the systems in which our products are used. To assist our customers, we maintain a staff of sales engineers that can recommend the proper Lee Company products to satisfy a particular system requirement. However, the buyer assumes the risk of incompatibility between Lee Company products and the fluid media.

Should any Lee Company product not satisfy this warranty, we will promptly repair or replace it within a four (4) year period or the product’s published cycle life, whichever is less, without responsibility for indirect or consequential damages, provided the product was used for its intended purpose, and in its intended environment.

Should any Lee product fail to perform to its specifications as stated in this handbook, a Returned Material Authorization, "RMA", number is required prior to returning the product. Please contact The Lee Company for the RMA number. Products returned without an RMA number may not be accepted.
## U.S. Sales Offices

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<thead>
<tr>
<th>Location</th>
<th>Phone Number</th>
<th>Email Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Westbrook, Connecticut</td>
<td>860 399-6281</td>
<td><a href="mailto:ct-sales@theleeco.com">ct-sales@theleeco.com</a></td>
</tr>
<tr>
<td>Detroit, Michigan</td>
<td>248 827-0981</td>
<td><a href="mailto:mi-sales@theleeco.com">mi-sales@theleeco.com</a></td>
</tr>
<tr>
<td>Chicago, Illinois</td>
<td>773 693-0880</td>
<td><a href="mailto:il-sales@theleeco.com">il-sales@theleeco.com</a></td>
</tr>
<tr>
<td>Huntington Beach, California</td>
<td>714 899-2177</td>
<td><a href="mailto:ca-sales@theleeco.com">ca-sales@theleeco.com</a></td>
</tr>
<tr>
<td>Tampa, Florida</td>
<td>813 287-9293</td>
<td><a href="mailto:fl-sales@theleeco.com">fl-sales@theleeco.com</a></td>
</tr>
<tr>
<td>San Bruno, California</td>
<td>650 238-2045</td>
<td><a href="mailto:ca-sales@theleeco.com">ca-sales@theleeco.com</a></td>
</tr>
<tr>
<td>Dallas/Ft. Worth, Texas</td>
<td>972 791-1010</td>
<td><a href="mailto:tx-sales@theleeco.com">tx-sales@theleeco.com</a></td>
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## International Sales Offices

### Lee Products Limited – London

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<thead>
<tr>
<th>Contact</th>
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<th>Email Address</th>
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</thead>
<tbody>
<tr>
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<td>+ 44 1753 886664</td>
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</tr>
<tr>
<td>email</td>
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<tr>
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<td></td>
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<tr>
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<tr>
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<tr>
<td>Subsidiary / Germany, Austria, Eastern Europe &amp; German speaking Switzerland</td>
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<td><a href="mailto:sales@leesrl.it">sales@leesrl.it</a></td>
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### The Lee Company

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<tr>
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<tr>
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### Distributor for People’s Republic of China, and Hong Kong

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### Agent for India

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### Agent for Singapore, Indonesia, Thailand and Malaysia

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The Lee Company
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