Technical Manual
MSI Hydraulic Adjustable Choke

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Revision A
TABLE OF CONTENTS

SECTION 1  WARNINGS ........................................................................................................... 1
SECTION 2  GENERAL DESCRIPTION .................................................................................. 3
  2.1  CHoke DESCRIPTION ................................................................................................... 3
  2.2  CHoke SPECIFICATIONS ........................................................................................... 3
  2.3  CHoke PERFORMANCE ............................................................................................... 5
  2.4  CYLINDER DESCRIPTION .......................................................................................... 5
  2.5  CYLINDER SPECIFICATIONS ...................................................................................... 5
  2.6  CHoke BALANCE PRESSURE ....................................................................................... 6
  2.7  HYDRAULIC PORT LOCATION ..................................................................................... 9
SECTION 3  MAINTENANCE ................................................................................................ 10
  3.1  PREVENTATIVE ........................................................................................................ 10
  3.2  INSPECTION .............................................................................................................. 10
  3.3  PICTORIAL INSPECTION .......................................................................................... 11
  3.4  PICTORIAL ASSEMBLY ............................................................................................. 14
  3.4.1  ASSEMBLING THE TEE SUBASSEMBLY ................................................................. 14
  3.4.2  ASSEMBLING THE BONNET SUBASSEMBLY ......................................................... 20
  3.4.3  ASSEMBLING THE HYDRAULIC CYLINDER AND BONNET SUBASSEMBLY ...... 24
  3.4.4  INSTALLING POSITION SENSOR (IF REQUIRED) ................................................. 34
  3.4.5  HYDRAULIC CHoke STEM SYNCHRONIZATION PROCEDURE ............................. 37
The MSI Hydraulic Adjustable Choke is used in high-pressure and high flow well service applications. High pressure equipment, if not used and maintained properly, can cause serious injury or death and damage to equipment and property. Not taking proper precautions and failing to perform routine maintenance and inspections can also contribute to loss of well control, and such loss could cause serious injury or death and damage to equipment and property.

The MSI hydraulic adjustable choke is designed to decrease pressure in a fluid flow situation, as a result, the velocity of the fluid stream increases drastically. Abrasive particles in the high velocity flow stream can cause excessive and premature erosion to the choke components. The downstream side of the choke though is protected by long wearing carbide thus reducing this wear. Therefore it is critical for safety and performance to ensure the choke is installed such that the direction of flow is away from the bonnet on adjustable chokes. Improperly flowing through the choke may cause damage and void the warranty. It is not recommended.

ALL OPERATORS AND MAINTENANCE PERSONNEL SHOULD BE THOROUGHLY TRAINED IN THE SAFE OPERATION, MAINTENANCE, AND INSPECTION OF THIS EQUIPMENT.

This product is not designed to be used for fully stopping the flow of fluids. In systems where this is required proper isolation valves should be used in conjunction with the choke.
FLUID DIRECTION THROUGH CHOKE

3/4" & 1" MAXIMUM ORIFICE (2" IRON)  2" MAXIMUM ORIFICE (3" IRON)
2.1 Choke Description

Hydraulic adjustable chokes are used in many oilfield applications to control the rate of flow. Usually an adjustable choke is used as part of a manifold installed downstream of the wellhead. The choke is adjusted during flowback of the well to control downstream pressure and flow rates. The MSI hydraulic adjustable choke is comprised of three main sub-assemblies. These sub-assemblies are the bonnet assembly, tee, and nipple assemblies (for 2” iron only).

2.2 Choke Specifications

MSI chokes are available in ¾”, 1”, and 2” maximum orifice sizes. The components that comprise the choke are made from various materials. The bonnet, tee, and nipple are made from forged alloy steel. The stem is manufactured from stainless steel and utilizes a solid carbide tip. The choke seat is also made from stainless steel that has been fitted with a carbide liner.
CHOKE MAIN SUB-ASSEMBLIES

3/4" & 1" MAXIMUM ORIFICE (2" IRON)

2" MAXIMUM ORIFICE (3" IRON)

BONNET ASSEMBLY

TEE ASSEMBLY

NIPPLE ASSEMBLY

BONNET ASSEMBLY

TEE ASSEMBLY
2.3 Choke Performance

MSI adjustable chokes are available in three trim sizes. Our 3/4” and 1” maximum trim sizes are available for use with our chokes that use 2” 1502 or WS20 connections. The 2” maximum trim size is only available for use with our chokes that use 3” 1502 or WS30 connections.

For liquid flow, the mathematical equation for determining $C_v$ is:

$$C_v = q \left( \frac{SG}{dp} \right)^{\frac{1}{2}}$$

Where:

$q =$ flow rate (gpm)

$SG =$ fluid specific gravity (1 for 60°F water)

$dp =$ pressure drop across choke (psi)

2.4 Cylinder Description

The hydraulically actuated chokes are operated with double acting hydraulic linear actuator or cylinder. The cylinder AA0036 is used with choke fittings that utilize 2” 1502 or WS20 connections and 3/4” or 1” maximum equivalent orifice size. AA0056 is used with the fittings that use 3” 1502 or WS30 connections and 2” maximum equivalent orifice size. Both cylinders use SAE J1926 straight thread O-ring type ports. The smaller cylinder AA0036 uses -8 port and AA0056 uses a -12 port.

2.5 Cylinder Specifications

<table>
<thead>
<tr>
<th>MSI Part Number</th>
<th>AA0036</th>
<th>AA0056</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic Pressure (max)</td>
<td>3,000 psig</td>
<td>3,000 psig</td>
</tr>
<tr>
<td>Port Size (Extend/Retract)</td>
<td>-8 SAE</td>
<td>-4 SAE</td>
</tr>
<tr>
<td>Fluid Displacement** (Extend/Retract)</td>
<td>9.2 fl.oz.</td>
<td>6.5 fl.oz.</td>
</tr>
</tbody>
</table>

**Please note the amount of fluid displacement is the amount to actuate the cylinder fully. This is not the total amount of the hydraulic control system. This volume does not include the amount needed for fittings and hydraulic lines. Every system is different based on set up and application we cannot specify minimum required fluid volumes for any particular hydraulic system.
2.6 **Choke Balance Pressure**

The pressure listed below is the hydraulic pressure required to balance the system, i.e. hold the choke stem at a desired flow position for an equivalent orifice value. This is not the pressure required to actuate the choke. An increase in hydraulic pressure over the calculated value is required to overcome the frictional forces of the packing and begin to actuate the choke stem. Once the stem begins to move, the hydraulic pressure should reduce to a value just over the calculated value. Further increases in pressure increase the speed at which the choke stem will move towards the seat.

<table>
<thead>
<tr>
<th>Line Pressure (psig)</th>
<th>2” Iron (1” max orifice)</th>
<th>3” Iron (2” max orifice)</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>92</td>
<td>88</td>
</tr>
<tr>
<td>1,000</td>
<td>185</td>
<td>176</td>
</tr>
<tr>
<td>1,500</td>
<td>277</td>
<td>264</td>
</tr>
<tr>
<td>2,000</td>
<td>370</td>
<td>352</td>
</tr>
<tr>
<td>2,500</td>
<td>462</td>
<td>439</td>
</tr>
<tr>
<td>3,000</td>
<td>555</td>
<td>527</td>
</tr>
<tr>
<td>3,500</td>
<td>647</td>
<td>615</td>
</tr>
<tr>
<td>4,000</td>
<td>740</td>
<td>703</td>
</tr>
<tr>
<td>4,500</td>
<td>832</td>
<td>791</td>
</tr>
<tr>
<td>5,000</td>
<td>925</td>
<td>879</td>
</tr>
<tr>
<td>5,500</td>
<td>1,017</td>
<td>967</td>
</tr>
<tr>
<td>6,000</td>
<td>1,109</td>
<td>1,055</td>
</tr>
<tr>
<td>6,500</td>
<td>1,202</td>
<td>1,143</td>
</tr>
<tr>
<td>7,000</td>
<td>1,294</td>
<td>1,230</td>
</tr>
<tr>
<td>7,500</td>
<td>1,387</td>
<td>1,318</td>
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<tr>
<td>8,000</td>
<td>1,479</td>
<td>1,406</td>
</tr>
<tr>
<td>8,500</td>
<td>1,572</td>
<td>1,494</td>
</tr>
<tr>
<td>9,000</td>
<td>1,664</td>
<td>1,582</td>
</tr>
<tr>
<td>9,500</td>
<td>1,757</td>
<td>1,670</td>
</tr>
<tr>
<td>10,000</td>
<td>1,849</td>
<td>1,758</td>
</tr>
<tr>
<td>10,500</td>
<td>1,942</td>
<td>1,846</td>
</tr>
<tr>
<td>11,000</td>
<td>2,034</td>
<td>1,934</td>
</tr>
<tr>
<td>11,500</td>
<td>2,126</td>
<td>2,021</td>
</tr>
<tr>
<td>12,000</td>
<td>2,219</td>
<td>2,109</td>
</tr>
<tr>
<td>12,500</td>
<td>2,311</td>
<td>2,197</td>
</tr>
<tr>
<td>13,000</td>
<td>2,404</td>
<td>2,285</td>
</tr>
<tr>
<td>13,500</td>
<td>2,496</td>
<td>2,373</td>
</tr>
<tr>
<td>14,000</td>
<td>2,589</td>
<td>2,461</td>
</tr>
<tr>
<td>14,500</td>
<td>2,681</td>
<td>2,549</td>
</tr>
<tr>
<td>15,000</td>
<td>2,774</td>
<td>2,637</td>
</tr>
</tbody>
</table>
HYDRAULIC BALANCE PRESSURE VS. LINE PRESSURE
3/4" & 1" EQUIVALENT ORIFICE CHOKES
HYDRAULIC BALANCE PRESSURE VS. LINE PRESSURE
2" EQUIVALENT ORIFICE CHOKES

HYDRAULIC PRESSURE (psi)

LINE PRESSURE (psi)
The ports on the hydraulic cylinder both act as inlet and outlet ports, so for the purposes of identification we will use the terms extend and retract. This will more clearly identify the result when pressurized hydraulic fluid is applied to the respective port. When hydraulic pressure is supplied to the extend port, this “pushes” the cylinder rod out from the cylinder. Thereby decreasing the equivalent orifice opening (reducing flow) of the choke until it is completely shut. Hydraulic pressure supplied to the retract port, will pull the cylinder rod into the cylinder. This will increase the equivalent orifice opening (increasing flow) of the choke until fully open.

**Note a 3/4”-1” maximum equivalent orifice opening choke utilizing a body with 2” connections shown above. The respective locations will be the same for a 2” maximum equivalent orifice opening choke that utilizes a body with 3” connections.**

For the connection port sizes refer to the table in section 2.5 Cylinder Specifications.
3.1 Preventative

The choke stem will periodically need to be lubricated. If the choke has a grease fitting, inject a few strokes of general purpose grease.

3.2 Inspection

After degreasing the parts, visually inspect for abnormal wear, corrosion, erosion, or any other physical damage.

1. Inspect the threads, packing area, shaft and carbide tip of the stem and replace as necessary. The cone of the carbide tip should be smooth and without grooves or cracks.
2. Inspect the threads and carbide liner of the seat and replace as necessary. The entry bevel of the carbide liner should be smooth and without grooves or cracks. Look down the orifice for washouts in the mid-section of the liner.
3. Always discard the packing when removed from the bonnet. Replace with new packing.
4. Replace the wingnut if the lugs are excessively deformed or damaged.
3.3 Pictorial Inspection

Clean and degrease the parts, and visually inspect for abnormal wear, corrosion, erosion, or other physical damage.

Inspect the stem threads. If there is abnormal wear on the threads (such as a step on the thread flank), replace the stem.

If there are any burrs or nicks present, these need to be removed.

Inspect stem packing sealing surface and shaft.

Sealing surface should be free of scratches or imperfections. Lightly buff out any light scratches to improve sealing surface finish.

If there is any wear on the sealing surface, replace the stem.

Inspect the carbide tip of the stem. The cone of the carbide tip should be smooth and without grooves or cracks.

The brazing between carbide tip and stem should be free of cracks or pits.

NOTE: THE STEP DEPICTED ON IMAGE HAS CRACKS ON BRAZING. THIS NEEDS TO BE REPLACED.

Replace stem as necessary
Inspect the threads of the seat for any damage.

Any burrs or nicks should be removed to prevent galling with fitting internal threads if reused.

Inspect the entry bevel of the carbide liner. It should be smooth and without grooves or cracks.

NOTE: THE SEAT DEPICTED ON IMAGES SHOWS CRACKING AND IS CHIPPED. THIS NEEDS TO BE REPLACED.

Look down the orifice for washouts in the mid-section of the liner.

Replace seat as necessary
Inspect the bonnet sealing surface and packing gland sealing surface.

Buff any light scratches or surface imperfections to improve sealing surface finish.

Replace bonnet as necessary.

Inspect wing nut for excess wear and damage.

Replace if severe damage is present.

Remove any nicks or burrs on threads if present.

**WARNING:** WING NUT DEPICTED AT RIGHT AND BOTTOM IS BEYOND SERVICEABLE LIFE AND IS A SAFETY HAZARD. IT SHOULD BE REPLACED.
3.4 Pictorial Assembly

NOTE - ALWAYS USE HIGH QUALITY GRAPHITE GREASE OR ANTI-SEIZE DURING ASSEMBLY. LUBRICATE ALL PARTS THOROUGHLY, ESPECIALLY THREADS.

3.4.1 Assembling the Tee Subassembly

Lubricate resilient seal gland on female connection (light general purpose grease)

Install resilient seal on gland
Install spiral retaining ring over male end

**For a 3” choke assembly only:** Ensure that the spiral retaining ring is over the step on the outer diameter of the male end (see image).

If this is not done, it will be very difficult to install the retainer segment set.

Slide the wingnut over the male end connection.
Install the nut retainer segment set.

If the spiral retaining ring was correctly installed over the male end outer diameter step, there should be plenty of space to install the 3rd segment.

Align all three segments behind wingnut until the ring groove is aligned and accessible.
Install spiral retaining ring on the ring groove on all three segments.

Apply a liberal amount of anti-seize to the internal threads on male end connection.

**For a 2” choke assembly only:** assemble the choke nipple subassembly:

- lubricate sealing gland with light general purpose grease and install resilient seal
- slide spiral retaining ring and wingnut over male end connection
- insert nut retainer set into wingnut
- install spiral retaining ring on the ring groove on all three segments.
For a 2” choke assembly only: assemble the choke nipple with the choke tee subassembly:

Lubricate (with anti-seize) the choke seat threads thoroughly

Using the appropriate choke seat wrench, insert the choke seat through the female end connection of the Tee fitting
Using a torque wrench, fully tighten the choke seat to the recommended torque below.

<table>
<thead>
<tr>
<th>Choke Size</th>
<th>Torque (ft*lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2”</td>
<td>100</td>
</tr>
<tr>
<td>3”</td>
<td>125</td>
</tr>
</tbody>
</table>

Tee subassembly is complete.
3.4.2 Assembling the Bonnet subassembly

Lubricate the choke stem seal gland with light general purpose grease

Position choke stem seal on gland, and using the appropriate tool, install seal
Verify choke stem seal is fully installed on gland

Lubricate the packing gland of the bonnet with light general purpose grease

Install the stem guide.
Identify correct orientation of new packing

INSERT THIS END FIRST

Install new packing as shown

Install packing retainer
Install snap ring in place

Lubricate inside of packing with light general purpose grease

For a 3” choke assembly only: Using light general purpose grease, install backup ring on seal gland as shown

If backup ring has a concave surface, install flat side first as depicted on image above

For a 3” choke assembly only: Using light general purpose grease, install o-ring on seal gland as shown.
Apply 1.5-2 turns of PTFE (Teflon®) tape on grease fitting in clockwise direction (when viewed from grease fitting threaded end)

Install grease fitting on bonnet hand tight

Wrench tighten 2-3 turns from the hand tight position

Never back off (loosen) grease fitting to achieve final alignment.

Position wingnut over bonnet as shown

Bonnet subassembly is complete

3.4.3 Assembling the hydraulic cylinder and bonnet subassembly
If position indication is required on the choke assembly, position the upper mount indicator bracket as shown.

*Use anti-seize on stay bolt threads.*

Insert bonnet stay bolts on hydraulic cylinder, install lock washers and hex nuts (hand tight)

Do NOT fully tighten hex nut at this time

*Use anti-seize on stay bolt threads.*

Install remaining two bonnet stay bolts, lock washers, and hex nuts (hand tight)

Do NOT fully tighten hex nut at this time
Lubricate the four holes on the bonnet flange and align it with the bonnet stay bolts

Install bonnet flange on bonnet stay bolts

If position indication is required on this choke assembly, position the lower mount indicator bracket as shown
Install 4 lock washer

*Use anti-seize on stay bolt threads.*

Install 4 hex nuts (hand tight)

Do NOT fully tighten hex nut at this time

Apply anti-seize to the bonnet flange internal threads
Install the previously assembled Bonnet subassembly

No specific torque needed. Lock screws will keep it in place and prevent unscrewing.

Assembly is ready for choke stem installation. Proceed to next steps

Note: The rod seal was previously installed on the bonnet assembly

Use anti-seize on threads

Position the rod seal retainer plate on the bonnet flange, and install the 4 hex screws (hand tight)

Do NOT fully tighten hex screws at this time. This will be done once the choke stem is in place and fully aligned with the retainer plate.
Apply anti-seize to the bonnet locking hex screws

Note: Flip the choke assembly on its side to install both bonnet locking hex screws. This screws prevent unscrewing of the bonnet assembly during use.

Install top hex screw to 16.5 ft-lbs

Install bottom hex screw to 16.5 ft-lbs
Verify packing is well lubricated. If not, lubricate inside of packing with light general purpose grease.

For a 2” choke assembly only: Apply anti-seize to the thread bushing and screw into hydraulic cylinder.

Insert choke stem through packing until threaded end comes out of bonnet assembly.

Apply anti-seize to choke stem threads thoroughly.
Fully thread hex nut on choke stem until it bottoms out (flat side of hex nut facing away from stem)

If position indication is required on this choke assembly, install position indicator arm as shown

*Note: Position indicator arm must be on same side of upper and lower mount brackets.*

**For a 2” choke assembly only:** Install lock washer and thread stem into stem bushing

**For a 3” choke assembly only:** Thread stem into hydraulic cylinder
Choke stem should be screwed all the way towards the hydraulic cylinder

*Note: No need to wrench tighten at this point, but if needed, a wrench may be used to turn the choke stem until fully seated. Do NOT use cheaters or extensions.*

*Note: There should be NO GAPS between the parts, and there should be NO THREADS visible before continuing*

Since the choke stem is in place now, at this point tighten the 4 hex screws on the rod seal retainer plate to 5.1 ft-lbs

Making sure anti-seize is applied on threads, fully tighten all 8 hex nuts on the bonnet stay bolts to the torque specified below:

<table>
<thead>
<tr>
<th>Choke Size</th>
<th>Thread Size</th>
<th>Torque (ft*lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2”</td>
<td>5/8” – 11</td>
<td>143</td>
</tr>
<tr>
<td>3”</td>
<td>1” - 8</td>
<td>620</td>
</tr>
</tbody>
</table>

*Note: Leaving the hex nuts loose and tightening them only after the bonnet and choke stem are in place helps the components align themselves better, and prevents the assembly from being on a bind. Consequently, this also makes threading of the choke stem easier.*
Locate grease fitting and grease the choke assembly

Hydraulic cylinder and bonnet subassembly is complete

Apply anti-seize to Tee fitting assembly threads

Carefully align and make up the connection between the bonnet and the choke tee
3.4.4 Installing position sensor (if required)

Remove bracket previously installed

Install screws on position sensor

Aligning the screws with the mounting holes, and position the sensor and screws on the bracket
Install the two locknuts

With position sensor in place, reinstall bracket on hydraulic cylinder assembly:

-Route the cable below the position sensor body and hex nut (see image)

-Position lock washer and bracket on edge of bonnet stay bolt

-Insert hex nut, and gradually turn it to move the bracket in place

-Fully tighten hex nut

Verify connection cable is routed correctly

Fully tighten second hex nut securing the bracket in place
Install cable fitting:

- Loosen hex nut (right arrow) to loosen cable from cable fitting

- Loosen thin hex nut (left arrow)

- Slide connector so that the bracket is between lock washer and fitting hex (middle arrow)

- Tighten thin hex (left arrow) nut to secure fitting on bracket

- Accommodate cable inside bracket so that there are nice radii and ensure cable is not on a bind

- Tighten hex nut (right arrow) by hand to secure cable on fitting. DO NOT OVER TIGHT TO PREVENT DAMAGE TO CABLE

Install eyebolt on indicator arm:

- Eyebolt is supplied with a regular hex nut

- Use this hex nut to position the eyebolt on the indicator arm

- Secure it with a locknut, ensuring it fully engages the eyebolt threads

Loop wire on eye bolt:

- Insert wire through one opening of loop sleeve

- Insert wire through eyebolt

- Insert wire through second opening on loop sleeve

- Position loop sleeve close to eyebolt
Pull the wire out of the position sensor about 1”. A good indicator for that is aligning the factory cable stop sleeve with the edge of the mounting bracket (as shown on the image).

Holding wire in the position described above, crimp the loop sleeve together using crimping pliers.

3.4.5 Hydraulic choke stem synchronization procedure

Remove hydraulic cylinder port plugs.
Install hydraulic hose connections

Caution: Before proceeding, verify that the choke stem is fully seated all the way towards the hydraulic cylinder. If not, the following step will cause damage to choke components since the stem is not synchronized with the choke seat position at this time.

Fully extend the hydraulic cylinder out to the choke “Close” position. At this point, the cylinder has bottomed out to its internal stop, but the choke stem is still not making contact with the choke seat.

Verify that choke stem is NOT making contact with choke seat (use a flashlight on the Tee inlet, and look through Tee outlet for light)
For a 2” choke assembly only: Hold stem bushing in place and unscrew the choke stem out until it makes contact with the choke seat, but don’t apply excessive force after that.

For a 3” choke assembly only: Hold hydraulic cylinder in place and unscrew the choke stem out towards the choke seat, but don’t apply excessive force after that.

*Note:* Seat the choke stem by hand if possible. Use a wrench if necessary to turn it until snug-tight, but don’t apply more force after that. 
Do NOT use cheaters, or extensions. 
Do NOT over tighten choke stem against seat.

For a 2” choke assembly only: Tighten the hex nut against the lock washer, position indicator arm, stem bushing, and hydraulic cylinder. **Use a wrench to hold the stem in place.**

For a 3” choke assembly only: Tighten the hex nut against the position indicator arm and the hydraulic cylinder. **Use a wrench to hold the stem in place.**

*Note:* If done correctly, the choke stem should be synchronized to the hydraulic cylinder travel and choke seat position.

Verify that position indicator arm is not rubbing against the bonnet stay bolts (if its, tap the plate to one side to separate it from the stay bolt)
Retract hydraulic cylinder to the choke “Open” position and verify the position indicator arm is not rubbing.
Disconnect hydraulic hoses and install factory hydraulic inlet/outlet plugs

Position indicator cover in place as shown

Secure the indicator cover by installing the 4 screws
Verify that position indicator arm is visible in the choke “Open” position

NOTE: Open position is the side further away from the choke body.

Choke assembly is complete