TORO®

Commercial Products

Hydraulic Hose Servicing

Part No. 94813SL

INTRODUCTION

One of the most dreaded failures in the turf maintenance business is hose failure because of the damaging effects of oil to the turf and the environment. Usually, the hose is replaced and the equipment is put back into service. However, the same problem may repeat too frequently and that is cause for concern. It is the job of the service technician to properly analyze the situation to avoid these repeat failures. Be sure to always fully investigate each hose failure to determine the true cause and use only genuine Toro replacement parts. Replacement parts made by other manufacturers could be incompatible and may void the product warranty of the Toro Company.

The purpose of this booklet is to provide you a fundamental knowledge on Hydraulic Hoses. The information contained in this booklet will give you a knowledge base that will help reduce repeat failures and greatly simplify the identification and resolution of hydraulic hose related problems. Contained in this booklet are sections on Troubleshooting, Hose Routing, Analyzing Hose Failures, Identifying & Measuring Hose Fittings, and Hose Maintenance.

The Toro Company would like to thank The Aeroquip Corporation and The Parker Hannifin Corporation for contributing to this booklet.

CAUTION

Keep body and hands away from pin hole leaks or nozzles that eject hydraulic fluid under high pressure. Use paper or cardboard, not hands, to search for leaks. Hydraulic fluid escaping under pressure can have sufficient force to penetrate skin and do serious damage. If fluid is injected into the skin it must be surgically removed within a few hours by a doctor familiar with this form of injury or gangrene may result. Before disconnecting or performing any work on the hydraulic system, all system pressure must be relieved by stopping the engine and lowering the implement to the ground.

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HOW TO ANALYZE HOSE FAILURES

FIVE MAJOR CATEGORIES OF HOSE FAILURE:

1. Improper assembly and installation
2. External Damage
3. Faulty Equipment
4. Faulty Hose
5. Improper Application (Using the wrong hose for the application).

1. Improper assembly and Installation

One major cause of Hose failure is improper assembly and installation. Anything from using the wrong fitting, to poor routing of the hose can result in failures.

2. External Damage

A crushed hose is an example of external damage. However, the hose may also be abraded and/or corroded. These are problems that can normally be solved once the cause is identified. The hose can be rerouted, clamped or an abrasion guard can be used.

3. Faulty Equipment

Frequent or premature hose failure can be the symptom of a mechanical problem with your equipment. This is an issue that should be considered since prompt corrective action can avoid serious and costly equipment breakdown.

4. Faulty Hose

On occasion, a failure is diagnosed to be with the hose. Possible failure causes are age, composition, and assembly errors (e.g. poor crimp where the fitting attaches to the hose).

5. Improper Application

If the wrong hose is used in an application, it will not last as long as expected. TORO ensures all hoses meet the criteria of the following areas for each application:

- *The maximum operating pressure of the hose.*
- *The recommended temperature range of the hose.*
- *The vacuum service rating of the hose.*
- *The fluid compatibility of the hose.*
- *The cycle time of the equipment (impulse life).*

ANALYZING FAILURES

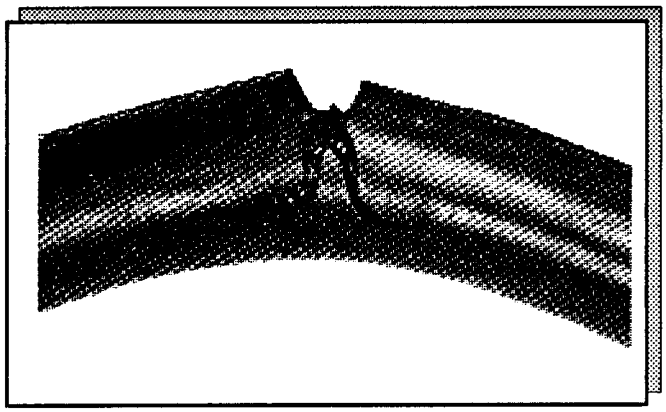
An examination of the failed hose can often offer a clue to the cause of the failure. The following list suggests symptoms to look for and the conditions that could cause them.

1. **Symptom** - The hose is very hard and has cracked.

   Cause: Plasticizers give the hose its flexibility. Excessive heat will leach the plasticizers out of the tube. Aerated oil causes oxidation to occur. This reaction of oxygen on a rubber product will cause it to harden. Any combination of **oxygen** and **heat** will greatly accelerate the hardening of the hose. Cavitation of the hydraulic system would have a similar effect.

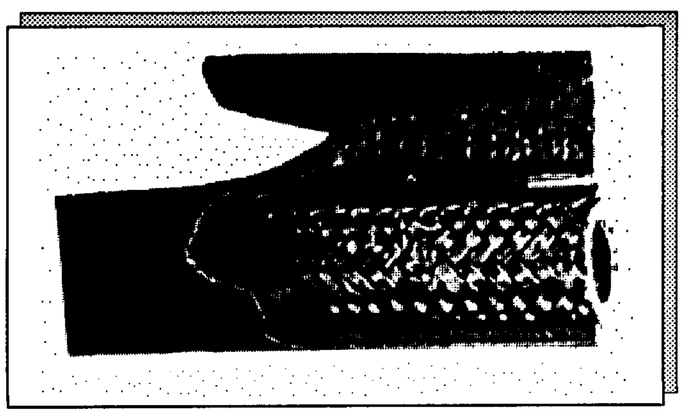
2. **Symptom** - The hose is cracked both externally and internally, but the elastomeric materials are soft and flexible at room temperature.

   Cause: The likely cause is intense cold conditions while the hose was flexed. Most standard hoses are rated at -40 degrees F (-40C).



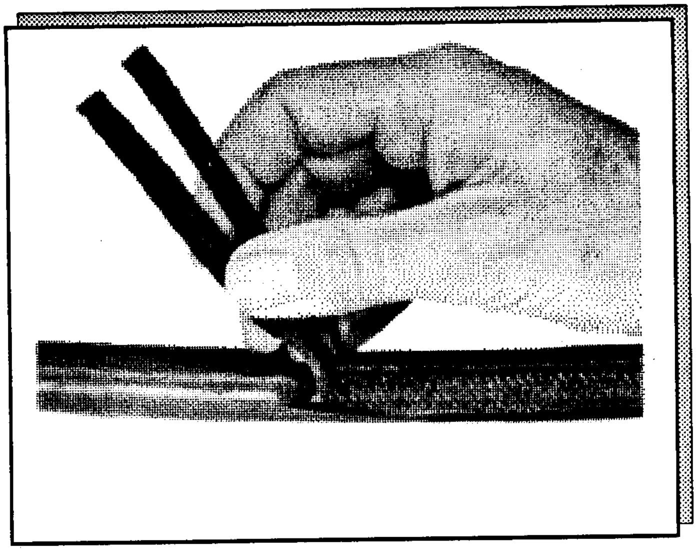
3. **Symptom** - The hose has burst and an examination of the wire reinforcement, after stripping back the cover, reveals random broken wires running the entire length of the hose.

   Cause: This symptom may indicate a high frequency pressure impulse condition.



4. **Symptom** - The hose has burst, but there is no indication of multiple broken wires the entire length of the hose.

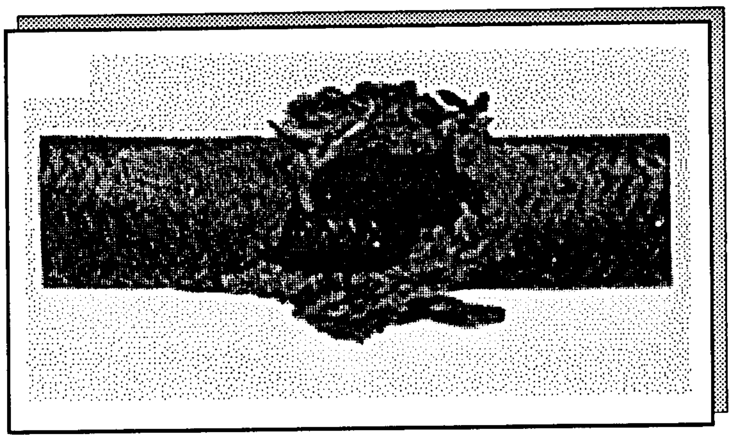
   Cause: This could indicate that the pressure has exceeded the minimum burst strength of the hose. The hydraulic circuit may have malfunctioned, which is causing unusually high pressure conditions.



5. **Symptom** - Hose has burst. Examination indicates that the wire reinforcement is rusted and the cover has been cut, abraded or deteriorated badly.

   Cause: The only function the cover has is to protect the reinforcement. Elements that may degrade or remove the outer covers are:

   - Abrasion
   - Cutting
   - Battery Acid
   - Steam cleaners
   - Chemical cleaning solutions
   - Fertilizers
   - Salt Water
   - Heat
   - Extreme Cold



Note: Once the cover protection is gone, the reinforcement is susceptible to attack from moisture or other corrosive material.

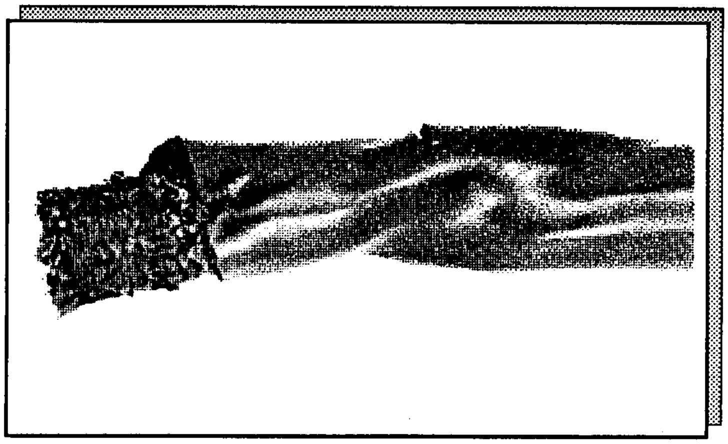
6. **Symptom** - The hose has burst on the outside bend and appears to be elliptical in the bent section. Or in the case of a pump inlet line, the pump is noisy and very hot. The pressure line from the pump is hard and brittle.

   Cause: Violation of the minimum bend radius is most likely the problem in both cases. Partial collapse of the hose may cause the pump to cavitate, creating both noise and heat. This is a very serious situation and can result in pump failure if not corrected.

7. **Symptom** - Hose appears to be flattened out in one or two areas and is kinked and twisted.

   Cause: Twisting of a hydraulic hose will tear loose the reinforcing layers, and allow the hose to leak through the enlarged gaps between the braided plaits of wire strands.

   Important:
   Be sure there is never any twisting force on a hydraulic hose.



8. **Symptom** - Hose has burst about six to eight inches away from the end fitting. The wire reinforcement is rusted. There are no cuts or abrasions of the cover.

   Cause: Improper assembly of the hose and fitting can allow moisture to enter around the socket. The moisture may "wick" through the reinforcement. The heat generated by the system may drive it out from around the fitting area, but six to eight inches away it will be entrapped between the tube and cover causing severe rusting of the wire reinforcement.

9. **Symptom** - There are blisters in the cover of the hose. These blisters contain oil.

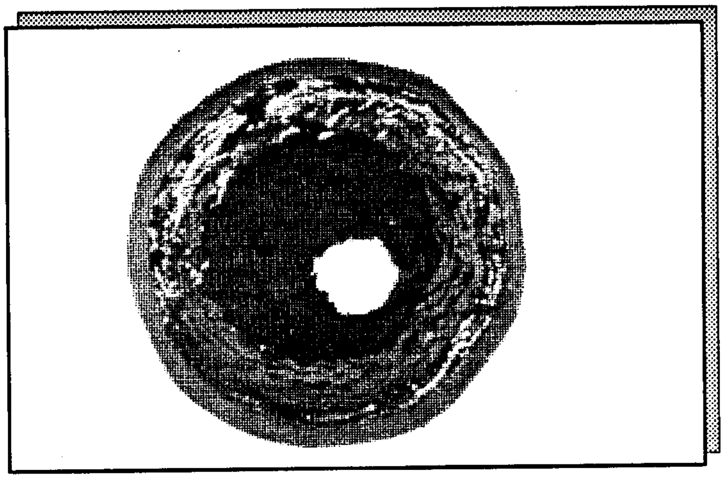
   Cause: A small pin hole in the tube is allowing high pressure oil to seep between it and the cover. Eventually the oil will form a blister wherever the cover adhesion is weakest. Other possibilities would be if the minimum bend radius is violated and hose is bent at the fitting. This will cause the nipple on the connector to dig into the inner liner making it thinner and thinner. So thin the high pressure oil will migrate through the hose and create bubbles on the hose.

10. **Symptom** - Fitting blew off of the end of the hose.

Cause: Misassembly, improper routing, incorrectly manufactured hose, or excess pressure may be the problem.

11. **Symptom** - The inner liner of the hose is badly deteriorated with evidence of extreme swelling.

Cause: Indications are that the tube is not compatible with the fluid being conveyed. Even though the fluid is normally compatible, the addition of heat can be the catalyst that can cause tube deterioration. Make sure that the operating temperatures, both internal and external, do not exceed the recommendations of the fluid or hose manufacturer.



12. **Symptom** - Hose has burst. The cover is badly deteriorated and the surface is cracked.

Cause: This could be simply old age. The "cracked" appearance may be the effect of weathering over a period of time. Try to determine the age of the hose. Some manufacturers print or emboss the date of manufacturer on the outside of the hose.

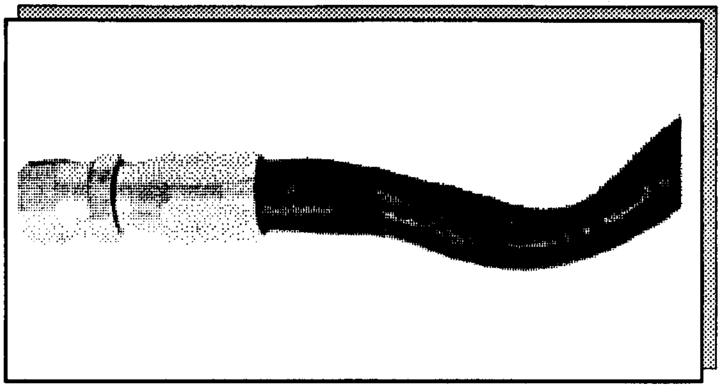
13. **Symptom** - Hose is leaking at the fitting because of a crack in the steel tube, adjacent to the braze on a split flange shoulder.

Cause: Because the crack is adjacent to the braze and not in the braze, this is a stress failure that could be brought on by a hose that is trying to shorten under pressure, but has insufficient length to do so. This problem can be corrected by changing the routing to relieve the forces on the fitting.

14. **Symptom:** Hose has not burst but it is leaking badly. A bisection of the hose reveals that the tube has been washed away to the reinforcement.

Cause: This failure indicates that erosion of the tube has taken place. A high velocity needle line fluid stream being emitted from an orifice and directed at a single point on the hose will hydraulically remove a section of material. Be sure that the hose is not bent close to a port that has an orifice. Where high velocities are encountered, contamination in the fluid can cause considerable erosion in bent sections of the hose assembly. This effect would be similar to a sandblasting process.

15. **Symptom** - Hose is badly flattened out in the burst area. The tube is very hard downstream of the burst but appears normal upstream of the burst.



NOTE: Fluid flows in one direction only (i.e. pump to control valve or return line).

Cause: The hose has been kinked or twisted either by bending it too sharply or by crushing it in some way so that a major restriction was created. As the velocity of the fluid increases through the restriction, the pressure decreases to the vaporization point of the fluid (which is cavitation). This condition causes heat and rapid oxidation to take place. Heat and oxidation harden the tube of the hose downstream of the restriction.

HOSE ROUTING AND INSTALLATION BASICS

HOW TO ROUTE AND INSTALL HOSE LINES

Routing for Good Appearance:

Routing for good appearance may seem too simplistic, but good appearance can result in better functioning and the use of less hose and fewer connections. To provide a good appearance in a flexible system, keep these points in mind:

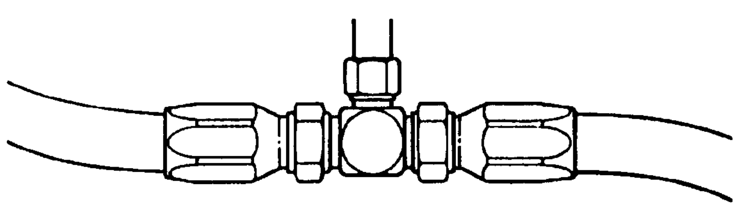
- Route hose assemblies in straight lines or follow the contour of the equipment on which they are used.
- Route hose lines together and parallel. This will prevent crisscrossing and abrasion of the hose.
- Use brackets and clamps to keep hoses in place and to prevent excessive rubbing and abrasion.
- Use hose assemblies of proper length. Excessive slack in hose lines is one of the most common causes of poor appearance and failure.

The Use of Adapters:

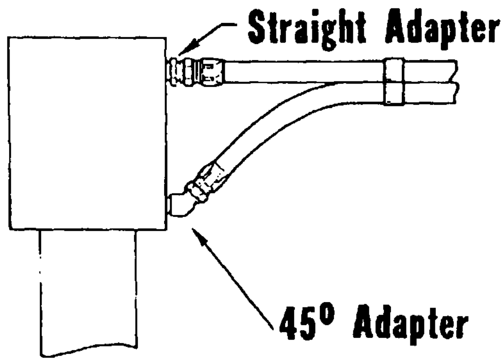
Adapters are used to allow routing of hose for good appearance. They also minimize the number of connections for less chance of leaks.

The following are three major functions of adapters:

1. To join a hose or tube to the component. The type of adapter to be used is determined by the type of porting in the component and the type of tube or hose fitting.
2. To connect two or more tubes together or a tube to a hose (See example below).

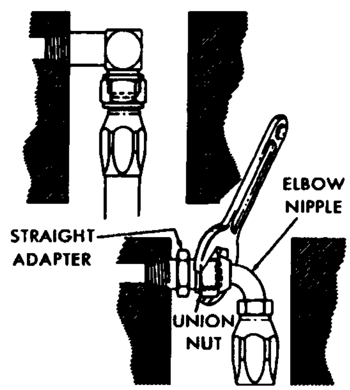


3. To connect hose assemblies to a bulkhead connection. An adapter provides an anchor in addition to connecting two or more tubes or hoses (see example below).



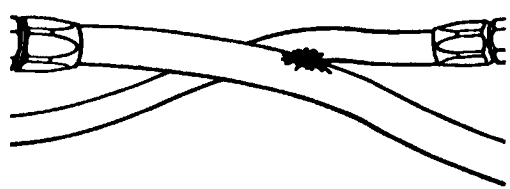
Accessibility:

Often times it is difficult to fit hydraulic connections in a system and make all of the fittings accessible with hand tools. The use of the proper routing and connections can maximize accessibility. As shown, two accessories make it almost impossible to service the union nut, which has a 90 degree adapter. By using a hose fitting with a 90 degree elbow, the union nut can be placed in a position where it can be reached conveniently with a wrench.



Abrasion:

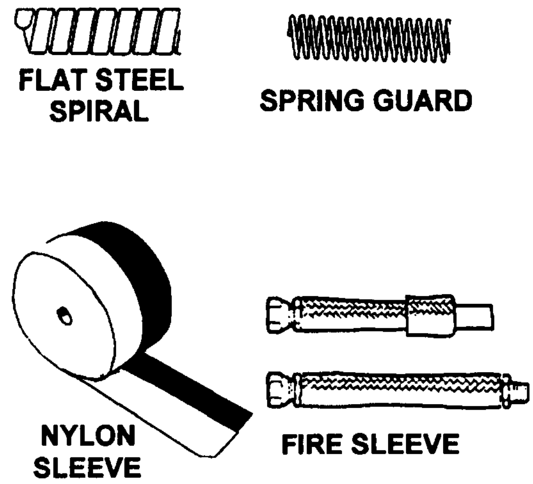
Constant abrasion at the same point on a hose may wear through the outer cover and weaken the reinforcement to the point of failure. Abrasion is caused by contact with sharp edges or moving parts. Clamps can sometimes be moved to different locations or attached to different points to move the hoses away from the abrasion area. In many cases elbow fittings are used to route the hose away from abrasion.



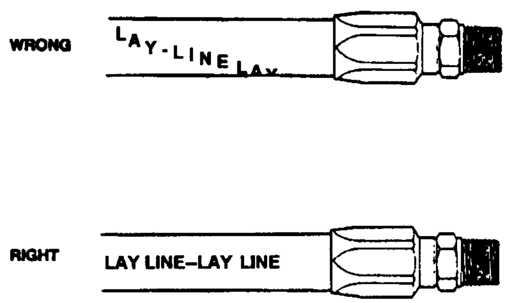
When two hoses crisscross, resulting in a sawing action which wears both hose lines, they can both be held by retaining clamps at the abrasion point. When a clamp is used, it should fit snugly and grip the hose around its entire circumference. Watch for abrasion in applications where the hose is flexing. Another method to protect the hose is to use a protective hose guard.

Examples of protective hose guards are:

1. Plastic Spiral Wrap
2. Flat Steel Spiral
3. Spring Guard
4. Nylon Sleeve
5. Fire Sleeve



NOTE: If lay lines on a hose are twisted, the hose is routed in a twist. A twisted hose will unwind a spiral wrap or guard on a hose. It will also unwind braided wires inside the hose and promote failure.



Ambient Heat:

Exposure to high external temperatures can drastically shorten hose life by affecting the outer cover and weakening the reinforcement. Route hose lines away from hot manifolds or other high outside temperatures whenever possible. Protective sleeves or baffles are used to protect the hose when the hose must be routed near high temperature objects.

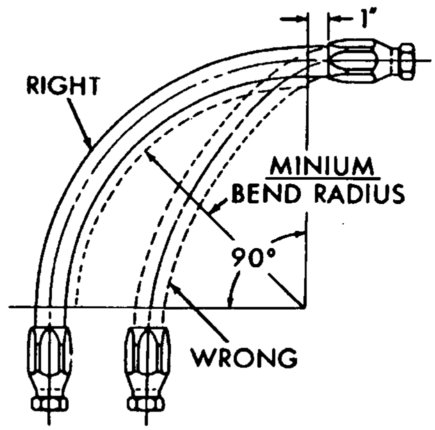
The Importance of Cleanliness:

Dirt is the enemy of a hydraulic system. The same technician that takes great care in order to keep dirt out of an engine, or away from roller bearings, often forgets to treat a hydraulic system the same way. A hydraulic system has the same precision, or more, and dirt will have the same adverse effect. Keeping your fluid system clean is vital to good hydraulic operation and long service life.

Minimum Bend Radius:

When installing a hose where it will be bent, observe the bend radius during the full range of motion and position the hose to keep the radius as large as possible. Exceeding the minimum recommended bend radius will dramatically reduce the service life of the hose. Minimum bend radius is particularly important on applications with high pressures, constant flexing or vacuum conditions.

To find the bend radius, measure the distance from the inside of the bend to an imaginary center point. Notice that the lines forming the imaginary point extend from a point one inch from the fittings at each end. Any time the hose is bent at the fitting, early failure will result because the internal nipple on the connector is digging into the inner liner making it thinner and thinner. So thin the high pressure oil will migrate through the hose. The first indication will be bubbles on the hose.

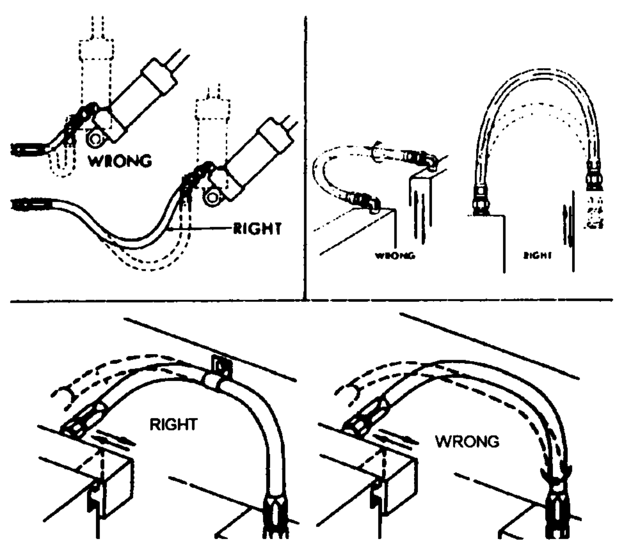


Make sure the hose flexes in the same plane as the bend. If you do not, there will be a twisting action placed on the hose each time the hose is flexed. Clamps are used to ensure proper flexing and positioning of the hose.

Flexing Applications:

In flexing applications, watch for abrasion. Bending beyond the limits of the minimum bend radius is also a problem often encountered during flexing applications. When the hose is bent more than the recommended minimum, the service life of the hose will be reduced.

Provide enough hose on either side of any clamp to allow for free movement, a fitting is not a flexible part of the assembly. Continuous flexing of a short hose assembly often tends to wear the hose at the point of connection with the fitting. Clamps are used to control twisting at the point where the hose changes planes. The clamp in effect serves to divide the hose into two assemblies. If the section of the hose is bent in the same plane as the movement, the bend will absorb the movement and hose twist is reduced. Allowing as much free hose as possible is another means to control twisting.



TROUBLESHOOTING

Whenever you have extensive use of fluid power systems, system leakage can, and usually does occur sometime during the machines service life. How to identify and cure the sources of hydraulic leaks will minimize the machines downtime and prevent repeat failures.

THE BASIC CAUSES OF FLUID SYSTEM LEAKAGE:

1. Human Error
2. Poor Protection of Components
3. Difficult to Reach Connections
4. Lack of Education
5. Use of Makeshift Tools
6. Inadequate Training

Find the leak:

First find the location of the leak. To make sure that the leak is not above the area suspected:

1. Clean off and wash down the area.
2. Watch for the leak to show.
3. Put a paper towel above the connection to catch any fluid leaking down from above.

CAUTION

Keep body and hands away from pin hole leaks or nozzles that eject hydraulic fluid under high pressure. Use paper or cardboard, not hands, to search for leaks. Hydraulic fluid escaping under pressure can have sufficient force to penetrate skin and do serious damage. If fluid is injected into the skin it must be surgically removed within a few hours by a doctor familiar with this form of injury or gangrene may result. Before disconnecting or performing any work on the hydraulic system, all system pressure must be relieved by stopping the engine and lowering the implement to the ground.

The next thing is to determine if the leak is at a valve, motor, pump shaft, cracked casting, rod packing, pipe joint, hose, or any other potential area for leaks.

To properly identify and cure hydraulic leaks, it is important to examine leak problem areas specific to individual hydraulic connectors.

SAE 37 DEGREE FLARE

How the Connection Seals:

The connection seals against the two 37 degree surfaces under compression.

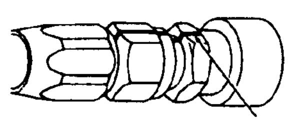
Causes of the Leaks:

Most leaks associated with an SAE 37 degree flare connection are due to lack of tightening or human error. To ensure that the connection is properly tightened, it must be torqued to the proper specification. It is impossible to tell if a nut has been tightened by looking at the connection. A torque wrench is recommended but is only helpful when it is used. To know if all the connections have been properly tightened a technician must rely upon his memory or, he can get in the habit of marking each connection after tightening.

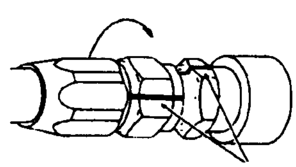
How to Cure the Leak:

An alternate method to determine if a joint has been tightened is commonly referred to as Flats From Finger Tight (FFFT). The following is a description for proper tightening of an SAE 37 degree connector using this method.

1. Assure the two connecting parts are clean. Sand, grass, or other contaminants will prevent a good seal, no matter how tight the fitting is torqued.
2. Tighten the nut by hand until the seats bottom against each other.
3. Using a permanent marker, draw a line lengthwise on the nut and extend it to the adapter.
4. Hold the adapter with a wrench and tighten the nut the specified number of flats indicated in the chart according to the hose size.



Mark a Line on the Nut and Adapter Before Torquing



Misalignment of the Mark shows the amount which the Fitting has turned.

Line Size	Rotate No. of Hex Flats (For machined flares only)
-04	2½
-05	2½
-06	2
-08	2
-10	1½-2
-12	1
-16	¾-1
-20	¾-1
-24	½-¾

NOTE: The misalignment of the marks will indicate how much the connection has been tightened.

What to do if the joint leaks after it has been tightened using the (FFFT) method?

Don't tighten the connection more, it is already at the proper torque value. Take the connection apart and look for:

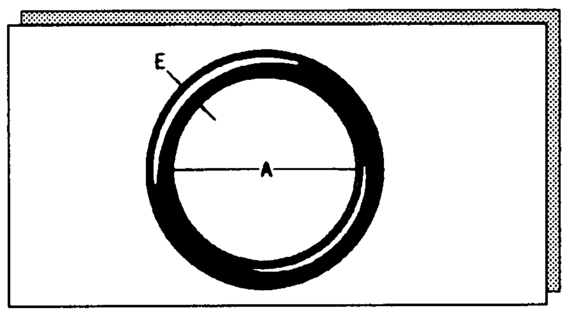
1. Foreign particles in the joint. If present, clean the joint.
2. Cracked seats in the connection. If the seats are cracked, replace the faulty part.
3. Seats mismatching or not concentric with the threads. Tighten the fitting, then loosen and visually inspect the pattern on the sealing surface to determine if the fitting is mismatched or not concentric. The pattern should be an even 360 degrees around the mating surfaces. If the seats mismatch, replace the faulty part.
4. Deep nicks in the seats. If nicks are present, replace the faulty part.
5. Excessive seat impression indicates over torque of the service nut. Threads will also stretch due to over torque conditions. If seat damage is present, replace the faulty part.
6. Tool marks or chatter marks on seats. If present, replace faulty part.
7. SAE 45 degree connections will leak, when connected to SAE 37 degree flare parts.

NOTE: Leak problems associated with mixing 37 degree connectors and a 45 degree connectors do not always show up until the unit has been in service for a few hours.

O-ring Basics

The following guidelines should be followed with hydraulic connections that use O-rings.

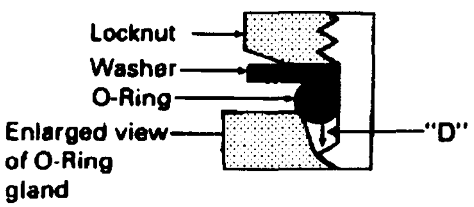
1. Use care to ensure that the O-ring is properly seated when the connection is made.
2. For maximum service life, use only genuine TORO replacement O-rings. Genuine replacements are made from materials to match the design requirements of the application. Not all O-rings will meet the design criteria (e.g. temperature, pressure, compatibility) and may result in repeat failures.
3. O-rings should be lubricated using the same oil recommended for the product. Lubrication is also helpful to prevent rolling or cutting upon installation and tightening.
4. Keep all sealing surfaces clean and grit free.
5. As a preventative measure against leakage, O-rings should never be used again.

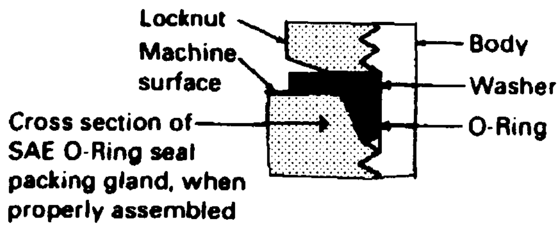


O-ring Size Designation	ORS Tube Size	Dimension A Inches(mm)	Dimension E Inches(mm)
-011	-4	0.301 (7.645)	0.1 (1.778)
-012	-6	0.364 (9.246)	0.1 (1.778)
-014	-8	0.489 (12.421)	0.1 (1.778)
-016	-10	0.614 (15.596)	0.1 (1.778)
-018	-12	0.739 (18.771)	0.1 (1.778)
-021	-16	0.926 (23.520)	0.1 (1.778)
-025	-20	1.176 (29.870)	0.1 (1.778)
-029	-24	1.489 (37.821)	0.1 (1.778)

Torque Values for SAE O-ring Boss ends when used with ORS connections, per SAE J1453					
Dash Size	Thread Size (inches)	in/lb	(Kg/Cm)	ft/lb	(Kg/m)
-03	3/8-24	96 -120	(146)-(183)	8 -10	(1.1)-(1.4)
-04	7/16-20	168 -192	(256)-(292)	14 -16	(1.9)-(2.2)
-05	1/2-20	216 -240	(329)-(365)	18 -20	(2.5)-(2.8)
-06	9/16-18	288 -312	(438)-(475)	24 -26	(3.3)-(3.6)
-08	3/4-16	600 -720	(913)-(1095)	50 -60	(6.9)-(8.3)
-10	7/8-14	864 -960	(1315)-(1461)	72 -80	(10.0)-(11.1)
-12	1 1/16-12	1500 -1620	(2282)-(2465)	125 -135	(17.3)-(18.7)
-14	1 3/16-12	1920 -2160	(2921)-(3286)	160 -180	(22.1)-(24.9)
-16	1 5/16-12	2400 -2640	(3651)-(4017)	200 -220	(27.7)-(30.4)
-20	1 5/8-12	2520 -3360	(3834)-(5112)	210 -280	(29.0)-(38.7)
-24	1 7/8-12	3240 -4320	(4929)-(6573)	270 -360	(37.3)-(49.8)

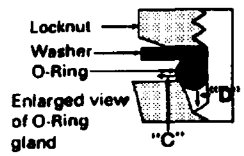
*Increased torque values are required for the increased pressure capabilities of ORS connections.

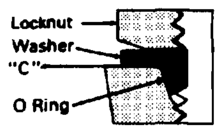




Why is O-ring Lubrication Important?

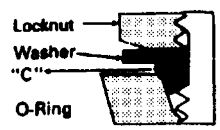
1. The fitting is engaged to the point where the O-ring touches the face of the boss. Lubrication on the O-ring permits it to move in direction "D" (down).
2. When the O-ring and the boss are dry, the motion of the assembly can cause friction and the O-ring can move in direction "C" (out).
3. The lock nut and washer will not bottom fully if the O-ring is between the washer and the face of the boss. The compressed rubber between the washer and the boss will extrude out from compression and the fitting will loosen and usually leak.

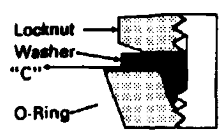




What happens when the lock nut and washer are not backed off prior to assembly?

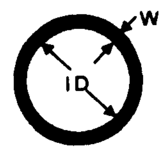
1. When the lock nut and washer have not been backed off, there is insufficient room for the O-ring seal to be compressed without being damaged.
2. The washer will not seat properly on the face of the boss. The compressed rubber between the washer and the boss will extrude from compression and the fitting will loosen and leak.





SAE J515 Straight Thread O-ring Connectors			
Dash Size	Tube OD Ref.	Dimension W inches(mm)	Dimenion ID inches(mm)
-2	1/8	0.064 ±0.003 (1.626) ± (0.076)	0.239 ±0.005 (6.071) ± (0.127)
-3	3/16	0.064 ±0.003 (1.626) ± (0.076)	0.301 ±0.005 (7.645) ± (0.127)
-4	1/4	0.072 ±0.003 (1.829) ± (0.076)	0.351 ±0.005 (8.915) ± (0.127)
-5	5/16	0.072 ±0.003 (1.829) ± (0.076)	0.414 ±0.005 (10.516) ± (0.127)
-6	3/8	0.078 ±0.003 (1.981) ± (0.076)	0.468 ±0.005 (11.887) ± (0.127)
-8	1/2	0.087 ±0.003 (2.210) ± (0.076)	0.644 ±0.005 (16.358) ± (0.127)
-10	5/8	0.097 ±0.003 (2.464) ± (0.076)	0.755 ±0.005 (19.177) ± (0.127)
-12	3/4	0.116 ±0.004 (2.946) ± (0.102)	0.924 ±0.006 (23.470) ± (0.152)
-14	7/8	0.116 ±0.004 (2.946) ± (0.102)	1.048 ±0.006 (26.619) ± (0.152)
-16	1	0.116 ±0.004 (2.946) ± (0.102)	1.171 ±0.006 (29.743) ± (0.152)
-20	1 1/4	0.118 ±0.004 (2.997) ± (0.102)	1.475 ±0.010 (37.465) ± (0.254)
-24	1 1/2	0.118 ±0.004 (2.997) ± (0.102)	1.720 ±0.010 (43.688) ± (0.254)
-32	2	0.118 ±0.004 (2.997) ± (0.102)	2.337 ±0.010 (59.360) ± (0.254)

Recommended torque values	
Dash Size	ft/lb(Kg/m)
-4	14 - 15 (1.9) - (2.1)
-5	18 - 20 (2.5) - (2.8)
-6	22 - 24 (3.0) - (3.3)
-8	36 - 39 (5.0) - (5.4)
-10	43 - 47 (5.9) - (6.5)
-12	68 - 75 (9.4) - (10.4)
-16	111 - 122 (15.4) - (16.9)
-20	145 - 160 (20.1) - (22.1)
-24	154 - 170 (21.3) - (23.5)
-32	218 - 240 (30.1) - (33.2)



SAE STRAIGHT THREAD O-RING SEAL

Most leaks associated with an SAE Straight Thread O-ring Connectors are caused by elbows that loosen, human error, or faulty/damaged parts.

How the Connection Seals:

The Straight Thread O-ring Connector seals with an O-ring on the male portion against a chamfer in the port. Using the Straight Thread O-ring Connectors in place of Pipe Threads improves sealing capability and greatly reduces the risk of hydraulic leakage.

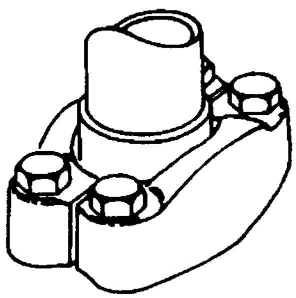
The Causes of Leaks:

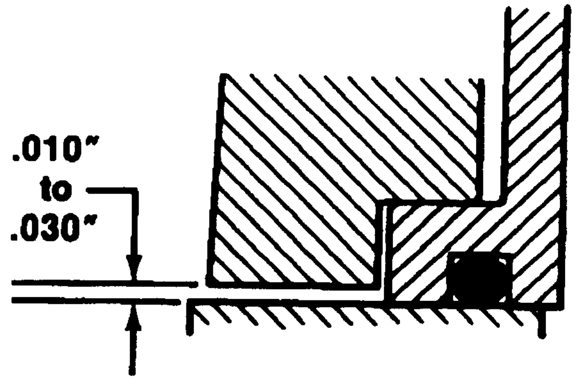
1. Elbow loosens after short service due to improper position of the lock nut and washer.
2. O-rings leak after long service due to lack of O-ring lubrication when installed.
3. O-rings leak after short service due to improper installation.
4. Connections instantly leak upon start up due to human error or faulty parts.

How to Cure the Leak

1. The lock nut and washer must be to the top side of the thread relief. The washer must be snug to the thread relief. If not, reject the part.
2. Be sure to lubricate the O-ring. This simple step is very important.
3. Thread the male O-ring half into the port until the washer or solid hex bottoms onto the machined surface.
4. Position the elbow for desired alignment by backing it out of the port up to one full turn.
5. Tighten the lock nut or solid hex.

SAE 4-BOLT SPLIT FLANGE

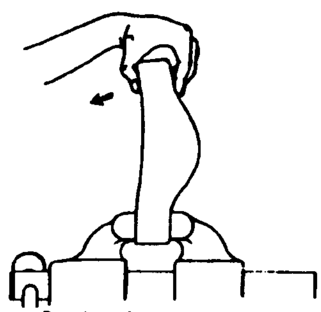




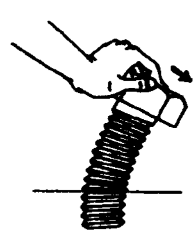
HOW THE CONNECTION SEALS:

The SAE 4-Bolt Split Flange connection is a face seal. The flanged head which contains an O-ring seal must fit squarely against the mating surface and be held there with even tension on all bolts. The flanged head protrudes past the split flange clamps by .010 inch (.38mm) to .030 inch (7.5mm). This ensures that the flanged head will make contact with the mating surface, compressing the O-ring to form the seal.

Recommended torque values Use Grade 5 bolts or better due to the high torque levels required.		
Connection Size	Recommended Torque ft/lb(Kg/m)	
	Code 61	Code 62
-08	15 - 18 (2.1) - (2.5)	15 - 18 (2.1) - (2.5)
-12	21 - 29 (2.9) - (4.0)	25 - 33 (3.5) - (4.6)
-16	27 - 35 (3.7) - (4.8)	42 - 50 (5.8) - (6.9)
-20	35 - 45 (4.8) - (6.2)	63 - 75 (8.7) - (10.4)
-24	45 - 58 (6.2) - (8.0)	117 - 133 (16.2) - (18.4)
-32	54 - 66 (7.5) - (9.1)	200 - 216 (27.7) - (29.9)
-40	79 - 91 (10.9) - (12.6)	
-48	138 - 150 (19.1) - (20.7)	
Note: Air wrenches tend to causeflange tipping.		



Bending of bolts and flanges soaks up much of the torque values.



The Causes of Leaks:

The SAE 4-Bolt Split Flange connection is extremely sensitive to installation errors and bolt torque. Because of the flange head protrusion and the flange clamp overhang, the flange tends to tip up in a seesaw fashion when the bolts are tightened on one end. This pulls the opposite end of the flange away from the flanged head and, when hydraulic pressure is applied to the line, pushes the flanged head into a cocked position allowing seal extrusion. Some areas to consider when troubleshooting a leak on this style of connection are as follows:

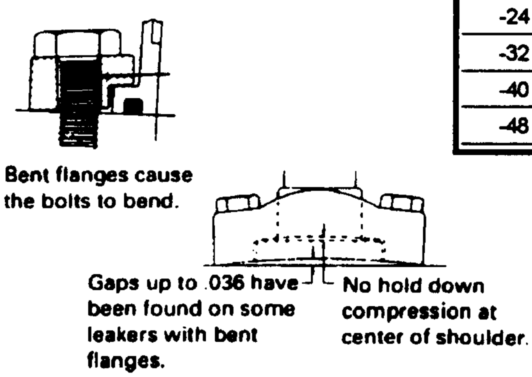
1. Split flanges not tightened down or are tightened unevenly.
2. Wrong size, missing, or damaged O-ring.
3. Sealing surfaces not smooth.
4. Wrong grade bolts substituted. Must be grade 5 or better.
5. Dirt or contamination on sealing surfaces.
6. Paint on sealing surfaces.

How to Cure the Leaks:

All bolts must be installed and torqued evenly. Finger tightening will help to get the flanges and shoulder started squarely. If lock washers are used, even more care must be taken to tighten the connection evenly.

NOTE: Excessive torque will often bend the flanges down until they bottom on the accessory. This also causes the bolts to bend outward. Bending of the flanges and bolts tend to lift the flange off the shoulder in the center area between the long spacing of the bolts. Either condition may result in a leak.

SAE J518 Codes 61 and 62 O-ring Seals				
Dash Size	Dimension L inches(mm)	Dimension M inches(mm)	Dimension N inches(mm)	SAE J120 O-ring Size
-08	0.734 (18.644)	1.012 (25.705)	0.139 (3.531)	210
-12	0.984 (24.994)	1.262 (32.055)	0.139 (3.531)	214
-16	1.296 (32.918)	1.574 (39.980)	0.139 (3.531)	219
-20	1.484 (37.694)	1.762 (44.755)	0.139 (3.531)	222
-24	1.859 (47.219)	2.137 (54.280)	0.139 (3.531)	225
-32	2.234 (56.744)	2.512 (63.805)	0.139 (3.531)	228
-40	2.734 (69.444)	3.012 (76.505)	0.139 (3.531)	232
-48	3.359 (85.319)	3.637 (92.380)	0.139 (3.531)	237



Basic O-ring dimensions are shown for reference only

O-RING FACE SEAL CONNECTION

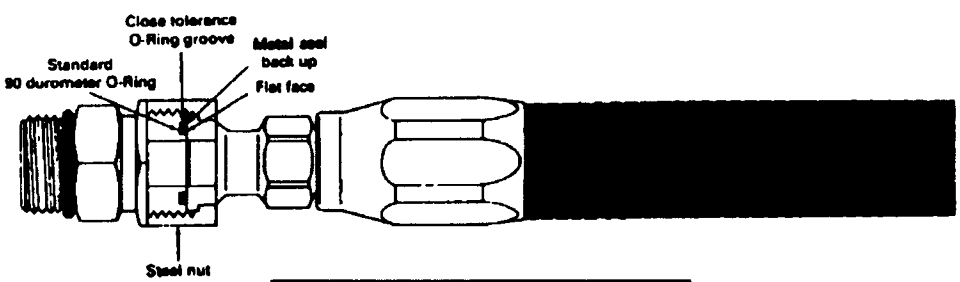
O-ring Face Seal fittings and adapters are flat face O-ring seal connections that are designed to meet SAE J1453 performance requirements. O-ring Face Seal connections are designed for working pressures up to 6000 psi. In order for O-ring Face Seal connections to eliminate leaks, care must be taken to avoid the following conditions.

The Causes of Leaks:

1. Lack of proper tightening.
2. Wrong size, missing, or damaged O-ring.
3. Sealing surfaces not smooth.
4. Dirt contamination on sealing surfaces.

How to Cure the Leaks:

1. Tighten the connection properly using the recommended torque values for maximum service life.
2. Make sure that the O-ring does not fall out before the connection is secured. Lubricant on the O-ring will help retain it in position.
3. The O-ring Face Seal connection is not the same size as those used on O-ring Boss or Split Flange fittings. It is critical that the correct O-ring is used. The proper sizes and dimensions are listed in Section 3 - *O-ring Basics.*



Recommended torque values for ORS Connections				
Dash Size	ft/lb(Kg/m)			
-4	10 - 12	(1.4)	-	(1.7)
-6	18 - 20	(2.5)	-	(2.8)
-8	32 - 35	(4.4)	-	(4.8)
-10	46 - 50	(6.4)	-	(6.9)
-12	65 - 70	(9.0)	-	(9.7)
-16	92 - 100	(12.7)	-	(13.8)
-20	125 - 140	(17.3)	-	(19.4)
-24	150 - 165	(20.7)	-	(22.8)

PIPE THREADS

Pipe threads are not recommended for high pressure applications, since they tend to leak more than any other style of connection.

NPT- National Pipe Taper or **NPTF**- National Pipe Taper Fuel (dry seal)

NPT threads are likely to leak much more than dry seal pipe threads. Either kind of pipe thread will leak if under tightened. There is not a general accepted standard for tightening either style of tapered threads. The tightening requirements change with each reuse and/or type of sealant used. Use a good pipe sealant on the male threads. When applying pipe sealant, do not put any on the first two threads or sealant will spread into the hose and the hydraulic system. Over tightening may crack the female port.

Cause of Leak	Possible Cure of Leak
1. Connector is not tight.	Tighten
2. Cracked port or connector.	Replace damaged parts
3. Damaged threads in connector.	Replace damaged parts
4. Contaminated threads, dirt, chips, etc.	Clean and inspect
5. High vibration loosening connection.	Tighten connector
6. Heat expansion of female threads.	Tighten while hot

MAINTENANCE

HOW TO CARE FOR HOSE LINES

Visual Signals:

A good way to forestall problems with a hydraulic system is to periodically look over your equipment. A daily visual inspection should be done by either a technician or the machines operator. Look for signs of leakage, a wet machine or hose, oil stains, or low levels in the reservoir. It's a good idea to examine the fluid in the reservoir regularly. Do more than just check the fluid level. If the oil has a milky appearance, it is saturated with air or water. In either case, your hydraulic system is in for trouble if left unattended. If your machine is equipped with cutting units, be sure to check all cutting unit hoses throughout the entire range of movement especially below the ground level operation of the cutting units. Check the hoses for routing, abrasion, or other visual signs that may cause the hose to fail prematurely.

Continue your visual inspection by looking at the hydraulic lines in the system. Watch for hose lines that are damaged due to abrasion or for lines that become overly tight during operation. These are conditions that can lead to a premature failure of the hose. You should also watch for twisted or flattened lines as a kinked line will restrict flow, and in the case of a pump supply line, could ruin a pump. Occasionally, a qualified technician should check the system pressures to make sure the hydraulic system is within the design limit specifications.

The machine operator should observe the action of the hydraulic cylinders constantly. If the movement becomes jerky or erratic, something is wrong and should be investigated. Air in the system, a bent cylinder rod, or other conditions should be corrected before continuing operation.

Audible Signals:

A good troubleshooter will listen for unusual sounds coming from a hydraulic system. The loud, shot-like sound that you hear when a water faucet is closed quickly is called "water hammer." This is caused by the sudden stoppage of moving liquid. The hydraulic surge created by this condition increases with the speed at which the liquid is moving. A pressure surge may go as high as four times the normal working pressure. This can cause great physical damage to fluid conductors and other components in a system. A shock wave travels at the speed of sound in hydraulic fluid, and normal hydraulic gauges will not be able to display pressure surges because the surge begins and ends so suddenly.

The main function of a hydraulic pump is to move liquids against comparatively high resistance. When the supply of fluid is insufficient to meet the demands of a pump, the pump goes into a state of hydraulic shock described as cavitation. When this occurs, the pump emits an unusual sound. If there is no back pressure, it sounds as if you were pumping marbles, and you can hear them rattling. When excessive pressure in present, the pump (or relief valve) emits a shrill whine that will have you holding your ears. Unusual sounds anywhere in a hydraulic system should be investigated by a fluid power technician.

Smell Signals:

When hydraulic oil is saturated with air, or when a hydraulic pump is cavitating, the air bubbles in the system go from a sub-pressure condition (vacuum) to a high pressure condition in a fraction of a second, which generates a great deal of heat. It has been estimated that a pocket of air in a hydraulic system may reach temperatures in excess of +2000° F (1093° C). This is hot enough to scorch surrounding oil and components. This condition can be noticed as the smell of "burned" oil in the reservoir.

Any of these abnormal conditions are cause for concern and require attention. Any factor that could cause the problem must be checked out. Nothing should be overlooked.

Touch Signals:

If a hydraulic pump is too hot to hold your hand on it, it may be telling you something. Studies show that below 135° F (75° C), oil oxidizes very slowly and that the rate of oxidation approximately doubles for every 18° F (10° C) increase in temperature. It is estimated that the working life of most oil is decreased by 50% for every 15° F (8° C) rise in temperature above 140° F (78° C). Oxidation causes sludge to form, reduces clearances, causes corrosion, and creates more heat, thus establishing a vicious cycle.

Just because the hydraulic reservoir is not hot does not mean that a heat problem does not exist. A good troubleshooter will feel the lines in various parts of the system to make sure there are no "hot spots". If any part of a hydraulic system is unusually hot, you can be sure there is a problem developing. Excessive heat can be very damaging to a fluid power system although most components are designed to tolerate intermittent temperatures up to 180° F (100° C).

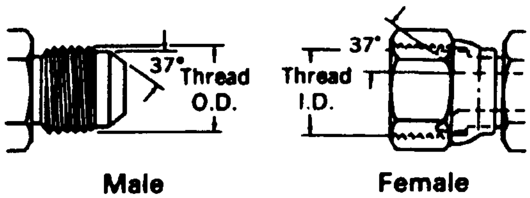
High frequency vibration is another condition that can damage a hydraulic system. You can feel these vibrations with your hand by touching the steel lines. This condition has been known to break weldments and other components, and should be corrected. You can also "see" this condition by placing an ordinary tumbler of water on a steel tube and watching the surface conditions. When the water pops off the surface, the condition is serious enough to warrant further investigation and corrective action.

CAUTION

Keep body and hands away from pin hole leaks or nozzles that eject hydraulic fluid under high pressure. Use paper or cardboard, not hands, to search for leaks. Hydraulic fluid escaping under pressure can have sufficient force to penetrate skin and do serious damage. If fluid is injected into the skin it must be surgically removed within a few hours by a doctor familiar with this form of injury or gangrene may result. Before disconnecting or performing any work on the hydraulic system, all system pressure must be relieved by stopping the engine and lowering the implement to the ground.

HYDRAULIC FITTING IDENTIFICATION

SAE 37° FLARE CONNECTION (FORMERLY JIC)



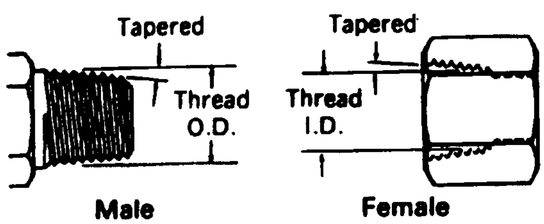
This connection is commonly used in many fluid power applications. The Male and Female connections have 37° seats. The seal takes place between the Male Flare and the Female Cone seat. The threads hold the connection mechanically and do not act as a sealing point.

NOTE: When using a -2, -3, -4, -5, -8, and -10 size SAE 37° fitting, the threads of the SAE 45° Flare Fitting are the same and will thread together. However, the sealing surface angles are not the same and the connections will not seal properly if inter-mixed.

SAE 37° Threads

Dash Size	Nominal Thread Size	Male Thread inches(mm)		Female Thread inches(mm)
-2	5/16-24	5/16	(7.5)	9/32 (7.1)
-3	3/8-24	3/8	(9.5)	11/32 (8.7)
-4	7/16-20	7/16	(11.1)	5/16 (7.5)
-5	1/2-20	1/2	(12.7)	7/16 (11.1)
-6	9/16-18	9/16	(14.3)	1/2 (12.7)
-8	3/4-16	3/4	(19.0)	11/16 (17.5)
-10	7/8-14	7/8	(22.2)	13/16 (20.6)
-12	1 1/16-12	1 1/16	(27.0)	31/32 (24.6)
-16	1 5/16-12	1 5/16	(33.0)	1 7/32 (31.0)
-20	1 5/8-12	1 5/8	(41.3)	1 17/32 (38.9)
-24	1 7/8-12	1 7/8	(47.6)	1 25/32 (45.2)
-32	2 1/2-12	2 1/2	(63.5)	2 13/32 (61.1)

NATIONAL PIPE TAPERED FUEL (NPTF)



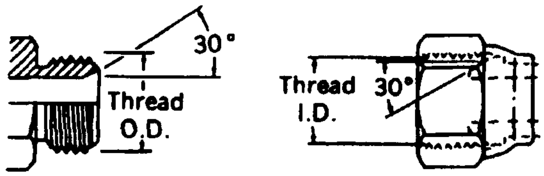
The NPTF connection is widely used in fluid power systems. It is not recommended for High Pressure hydraulic systems. The thread is tapered and the seal takes place by deformation of the threads.

Pipe Threads-Tapered Fuel

Measure thread diameter and subtract 1/4" to find nominal size

Dash Size	Nominal Thread Size	Male Thread inches(mm)		Female Thread inches(mm)
-2	1/8-27	13/32	(10.3)	11/32 (8.7)
-4	1/4-18	9/16	(14.3)	15/32 (11.9)
-6	3/8-18	11/16	(17.5)	19/32 (15.1)
-8	1/2-14	27/32	(21.4)	23/32 (18.3)
-12	3/4-14	1 1/16	(27.0)	15/16 (23.8)
-16	1-11 1/2	1 5/16	(33.0)	1 3/16 (30.2)
-20	1 1/4-11 1/2	1 11/16	(42.9)	1 17/32 (38.9)
-24	1 1/2-11 1/2	1 29/32	(48.4)	1 3/4 (44.5)
-32	2-11 1/2	2 3/8	(60.3)	2 1/4 (57.2)

NATIONAL PIPE STRAIGHT MECHANICAL (NPSM)



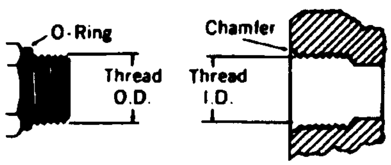
Male Female

The NPSM connection is used in fluid power systems. The female half has a straight thread and an inverted 30° seat. The male half of the connection has a straight thread and a 30° internal chamfer. The seal takes place in compression of the 30° seat on the chamfer. The threads hold the connection mechanically.

Pipe Threads-Straight Mechanical

Dash Size	Nominal Thread Size	Male Thread inches(mm)		Female Thread inches(mm)	
-2	1/8-27	13/32	(10.3)	11/32	(8.7)
-4	1/4-18	9/16	(14.3)	15/32	(11.9)
-6	3/8-18	11/16	(17.5)	5/8	(15.9)
-8	1/2-14	29/32	(23.0)	3/4	(19.0)
-12	3/4-14	1 1/16	(27.0)	31/32	(24.6)
-16	1-11 1/2	1 5/16	(33.0)	1 7/32	(31.0)
-20	1 1/4-11 1/2	1 11/16	(42.9)	1 9/16	(39.7)
-24	1 1/2-11 1/2	1 29/32	(48.4)	1 25/32	(44.2)
-32	2-11 1/2	2 3/8	(60.3)	2 1/4	(57.2)

SAE STRAIGHT THREAD O-RING BOSS (ORB)



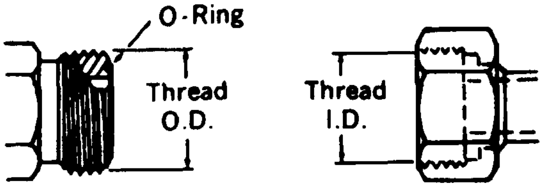
Male Female

This connection is recommended for optimum leakage control in medium and high pressure hydraulic systems. The Male connection has a straight thread with an O-ring. The Female connection has a straight thread and a chamfer to accept the O-ring. The seal takes place by compressing the O-ring into the chamfer. The threads hold the connection mechanically.

Straight Thread O-ring Boss (ORB)

Dash Size	Nominal Thread Size	Male Thread inches(mm)		Female Thread inches(mm)	
-2	5/16-24	5/16	(7.5)	9/32	(7.1)
-3	3/8-24	3/8	(9.5)	11/32	(8.7)
-4	7/16-20	7/16	(11.1)	5/16	(7.5)
-5	1/2-20	1/2	(12.7)	7/16	(11.1)
-6	9/16-18	9/16	(14.3)	1/2	(12.7)
-8	3/4-16	3/4	(19.0)	11/16	(17.5)
-10	7/8-14	7/8	(22.2)	13/16	(20.6)
-12	1 1/16-12	1 1/16	(27.0)	31/32	(24.6)
-16	1 5/16-12	1 5/16	(33.0)	1 7/32	(31.0)
-20	1 5/8-12	1 5/8	(41.3)	1 17/32	(38.9)
-24	1 7/8-12	1 7/8	(47.6)	1 25/32	(45.2)
-32	2 1/2-12	2 1/2	(63.5)	2 13/32	(61.1)

O-RING FACE SEAL



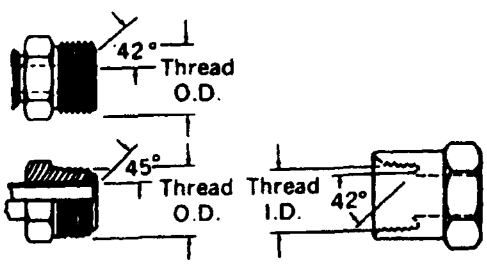
Male **Female**

The O-ring Face Seal offers the finest leakage control connection available. The Male connection has a straight thread and an O-ring in the face of the connection. The Female connector has a straight thread and a machined flat face. The seal takes place by compressing the O-ring onto the flat face of the Female connector. The threads hold the connection mechanically.

O-ring Face Seal

Dash Size	Nominal Thread Size	Male Thread inches(mm)		Female Thread inches(mm)
-4	9/16-18	9/16	(14.3)	1/2 (12.7)
-6	11/16-16	11/16	(17.5)	5/8 (15.9)
-8	13/16-16	13/16	(20.6)	3/4 (19.0)
-10	1-14	1	(25.4)	15/16 (23.8)
-12	1 3/16-12	1 3/16	(30.2)	1 3/32 (27.8)
-16	1 7/16-12	1 7/16	(36.5)	1 11/32 (34.1)
-20	1 11/16-12	1 11/16	(42.9)	1 19/32 (40.5)
-24	2-12	2	(50.8)	1 29/32 (48.4)

SAE INVERTED



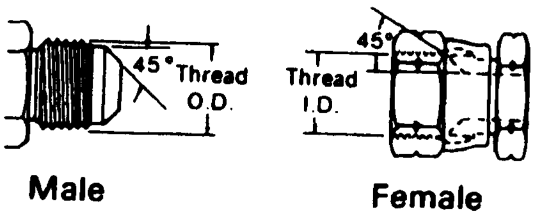
Male **Female**

The SAE Inverted connection is frequently used in automotive applications. The Male connector can either be a 45° flare in the tube fitting form, or a 42° seat in the machined adapter form. The female has a straight thread with an inverted flare. The seal takes place on the flared surfaces. The threads hold the connection mechanically.

SAE Inverted

Dash Size	Nominal Thread Size	Male Thread inches(mm)		Female Thread inches(mm)
-2	5/16-28	5/16	(7.5)	9/32 (7.1)
-3	3/8-24	3/8	(9.5)	11/32 (8.7)
-4	7/16-24	7/16	(11.1)	13/32 (10.3)
-5	1/2-20	1/2	(12.7)	7/16 (11.1)
-6	5/8-18	5/8	(15.9)	9/16 (14.3)
-7	11/16-18	11/16	(17.5)	5/8 (15.9)
-8	3/4-18	3/4	(19.0)	11/16 (17.5)
-10	7/8-18	7/8	(22.2)	13/16 (20.6)
-12	1 1/16-16	1 1/16	(27.0)	1 (25.4)

SAE 45°



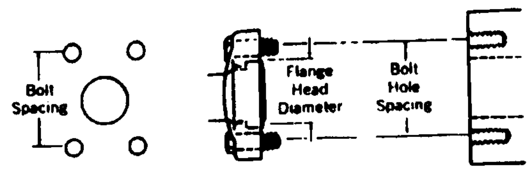
The SAE 45° connector is commonly used in automotive, refrigeration, and truck piping systems. Frequently, the connection is made of brass. The Male and Female connectors have 45° seats. The seal takes place between the male flare and the female cone seat. The threads hold the connection mechanically.

NOTE: In the -2, -3, -4, -5, -8, and -10 sizes, the threads of the SAE 45° flare and SAE 37° flare are the same. However, the sealing surfaces angles are not the same and will result in a leak.

SAE 45° Threads

Dash Size	Nominal Thread Size	Male Thread inches(mm)		Female Thread inches(mm)
-2	5/16-24	5/16	(7.5)	9/32 (7.1)
-3	3/8-24	3/8	(9.5)	11/32 (8.7)
-4	7/16-20	7/16	(11.1)	3/8 (9.5)
-5	1/2-20	1/2	(12.7)	7/16 (11.1)
-6	5/8-18	5/8	(15.9)	9/16 (14.3)
-8	3/4-16	3/4	(19.0)	11/16 (17.5)
-10	7/8-14	7/8	(22.2)	13/16 (20.6)
-12	1 1/16-14	1 1/16	(27.0)	31/32 (24.6)

SAE 4 BOLT SPLIT FLANGE



Male　　　　Female

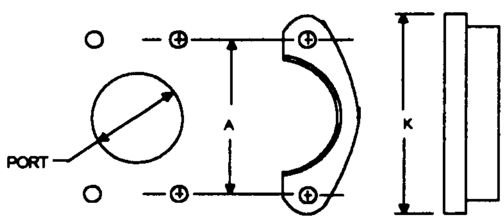
The SAE 4 Bolt Split Flange connection is commonly used in fluid power systems. There are two pressure rating codes for the 4 Bolt Split Flange connection:

Code 61 is referred to as the "standard" series.

Code 62 is the 6,000 psi. series.

The design concept for both series is the same, but the bolt hole spacing and head diameters are larger for the high pressure code 62 connection.

The Female port is an unthreaded hole with four bolt holes in a rectangular pattern around the port. The Male consists of a flange head, grooved for an O-ring and either a captive flange or split flange halves with bolt holes to match the port. The seal takes place on the O-ring which is compressed between the flange head and the flat surface surrounding the port. The threaded bolts hold the connection together.



Split Flange Dimensions

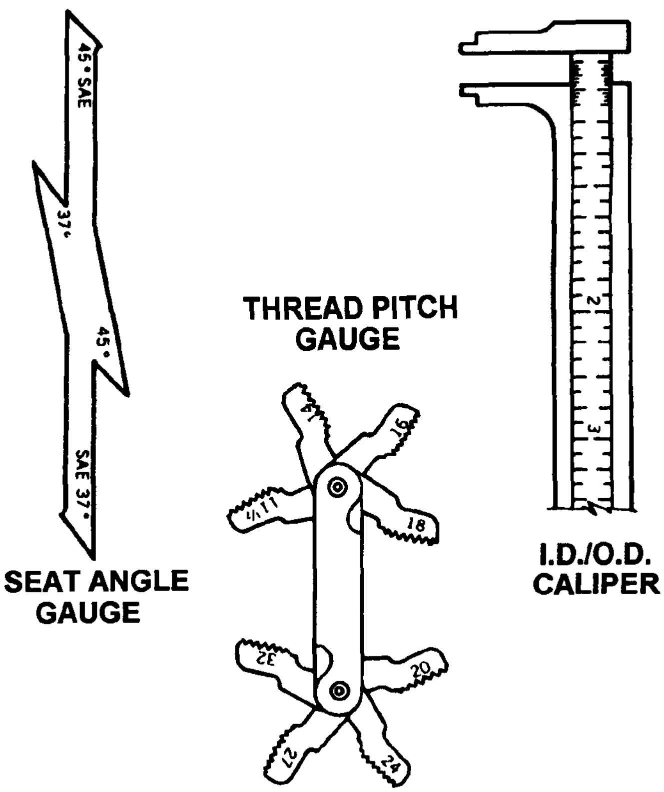
Dash Size	Port Diameter inches(mm)		Bolt Hole Spacing A inches(mm)				Head Diameter K inches(mm)			
			Code 61		Code 62		Code 61		Code 62	
-8	1/2	(12.7)	1 1/2	(38.1)	1 19/32	(40.5)	1 3/16	(30.2)	1 1/4	(31.8)
-12	3/4	(19.0)	1 7/8	(69.9)	2	(50.8)	1 1/2	(38.1)	1 5/8	(40.9)
-16	1	(25.4)	2 1/16	(52.4)	2 1/4	(57.2)	1 3/4	(44.5)	1 7/8	(47.6)
-20	1 1/4	(31.8)	2 5/16	(58.3)	2 5/8	(66.7)	2	(50.8)	2 1/8	(54.0)
-24	1 1/2	(38.1)	2 3/4	(69.9)	3 1/8	(79.4)	2 3/8	(60.3)	2 1/2	(63.5)
-32	2	(50.8)	3 1/16	(77.8)	3 13/16	(96.8)	2 13/16	(71.4)	3 1/8	(79.4)

MEASURING

Measuring Tools:

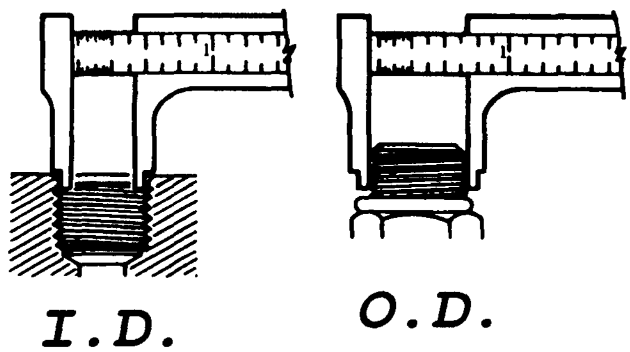
These tools are used to make accurate inspections of the frequently used connectors in fluid power applications:

1. **Seat Angle Gauge**
2. **Thread Pitch Gauge**
3. **I.D./O.D. Caliper**

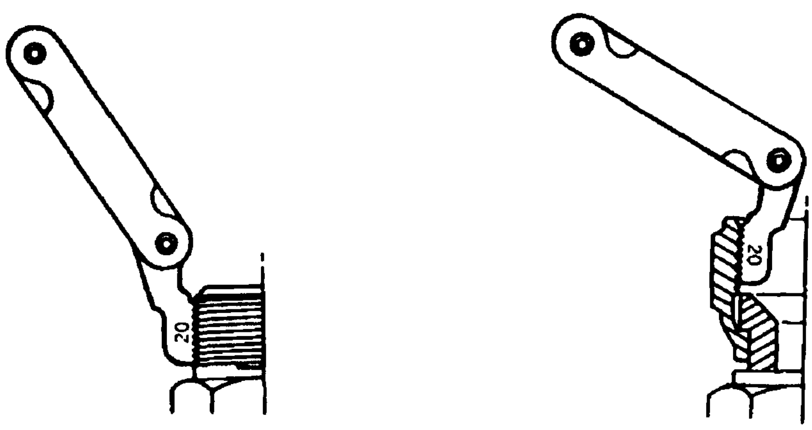


Measuring Threads:

Measure the O.D. of the Male threads and the I.D. of the Female threads with an I.D./O.D. Caliper. Compare the dimension to the specific chart for the connector you are measuring.

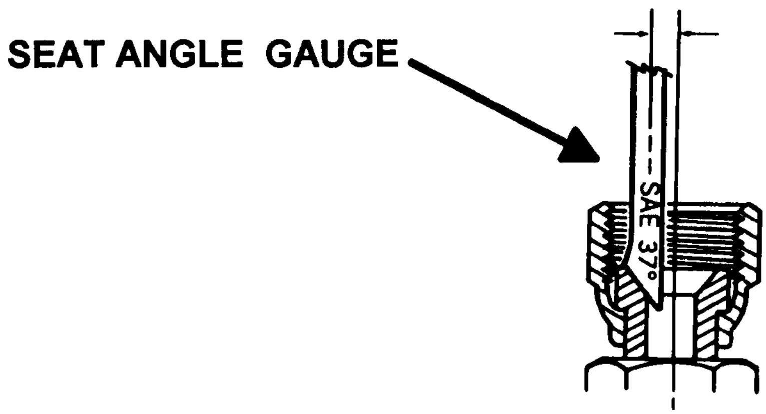


Measure the distance between threads in the connector with a Thread Pitch Gauge. Place the gauge on the threads until the fit is tight. Compare the measurement to the specific chart for the connector you are measuring to determine the size.

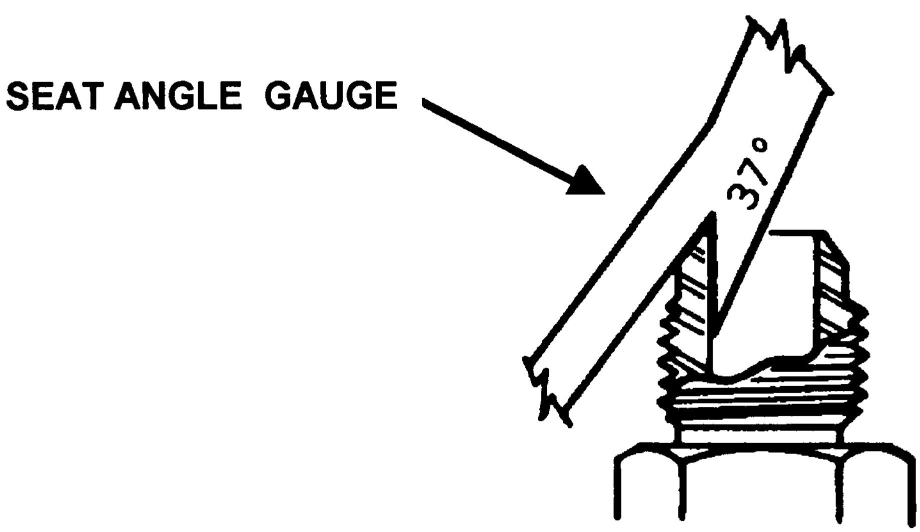


Measuring Sealing Surface Angles:

Female connections are measured by inserting the Seat Angle Gauge into the fitting. If the centerline of the gauge and connection are parallel, the correct angle has been determined.



Male flare connections are measured by placing the Seat Angle Gauge on the sealing surface. If the gauge and angle fit tight, the correct angle has been determined.

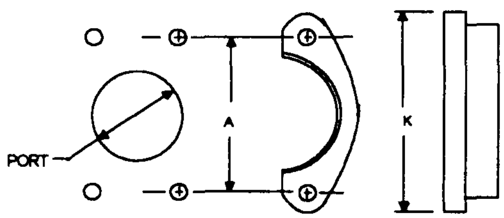


Measuring Non-Threaded Connections:

Four Bolt Flange - Measure the port hole diameter at the longer bolt hole spacing (center-to-center) and the flange head diameter using the I.D./O.D. Caliper. Refer to Section 3 - *SAE 4-Bolt Split Flange* for O-ring size information.

Dash Size - Most fluid power system sizes in the United States are measured by dash numbers. These are universal abbreviations for the size of the component expressed as the numerator with the denominator always being 16. For example, a -4 port is 4/16 inch (1/4 inch). Dash numbers are nominal abbreviations intended to make identification and ordering of components easier.

Example: Four Bolt Split Flange Measuring Chart



Split Flange Dimensions

Dash Size	Port Diameter inches(mm)	Bolt Hole Spacing A inches(mm)		Head Diameter K inches(mm)	
		Code 61	Code 62	Code 61	Code 62
-8	$^{1}/_{2}$ (12.7)	$1^{1}/_{2}$ (38.1)	$1^{19}/_{32}$ (40.5)	$1^{3}/_{16}$ (30.2)	$1^{1}/_{4}$ (31.8)
-12	$^{3}/_{4}$ (19.0)	$1^{7}/_{8}$ (69.9)	2 (50.8)	$1^{1}/_{2}$ (38.1)	$1^{5}/_{8}$ (40.9)
-16	1 (25.4)	$2^{1}/_{16}$ (52.4)	$2^{1}/_{4}$ (57.2)	$1^{3}/_{4}$ (44.5)	$1^{7}/_{8}$ (47.6)
-20	$1^{1}/_{4}$ (31.8)	$2^{5}/_{16}$ (58.3)	$2^{5}/_{8}$ (66.7)	2 (50.8)	$2^{1}/_{8}$ (54.0)
-24	$1^{1}/_{2}$ (38.1)	$2^{3}/_{4}$ (69.9)	$3^{1}/_{8}$ (79.4)	$2^{3}/_{8}$ (60.3)	$2^{1}/_{2}$ (63.5)
-32	2 (50.8)	$3^{1}/_{16}$ (77.8)	$3^{13}/_{16}$ (96.8)	$2^{13}/_{16}$ (71.4)	$3^{1}/_{8}$ (79.4)

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