Fluid Power Systems
Fluid Connector Technology Best Practices

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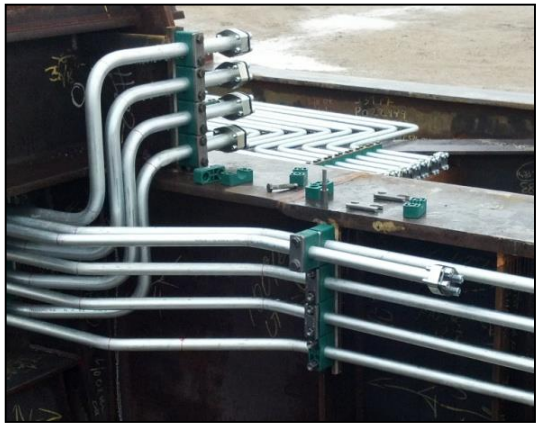
IADC ART BOP Controls
Houston, TX

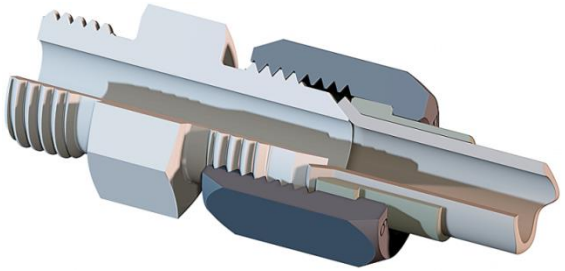


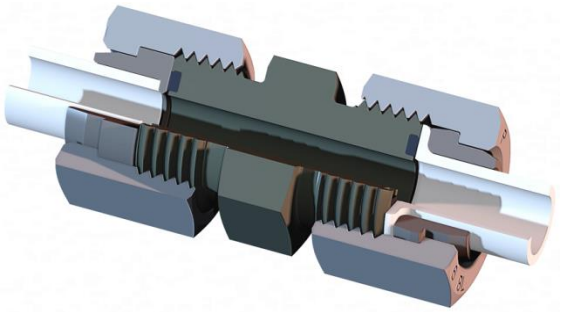
ENGINEERING YOUR SUCCESS.

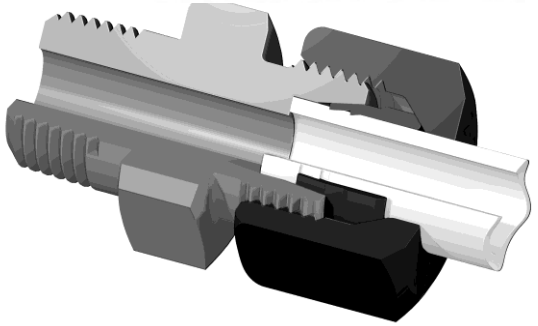
Topics

- Industry Standardization & Threaded Connections
- Fluid Power Flanges
- Industry Advancements
- Piping for Fluid Power Systems
  - Phastite for Pipe
- Line Sizing, Routing & Pitfalls
- Hose
- Takeaways

Fluid Power Connections 101







Industry Standardization for Fluid Connectors

General Responsibilities & Goals:

- Safety/Reliability
- Performance Requirements
- Interchangeability
- Grow with users changing requirements
- Similar to IADC, combination of users & manufacturers on technical committees
- Hose, Fittings, Flanges, Transportation Fittings

Product Selection Criteria:

- **S.T.A.M.P.E.D:**
  - **S**ize
  - **T**emperature
  - **A**pplication
  - **M**edia
  - **P**ressure
  - **E**nvironment
  - **D**uty Cycle
- As well as…….
  - Sealing/Reliability/Robustness
  - Hose adaptability
  - Inch & metric tube adaptability
  - Installation, serviceability & maintenance
  - Acceptance / Availability / Standardization

Parallel &Tapered Threaded Ports

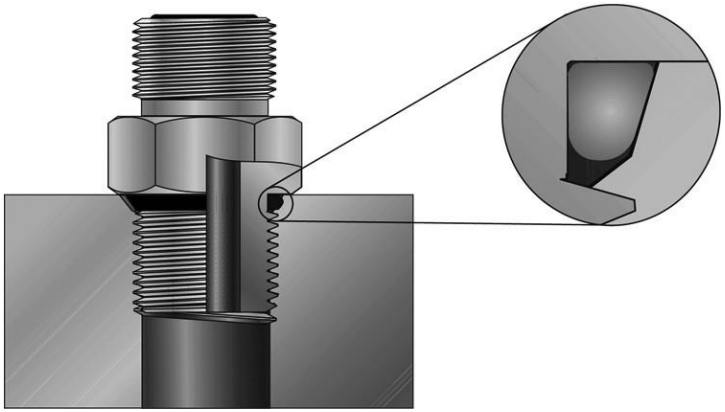
- Parallel threads serve ***one*** function
  - holding/retaining the fitting under load
  - **Preferred** connection technology for fluid power systems

- Tapered threads serve ***two*** functions:
  - For holding in the fitting under load
  - Sealing (plus sealant)
  - **Not preferred** connection for fluid power systems

Threaded O-Ring Ports

Boss:

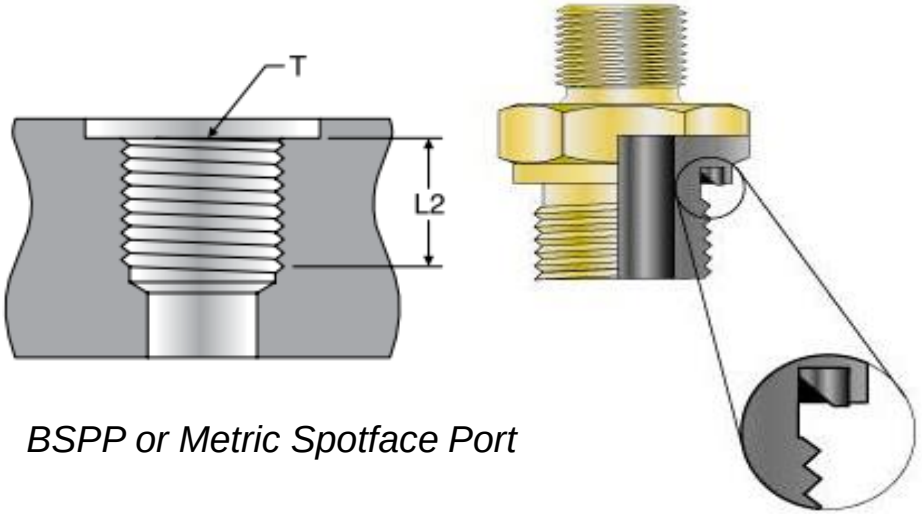
- SAE J1926-1 / ISO 11926-1 (UN/UNF)
- ISO 6149-1 (Metric)
- Adjustability (shapes)
- common
- Standard o-rings



O-Ring Boss Port

Boss:

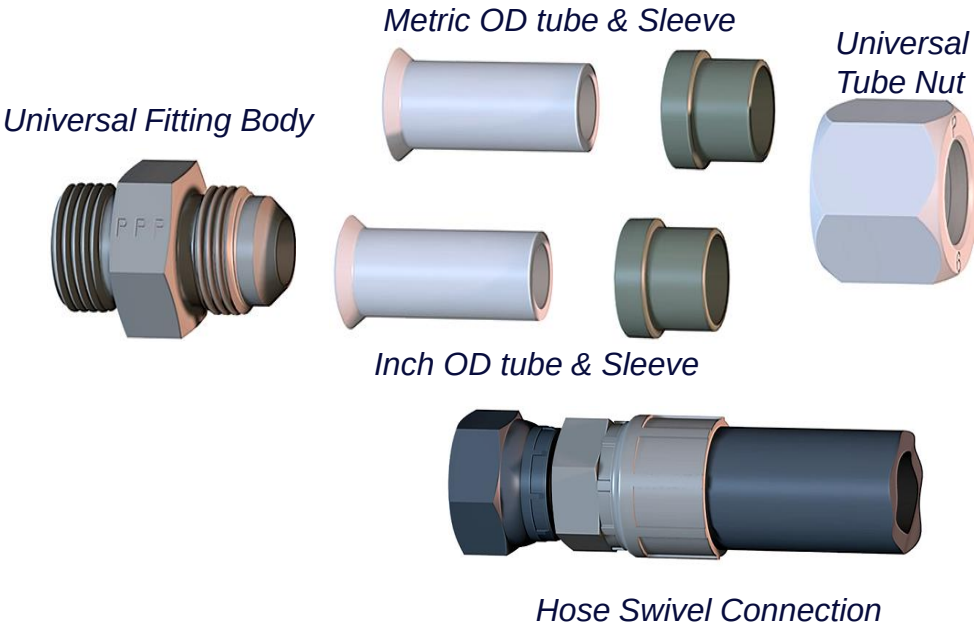
- ISO 9974 & 1179
- Metric & BSPP thread
- No adjustability – need 2 fittings
- Seals on top of port or port “spotface”
- Often uses special seal



BSPP or Metric Spotface Port

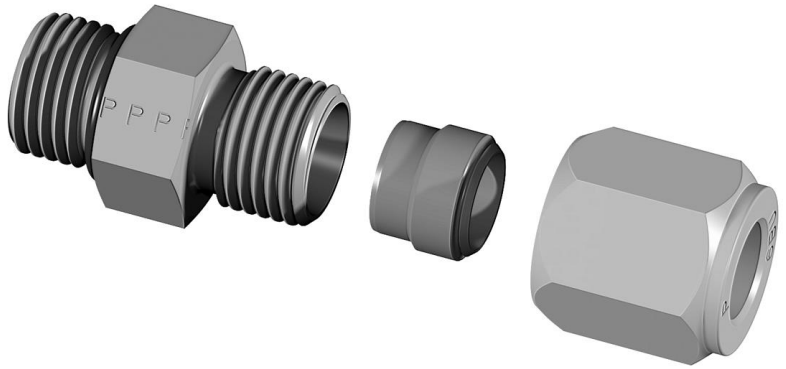
Tube/Hose End: 37° Flare

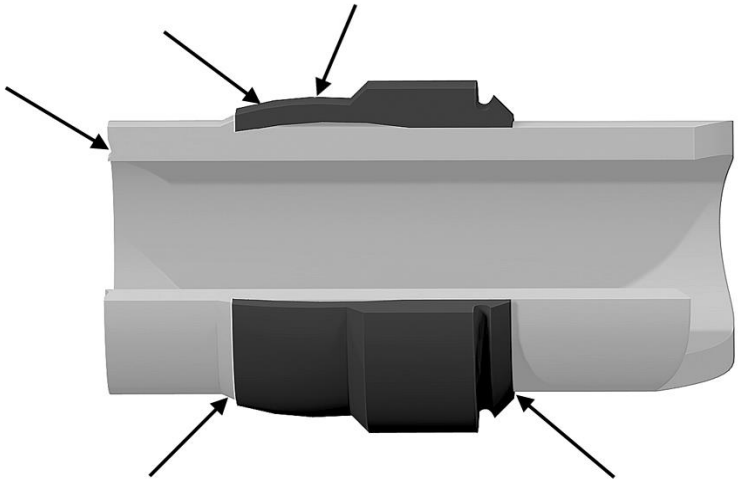
- 3 Piece Fitting (aka JIC)
- Common tube/hose adapter
  - Inch & metric tube
  - ¼”/6mm - 2”/42mm
- All metallic sealing
- Tighten by turns or torque
- ISO & SAE Standard
- Torque & vibration sensitive



Tube End: SAE Bite Type/Flareless

- Bite-type ferrule fitting
  - Inch tube only
  - ¼” to 2” tube OD
- Visible/heavy bite
- Common industrial & energy segment fitting
- All metallic sealing
- Limited hose connections
- Sour gas limitations due to to 17-4 PH Ferrule

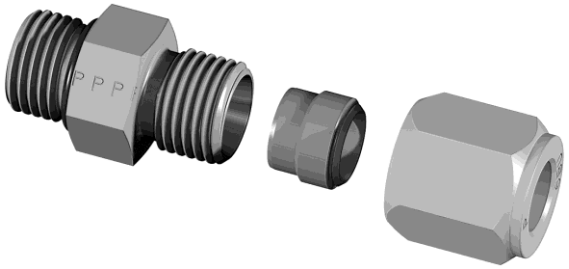


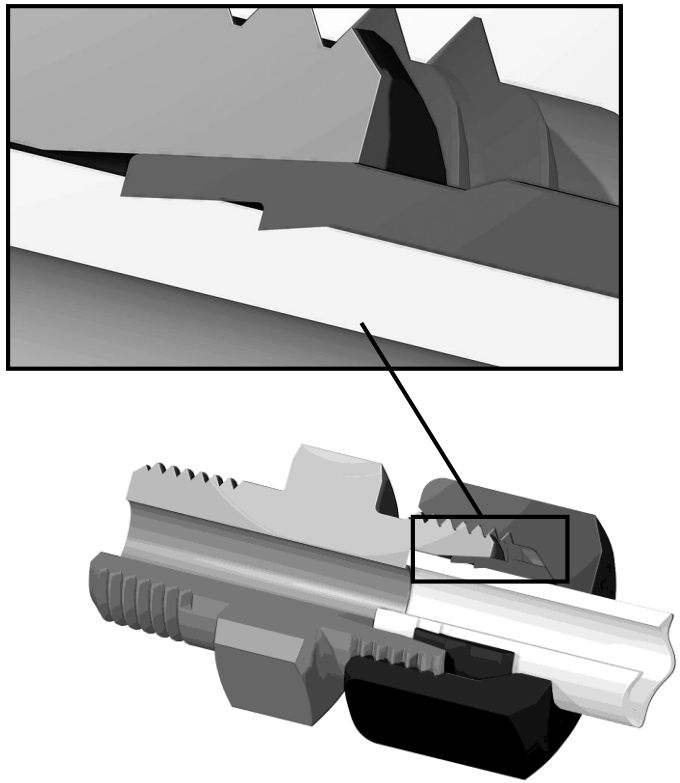


Multiple inspection points to ensure proper/safe bite

Tube/Hose End: *Metric* 24° Bite-Type/Flareless

- Metric bite-type fitting
  - 3 series (LL, L, S)
  - 6mm to 42mm tube OD
- Metric tube only
- ISO 8434 & DIN 2353 standard
- Large breadth of product availability: fittings, weld nipples, banjo fittings, & hose adapter
- All metallic sealing



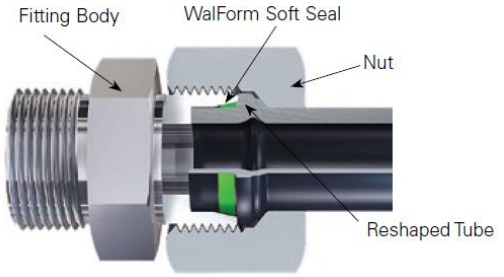


Tube/Hose End: Metric 24° Soft Seal

- ISO 8434 body/nut
- Separation of sealing & holding functions
- Modified tube attachment methods:
  - Ferrule/Bite-Ring adaptations to include elastomeric sealing
  - Tube forming directly on tube with elastomeric sealing (no ferrule)

Modified "Sealing" Ferrule solution:
Courtesy: Parker EO-2

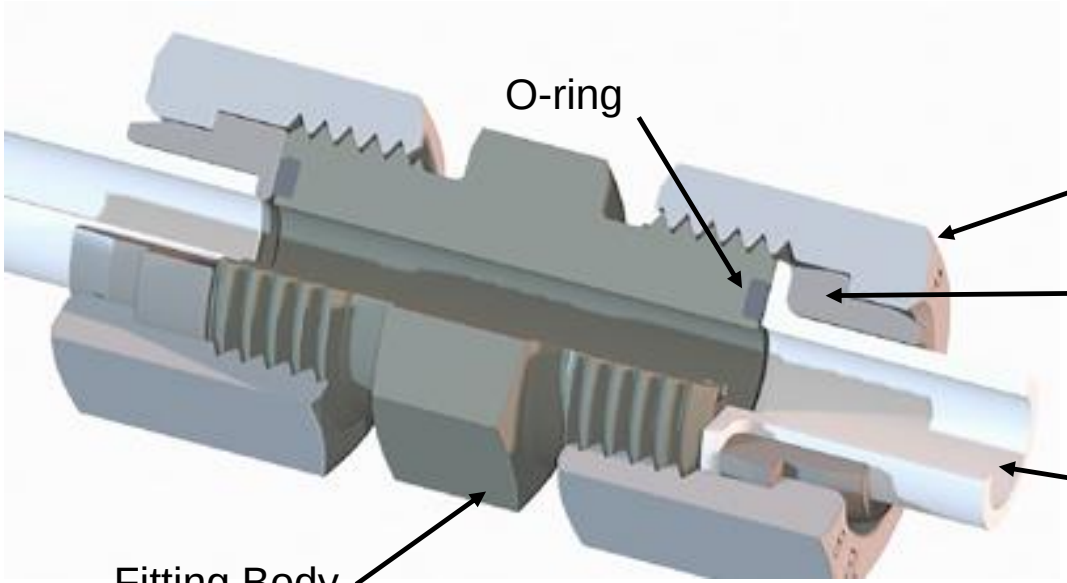
Cutaways of 3 fitting manufacturer's solutions *(Parker, Voss, Eaton)* for a formed tube (ferrule-less) option to metric bite type fitting



Tube/Hose End: O-Ring Face Seal

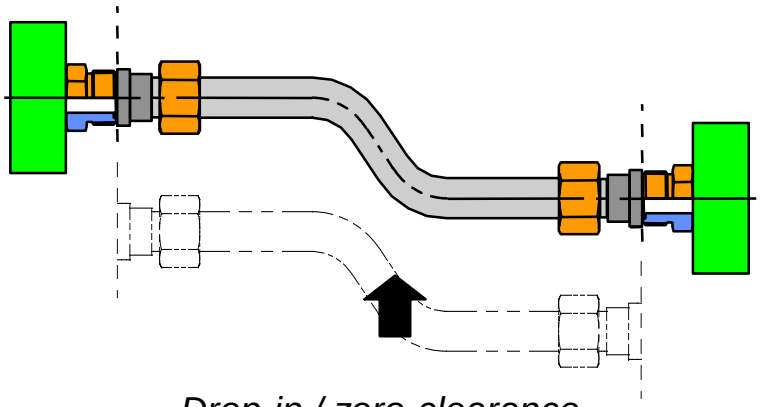
- Flat face with a precision o-ring groove
- Tube/hose end has mating 90° surface
- SAE J1454/ISO 8434-3 standard
- Sealing: compressing o-ring between two flat surfaces
- Inch/Metric tube (similar to JIC/37)

Introduced in 1984, O-Ring Face Seal fittings (ORFS) solved many fitting leakage issues of the fluid power industry

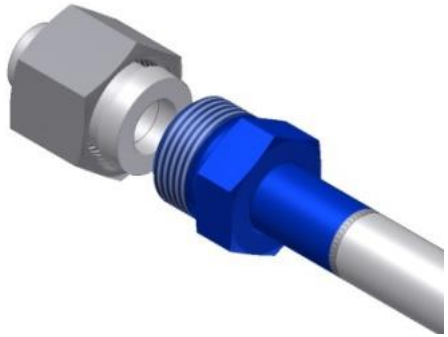


Tube/Hose End: O-Ring Face Seal

- Zero clearance fitting system
- High resistance to over-torque
- Higher temp seals available
  - Elastomeric up to 600°F / 315°C
  - Metallic up to 1200°F / 650°C
- Mechanical forming/flanging
- Weld fittings/glands



Drop-in / zero-clearance feature of ORFS fittings



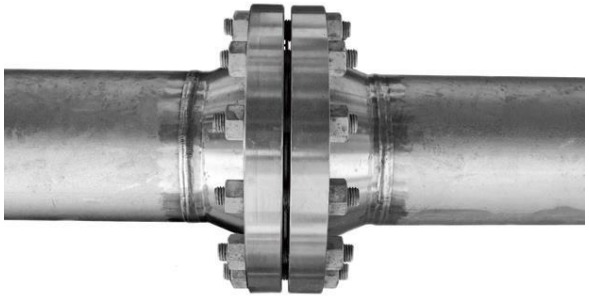
Mechanically attached and weld attached

Tube/Hose End – Twin Ferrule Compression Fittings

- High-integrity fitting
- Very popular instrumentation fitting
- *Defacto* interchangeability, no industry standard
- Limited tooling required for pre-setting
- Broad range of configurations
- Wide temperature range
- Modest vibration/shock resistance
- Single ferrule fitting option/improvement

SAE/ISO Fluid Power Flanges

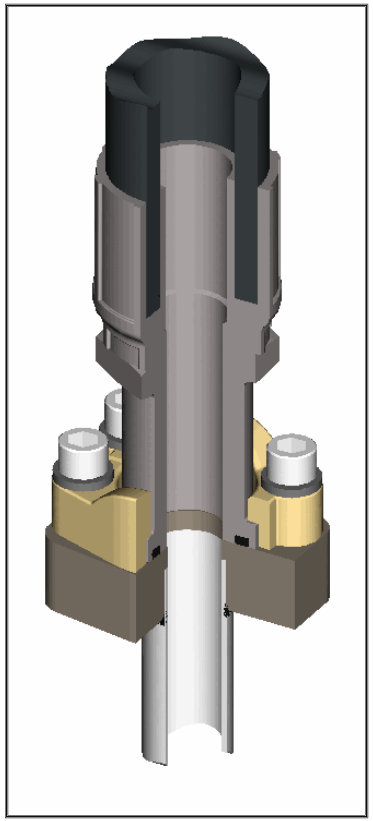
SAE 4-bolt socket weld companion flange set



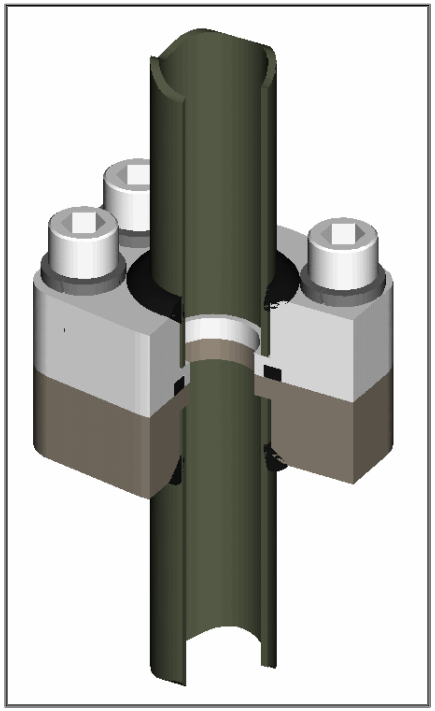
Note: ANSI B16.5 (150# -2500#) flanges are not recommended for fluid power/hydraulic service)

- Pipe, Tube & Hose Connections
- SAE and ISO standard flange (SAE J518 / ISO 6162 / ISO 6164
- Typically used in 1”-5” sizes
- Common platform in **welded** and **non-welded** piping systems
- SAE 4 Bolt: Two pressure classes (3k/6k)
- DIN/ISO 6164: Multiple pressure classes

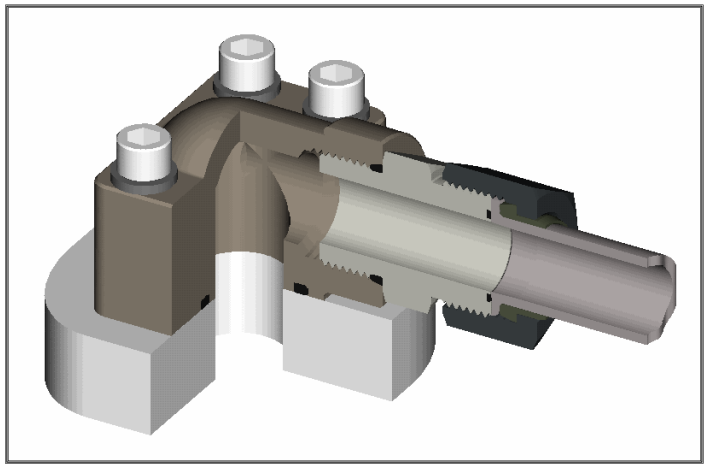
Hydraulic Flange Versatility



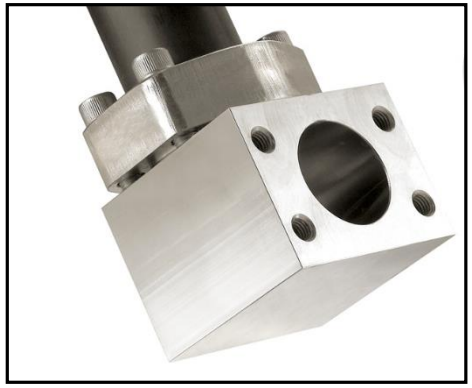
SAE Hydraulic Flange to ***Hydraulic Hose*** using split flanges



Companion Flange – Tube to Tube or Pipe to Pipe



Compact 90° Flange



Flange ***Blocks/tees/manifolds***

Non-Welded SAE Flange Piping

Fluid Power Flanges

	ISO 6162-1	ISO 6162-2	ISO 6164
Size (flange)	½“ – 5”	½“ – 3”	1/2” – 5” & larger (proprietary)
Flange pressure	**5000** psi (350 bar)	6000 psi (420 bar)	6000 psi (up to 420 bar)

PRESSURE RATINGS OF SAE FLANGES

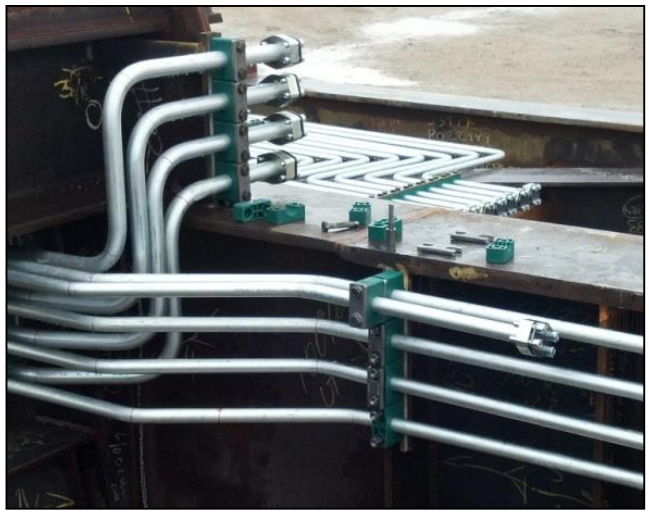
CODE 61 SAE J518-1 / ISO 6162-1					
		MAX WORKING PRESSURE		GRADE 8 AND EQUIVALENT FASTENER TORQUE VALUE	
DASH SIZE	INCH SIZE	PSI	MPA	SOCKET HEAD UNC (LB-FT)	HEX HEAD UNC (LB-FT)
-8	1/2”	5000	35	24	18
-12	3/4”	5000	35	44	33
-16	1”	4600	32	44	33
-20	1 1/4”	4000	28	68	52
-24	1 1/2”	3000	21	111	80
-32	2”	3000	21	111	80
-40	2 1/2”	2500	17.5	111	80
-48	3”	2300	16	218	160
-56	3 1/2”	500	3.5	218	160
-64	4”	500	3.5	218	160
-80	5”	500	3.5	218	160

Courtesy: *Anchor Fluid Power*

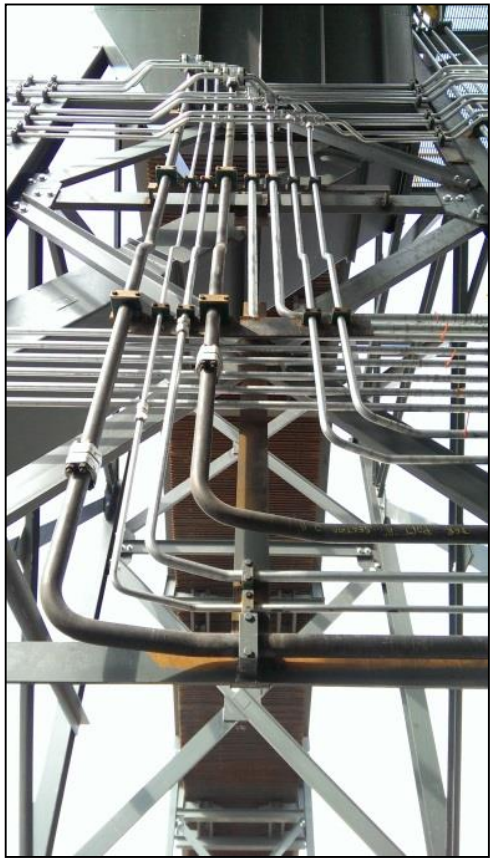
- UNC or Metric fasteners
- SHCS recommended
- SAE 3000 Pressure ratings
- Small flanges (SAE ½”, ¾”)
- ISO 6162-2 now includes 3”/DN80

Hydraulic Flanges-Versatility

Mobile Land Drill Rig



Industrial/ Processing



Offshore/*Subsea

Marine/Shipbuilding

Advancements in Connectors

- Full SAE J1926/ISO 11926 port depth
- Higher temp o-rings available
  - O-Rings rated up to 600°F / 315°C
- Mechanical forming/flanging
- Higher Pressure Ratings for JIC/37
- Radial / Seal-Sub Flanges
- Non-Welded Hydraulic Piping

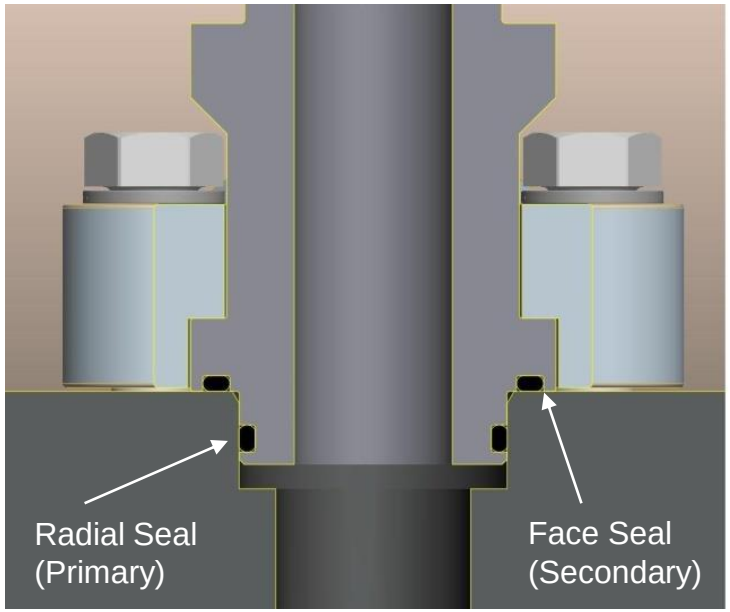
SAE J1926-3

SAE J1926-2

JIC Fittings with soft-seal nose/ w/ full J1926 port length (J1926-2)

SealSub Flanges

- Subsea radial sealing flanges
  - SAE J518-2 footprint/bolting
  - Size range ½”-2”
  - Parker, DMIC, Anchor, DTL
  - Pipe Weld, Non-welded piping, Hose, Quick Disconnects
  - No industry standard, SAE reviewing



Cutaway of Seal-Sub SAE J518-2 Flange


Seal-sub Adapters &
Non-Welded Piping

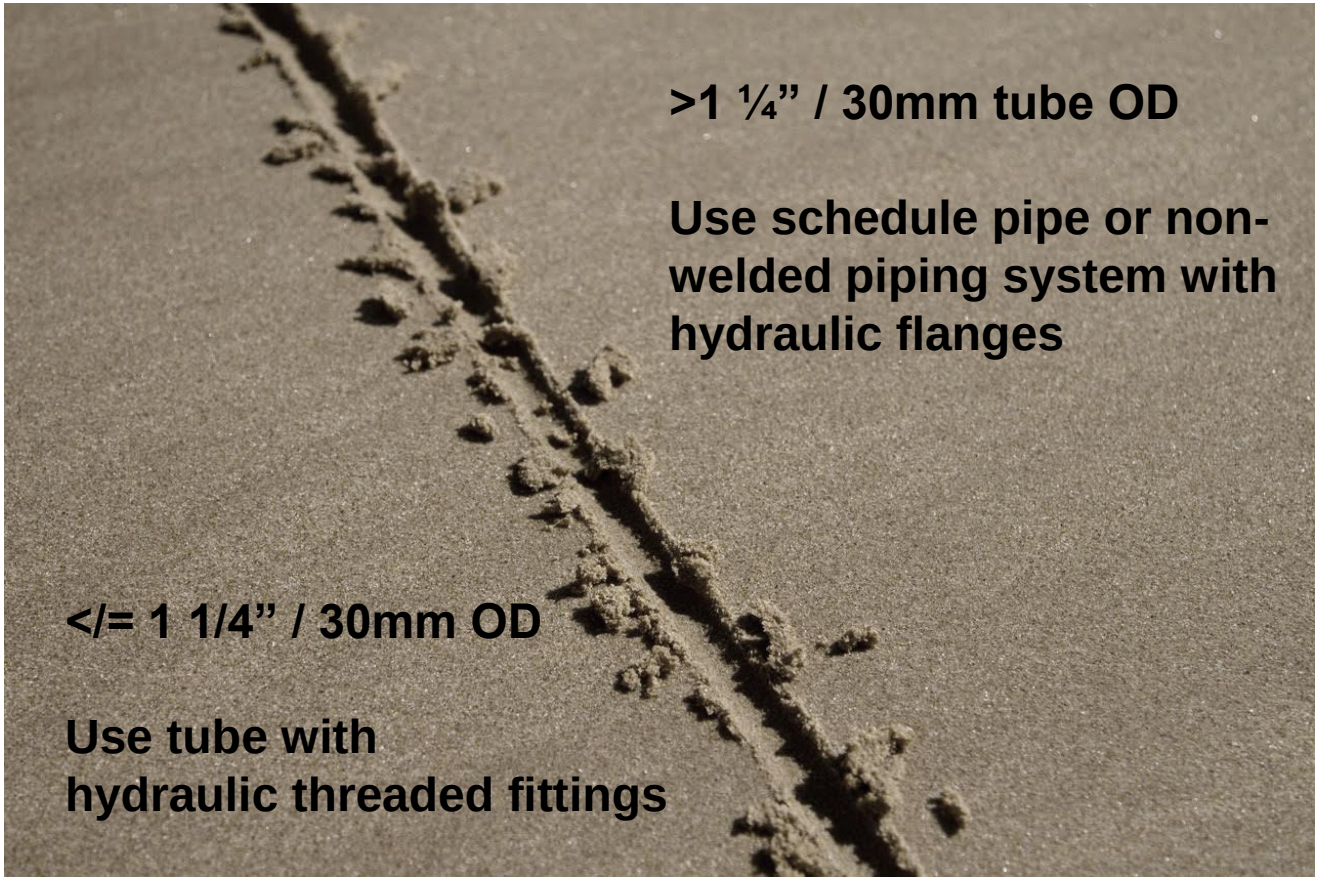
Split Flanges w/ A286 SHCS

Quick
Disconnect

PIPING

PIPING FOR FLUID POWER SERVICE

Piping vs. Tube



Forged SW/Pressure Pipe Fittings

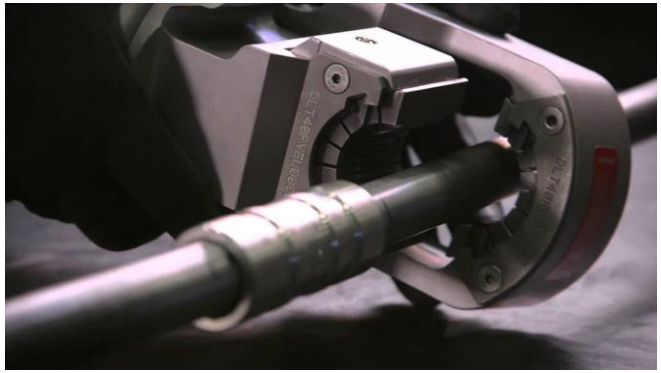
Butt-Weld Fittings & Pipe

In the past, threaded mechanically attached hydraulic fittings were considered reliable only up to ¾”-1” OD – frequently resulting in welded pipe systems being used as small as ½” NPS/schedule pipe

Non-Welded Hydraulic Piping

- Pipe welding imparts challenges for hydraulic systems:
  - High fabrication time & labor
  - Contamination/cleanliness
  - Safety
  - Airborne Chromium/PEL
  - Inspection/NDE
  - Pipe pickling/passivation

Crimp *Style*



Courtesy*: Pyplok*

Swage Style

Courtesy: *Lokring*

Flare Flange Style

Non-Welded Hydraulic Piping

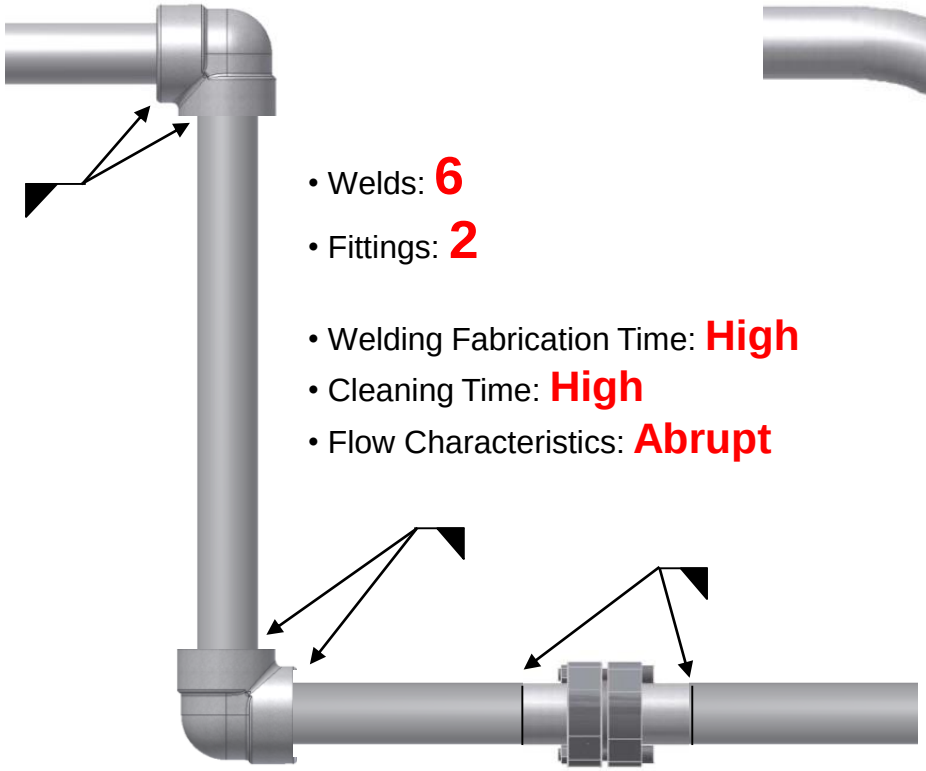
Typical Industry Approach:

- Replacement of SW & BW piping systems
- Crimp, Swage, Groove, Flare
- System of seamless tubes/pipes, flanges, valves, manifolds & clamps
- Couplings and ISO 6162/6164 service break/flanges
- Combined with cold bending
- Combined with service provider
- Carbon steel and stainless Steel
- ASME B31.3
- Typically carry type approval such as DNV and/or ABS to Marine and Offshore Systems

Typical Flare Flange Connectivity of large bore fluid power piping. *Courtesy: Parker Hannifin Parflange F37*

Non-Welded - Visual

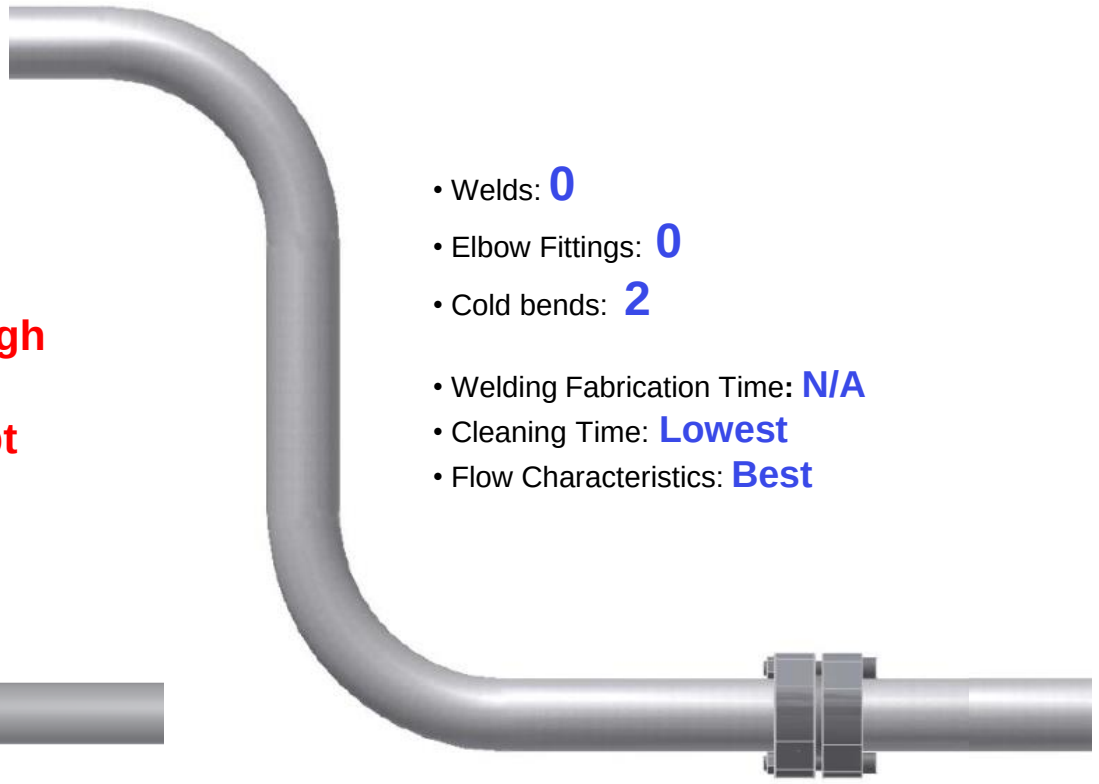
Welded piping



- Welds: **6**
- Fittings: **2**

- Welding Fabrication Time: **High**
- Cleaning Time: **High**
- Flow Characteristics: **Abrupt**

Non-Welded piping



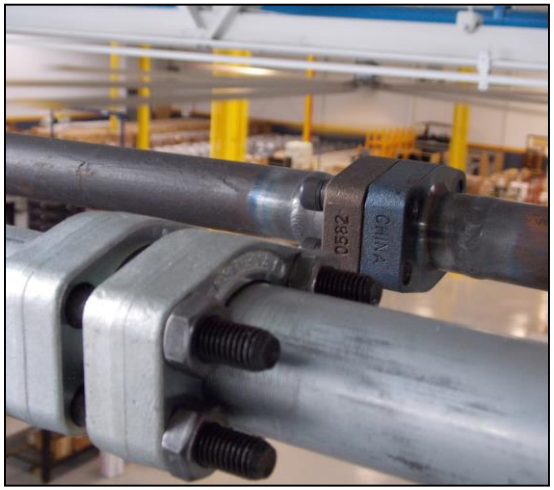
- Welds: **0**
- Elbow Fittings: **0**
- Cold bends: **2**

- Welding Fabrication Time**:** **N/A**
- Cleaning Time: **Lowest**
- Flow Characteristics: **Best**

Pipe Cleanliness Comparison

Post Welding, 1st Flushing Bag Comparison

1" piping, 350 ft / 100 meter run



Welded vs. Non Welded

"The experience of designers and users of hydraulic and lube oil systems has verified the following fact: over 85% of all system failures are a direct result of contamination! " – The Handbook of Hydraulic Filtration

Total Welding Comparison

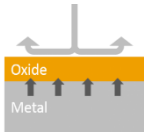
Review WPS
Welder Certification

Safety Plan/Firewatch

Welding
Consumables and
Equipment

Pipe Painting

PPE



Subcontract
Pickling/Passivation

Certified
Welder

1st Weld Pass:
Pre-Heat, Weld,
Cool,
Clean/Grind,
Inspect

Subsequent
Weld
Passes/Processes:

Certified Weld
Inspection (CWI)

Independent NDT

Gross Leak and/or
Hydrostatic Test

PHASTITE PIPING SYSTEM

NON-WELDED PERMANENT PIPING SYSTEM

Phastite for Pipe

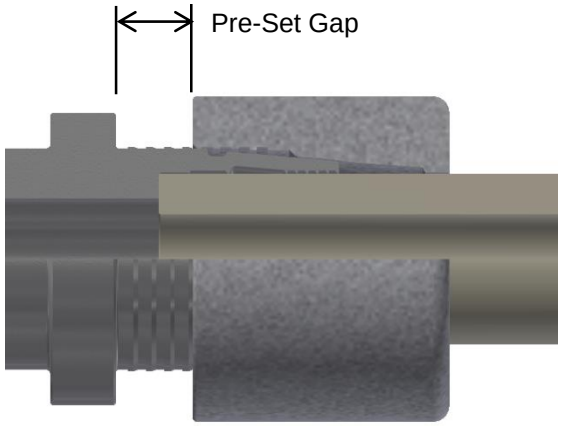
- Stainless steel, **permanent**, non-welded, axially swaged mechanically attached pipe fitting system
- Designed for rigors of O&G fluid power piping systems
- Currently qualified for common stainless steel hydraulic piping sizes ¾” - 2”
- One fitting series for a wide range of pipe schedules:
  - 40/STD, 80/XS, 160, & XXS
- Tolerance control built into fitting
  - Design accounts for liberal pipe tolerance

One Phastite fitting series for Sch 40/Std to Double Extra Heavy (XXS) pipe schedules

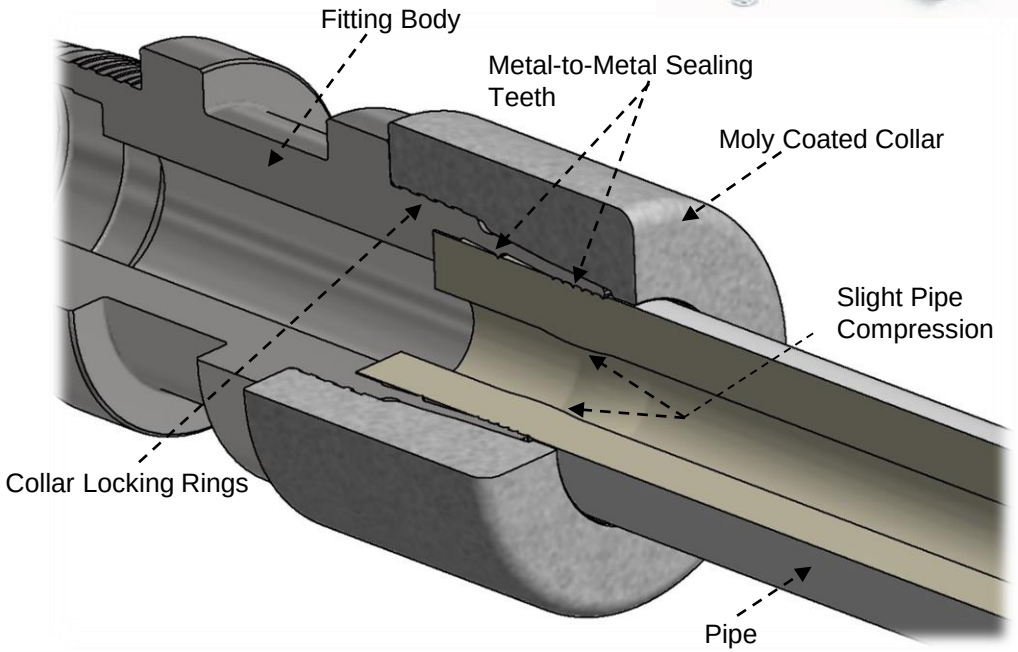
Phastite: Top Level

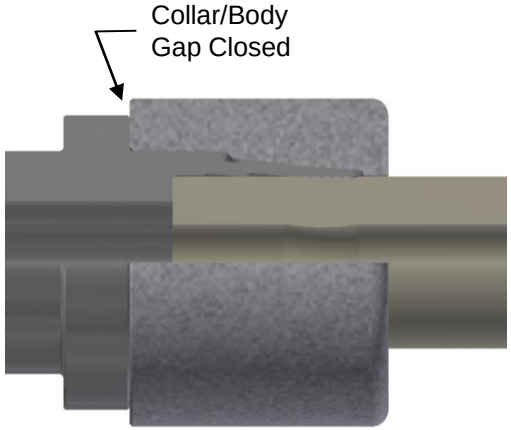
- For new construction, upgrades, & repair
- All stainless steel construction
  - 316 SS body with high strength duplex SS collar
  - No hidden elastomers, seals, or o-rings on pipe connection
- Pipe Fabrication – from hours to minutes
  - No open flame / hot works permitting
  - No x-ray or certified weld inspection (CWI)
  - No airborne hex chromium exposure
  - Eliminates many pipe welding requirements
    - Gapping, tacking, cool/wait time, grinding, pickling/passivation, clean-up, visual/NDE

Phastite: Design

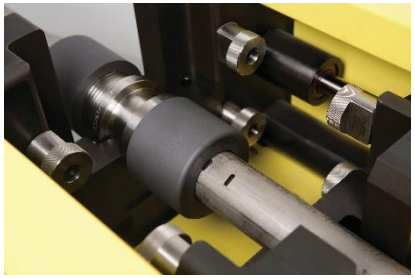


Before Swage/Compression





After Swage/Compression



Phastite: Ratings/Approvals

- 6000 psi dynamic/10,000 psi static operating pressure
  - 8k at 3:1 design factor
- Subsea depth of up to 15,000 ft
- Approvals:
  - ASME B31.1/B31.3 piping rules compliant
  - DNV-GL Technical Qualification (TQ) 2013 (subsea, offshore, topside O&G)

Statement No.: ParkerQP2013/3

DET NORSKE VERITAS

TECHNOLOGY CERTIFICATE

This is to certify that

Parker Phastite Pipe Fittings

are in accordance with DNV-DSS-401 Technology Qualification Management /1/.

DNV considers Parker Phastite qualified for its intended use, as defined in /2/.

This is not a product certificate.

Technology owner:	Parker Hannifin Corporation
Name of technology:	Phastite Pipe Fitting
Description:	Phastite Pipe Fittings are permanent "Mechanically Attached Fittings (MAFs)" that replace the need for welded pipe fittings used in pressure piping systems for onshore, topside and subsea oil and gas hydraulic applications. Phastite fittings are assembled using a specially designed hydraulic press known as "PhasTool".
Application:	Interconnecting piping between components such as pumps, valves, motors, accumulators etc. on hydraulic piping systems for subsea controls and marine topsides drilling/production equipment.
Involvement:	DNV has been involved in the qualification process as required for Technology Qualification Management acc. to /2/.
Limitations:	Max. Pressure Rating Static/Dynamic*: 10,000/6,000 psi Min. Temperature: -40°F Max. Temperature: 180°F Max. Water Depth: 15,000 ft Materials: 22 Cr duplex (collar), 316/316L (body) Design Life: 25 years Service: Non-sour, NACE compliant Min. Allowable Cathodic Protection: -1.05 V vs. SCE Pipe Specifications: ASTM A312, 3/4", 1", 1-1/2", 2" Sch. 40, 80, 160 and XXH, 304/304L, 316/316L, 317/317L, 321, 347

Fire testing was recommended by DNV, but not included in the qualification plan and not performed.

Qualification is based on the design and material of the tested specimens only. Further limitations given in /3/, /4/, /5/.

*Static pressure rating means 30,000 or less pressure cycles in a life time (dynamic is above 30,000 cycles).

Reference documents:	/1/ DNV-DSS-401, Technology Qualification Management, December, 2012.
	/2/ DNV-RP-A203, Qualification of New Technology, December, 2012.
	/3/ Parker Report, Technical Qualification Plan, Ver. 04, April 17, 2013.
	/4/ DNV Report No. 13UKCGC-8, Technology Qualification Report, Rev.0, July 8, 2013.
	/5/ Parker Report, Qualification Basis of Parker Phastite Pipe Fittings, Ver. 05, May 25, 2012.

Dublin, July 8, 2013
for Det Norske Veritas (U.S.A.), Inc.

Børresen, Sven-Erik
Sven-Erik Børresen
Senior Engineer

William Kovacs, PE
Project Engineer

This Certificate is valid until *July 8, 2017*

Oliver C. Moghissi, Ph.D.
Director, Materials & Corrosion Technology Center

If any person suffers loss or damage which is proved to have been caused by any negligent act or omission of Det Norske Veritas, then Det Norske Veritas shall pay compensation to such person for his proved direct loss or damage. However, the compensation shall not exceed an amount equal to ten times the fee charged for the service in question, provided that the maximum compensation shall never exceed USD 2 million. In these provisions "Det Norske Veritas" shall mean the Foundation Det Norske Veritas as well as all its subsidiaries, directors, officers, employees, agents and any other acting on behalf of Det Norske Veritas. DNV shall not be kept legally liable for not having identified failure modes or causes that has resulted in loss or damage or for not having prescribed the qualification activities necessary to avoid the loss or damage.

Det Norske Veritas (U.S.A.) Inc. 5777 Frantz Road Dublin, OH 43017 Phone: 614-761-1214 Fax: 614-761-1633

DET NORSKE VERITAS AS

TQ Certificate for Phastite.

ASME
SETTING THE STANDARD

Power Piping
ASME Code for Pressure Piping, B31.1

Process Piping
ASME Code for Pressure Piping, B31.3

DNV·GL

Phastite – Additional Considerations

- Zero heat application process
- Pre-assembled fittings with no loose parts
- A visual validation of a leak-tight connection *(close the gap*)
- Highly vibration tolerant
- Clean: requires ***no added lubrication***
- 100% traceable (HCT) manufacturing
- Use with standard ASTM A312 S/S pipe
- Highly corrosion resistant
- Connects in minutes with hydraulic too

Phastite is fully integrated with seal-sub radial seal service break flanges for optimum subsea performance & acceptance.

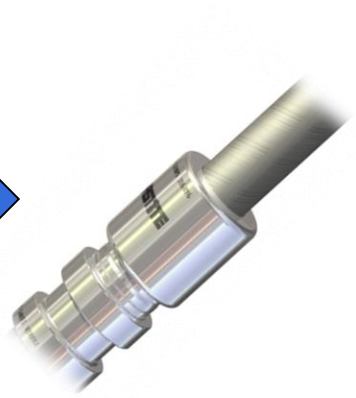
Phastite Fabrication

- Workbench mounted assembly tool
  - completes the Phastite connection in 1-2 minutes in 4 easy steps
  - 10x the speed of welding
- A greater labor impact is realized when combined with cold bending

1

Inspect pipe with go/no-go gauge

2

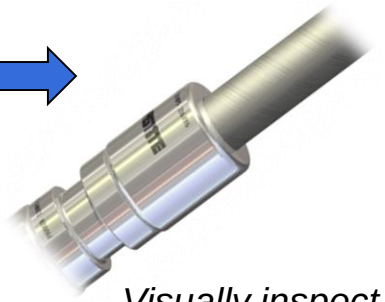


Insert pipe & fitting into Phastool

3

Swage

4



Visually inspect ready-to-use assembly.

Phastite: Extensively Tested and Validated

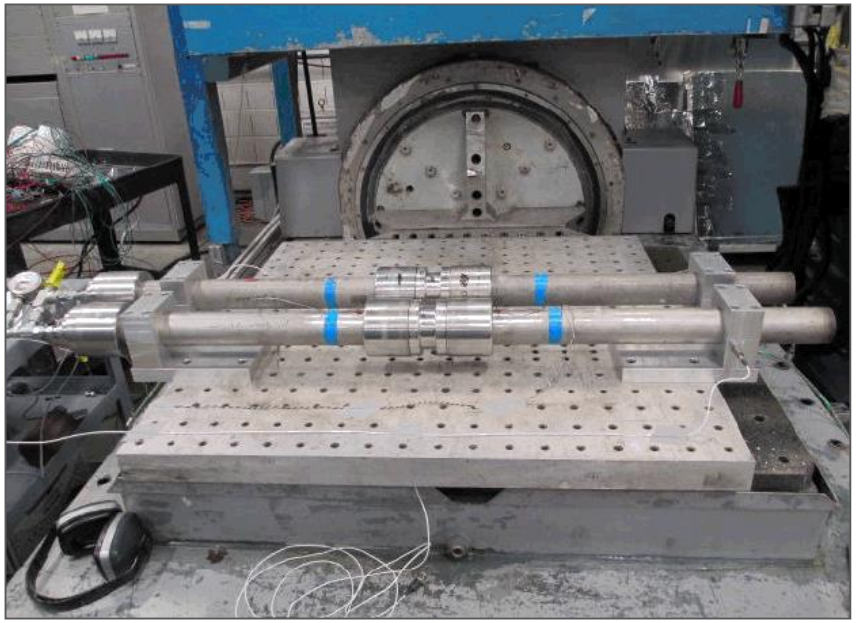
Bending Test

Hyperbaric Chamber Test

ASTM G44 Splash Zone Test

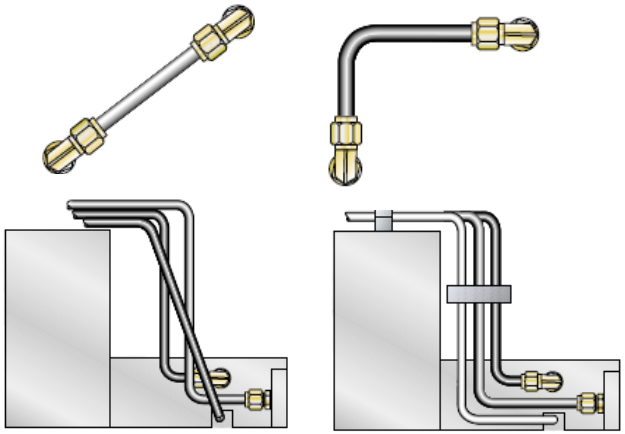
Extensively Tested and Validated

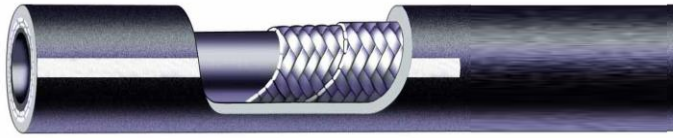
Burst Test to ASTM F1387



Vibration Test to ASTM F1387. Vibration Under Internal Pressure of 10,000 PSI for 250,000 Cycles

Axial Tension Test to ASTM F1387

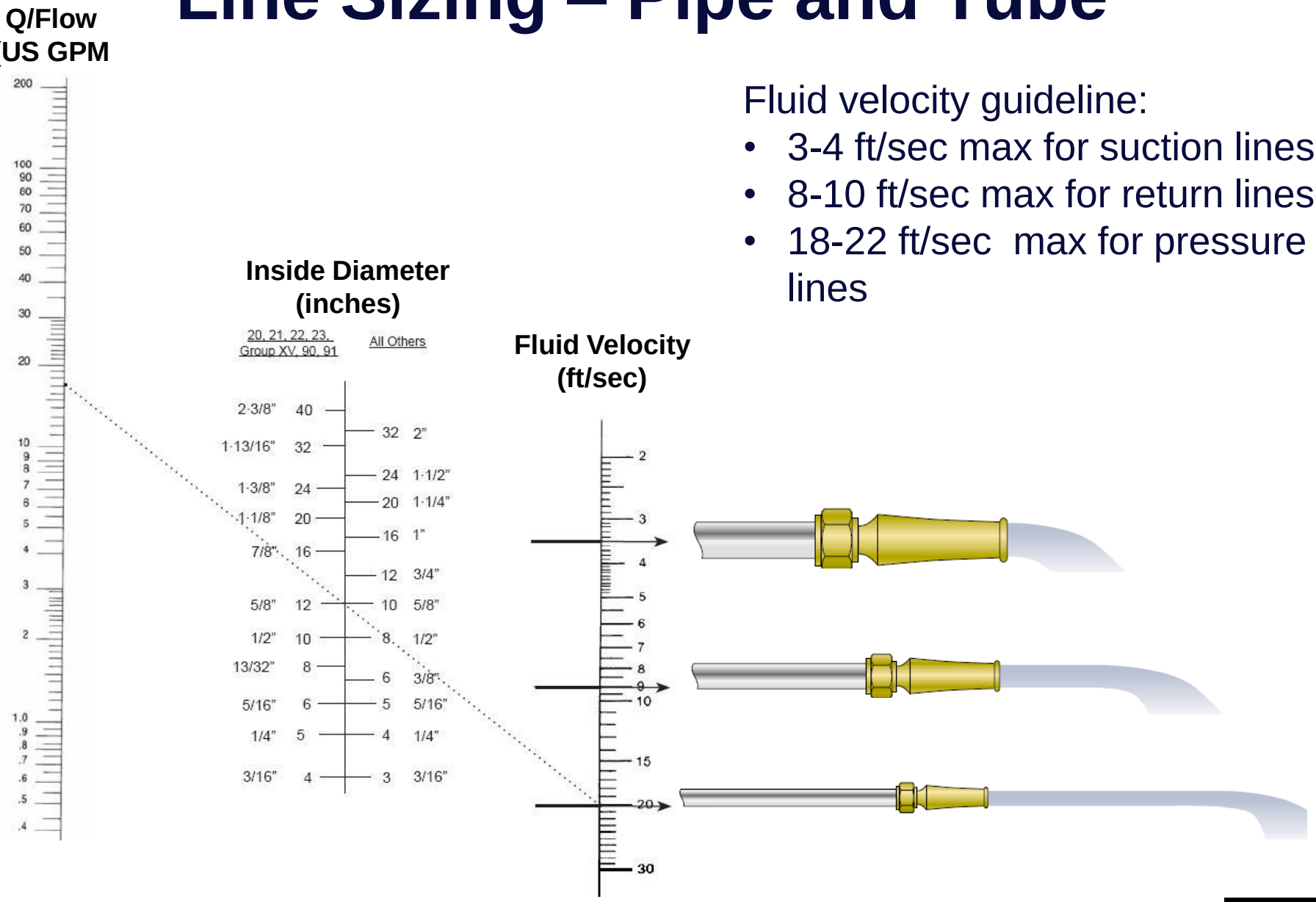




ADDITIONAL GUIDELINES

LINE SIZING, ROUTING, PITFALL AVOIDANCE

Line Sizing – Pipe and Tube



Fluid velocity guideline:

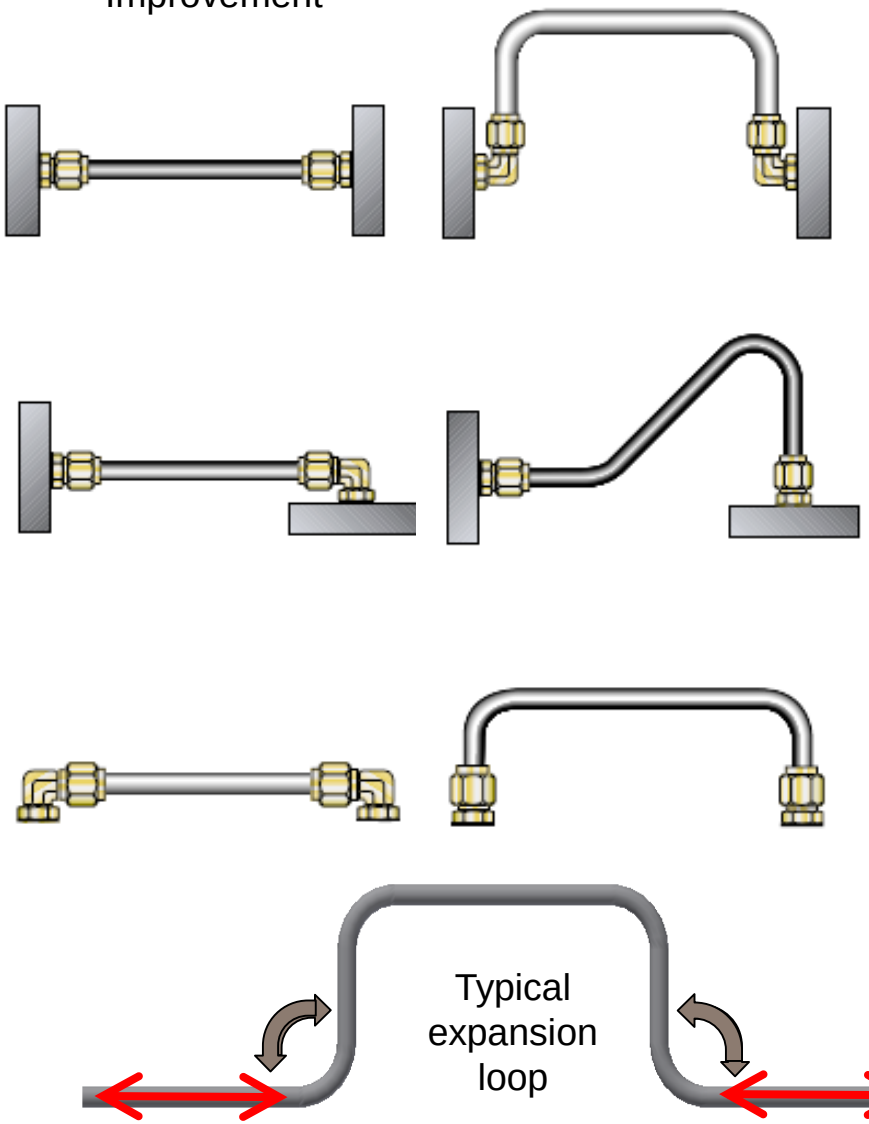
- 3-4 ft/sec max for suction lines
- 8-10 ft/sec max for return lines
- 18-22 ft/sec max for pressure lines

Note: **Tube is sized by OD, Hose is Sized by ID. Important for Flowpath matching**

Routing

Needs Improvement

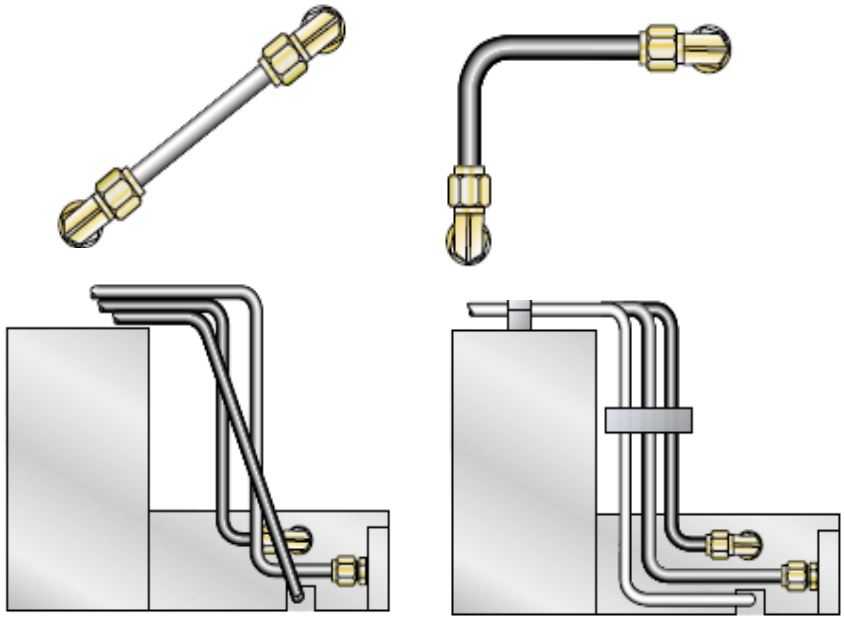
Preferred



Typical expansion loop

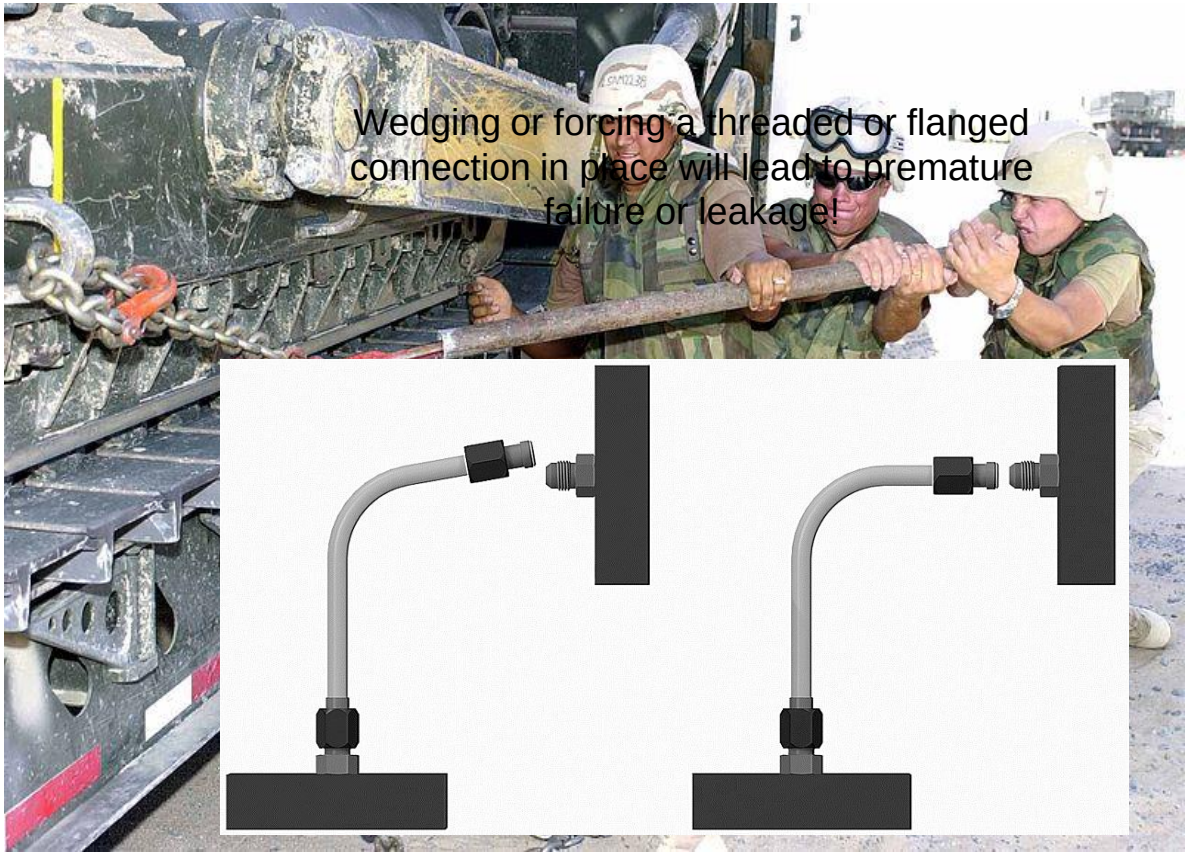
Needs Improvement

Preferred



Takeaways: square and parallel, allow for expansion/contraction, PLAN for service breaks, PLAN for service/access to connections

Installation



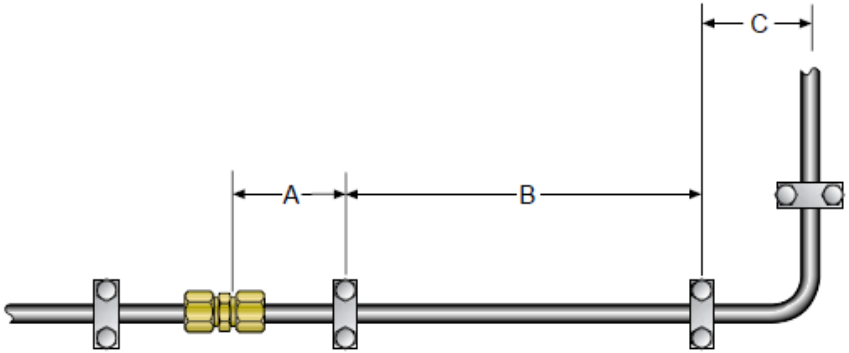
If you have to use a cheater bar…….

Clamping

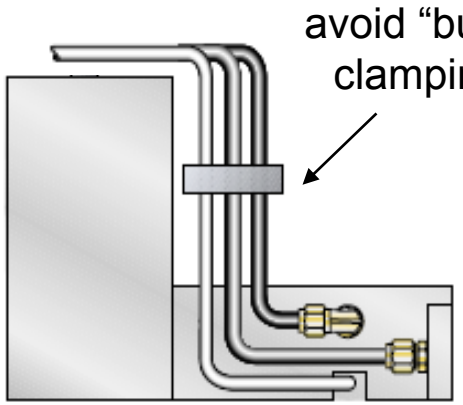
Several manufacturers provide industry standard (DIN 3015) clamps to the industry

Instrumentation tube clips

Clamping Guidelines



Published Spacing Guidelines

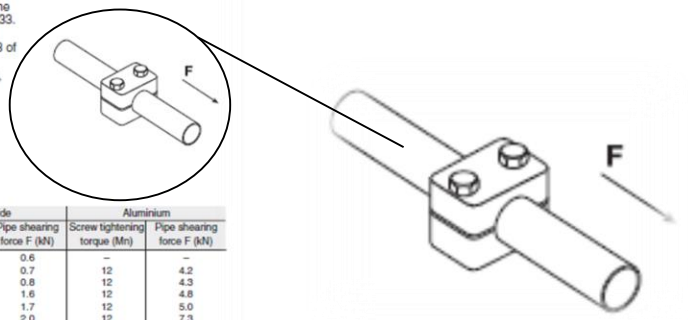


Tube clamps

DIN 3015

Screw tightening torque and axial pipe shearing forces

The indicated screw tightening torque and axial pipe shearing forces refer to the assembly with cover plates and outside hexagon bolts according to DIN 931/933. The axial pipe shearing force (according to DIN 3015, part 10) is an average value, determined by three tests made with a steel pipe according to DIN 2448 of St. 37, for which static friction is assumed (temperature during tests: 23°C). When loading the clamp with the indicated test force (F) in axial pipe direction, the pipe must not slide in the clamp.



Light series (DIN 3015, part 1)

Size	Fixing screw DIN 931/933	Polypropylene		Polyamide		Aluminium	
		Screw tightening torque (Mn)	Pipe shearing force F (kN)	Screw tightening torque (Mn)	Pipe shearing force F (kN)	Screw tightening torque (Mn)	Pipe shearing force F (kN)
0	M6	8	0.6	10	0.6	–	–
1	M6	8	1.1	10	0.7	12	4.2
2	M6	8	1.2	10	0.8	12	4.3
3	M6	8	1.4	10	1.6	12	4.8
4	M6	8	1.5	10	1.7	12	5.0
5	M6	8	1.9	10	2.0	12	7.3
6	M6	8	2.0	10	2.5	12	8.9

Heavy series (DIN 3015, part 2)

Size	Fixing screw DIN 931/933	Polypropylene		Polyamide		Aluminium	
		Screw tightening torque (Mn)	Pipe shearing force F (kN)	Screw tightening torque (Mn)	Pipe shearing force F (kN)	Screw tightening torque (Mn)	Pipe shearing force F (kN)
1	M10	12	1.6	20	4.2	30	12.1

Published Load & Shear Force - *Courtesy Stauff*

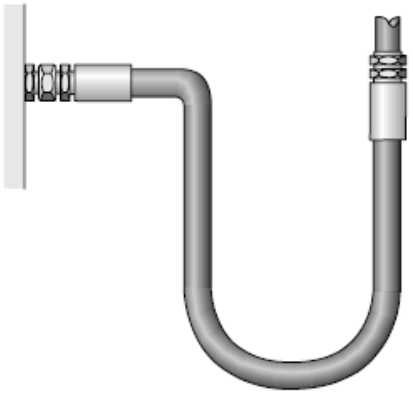
Double Heavy Clamp
- *Courtesy Stauff*

Hydraulic Hose Selection

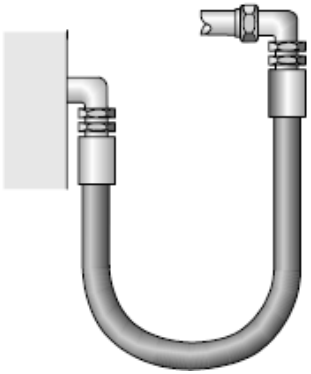
- What is the Application of the hose?
  - Equipment Type
  - Suction/Pressure/Return
- Where will the hose be used?
  - Temperature & corrosion
  - Minimum Bend Radius
  - Routing requirements: clamps/protection sleeves
  - Duty cycle
  - Abrasion (external)
  - Media (internal)
  - Fitting/adapter selection
  - Specific hose construction (spiral, braided, low volumetric expansion)

Hose Routing

Needs Improvement



Preferred



Needs Improvement

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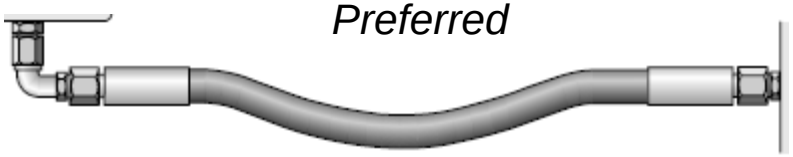
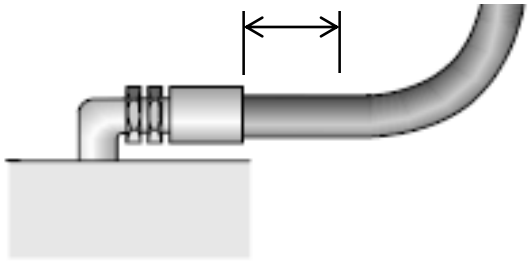
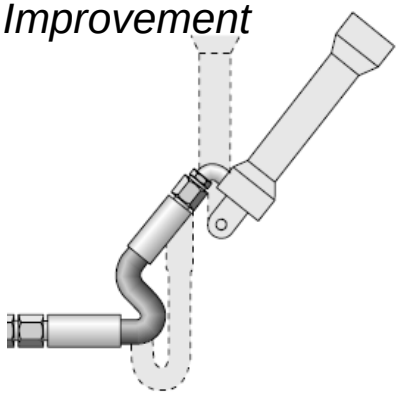


Min 2x Hose OD



Needs Improvement

Needs Improvement



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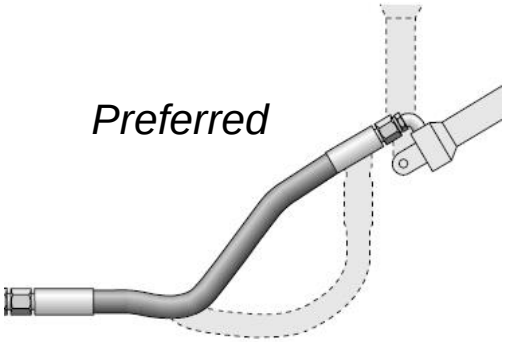

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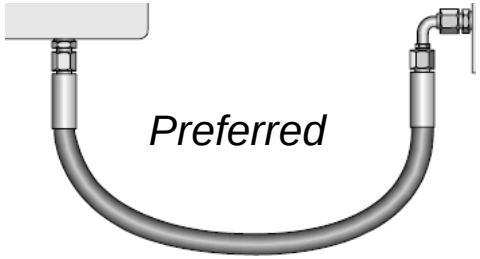


Hose Routing/Safety

- Typical hydraulic hose expands in diameter & shortens in length when pressurized
- Thermoplastic hose for subsea service
- Follow velocity guidelines
- Flex connect at HPU and equipment takeover points when possible
- Hose is not an accumulator
- Don’t intermix manufacturer’s fittings/hose/crimping system

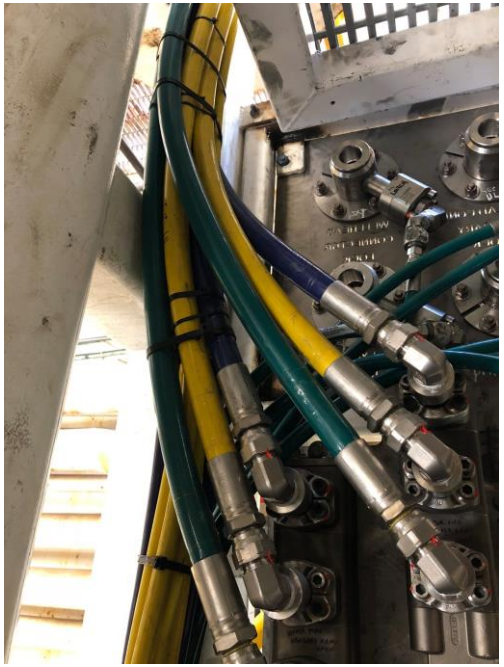


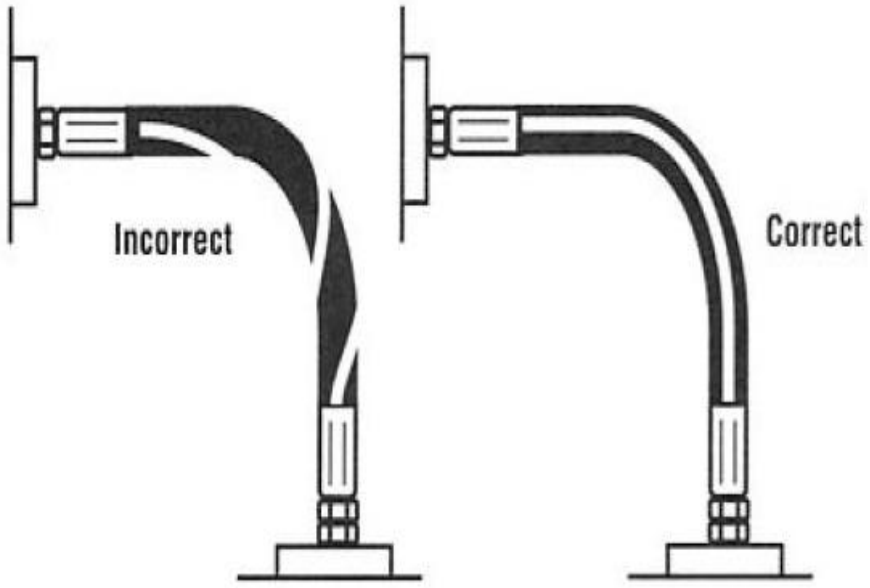
Photo courtesy:
Connector Specialists

Hose Whip Restraints

Avoid Hose Twist

Use two wrenches to install a hose assembly. This will reduce chance of hose twist.

"*a twist in a hose as little as 7-10% can result in a 90% loss of service life in the hose….*" Use the layline of the hose as a guide to determine if there is hose twist



Source: International Fluid Power Society

Summary

QUESTIONS?