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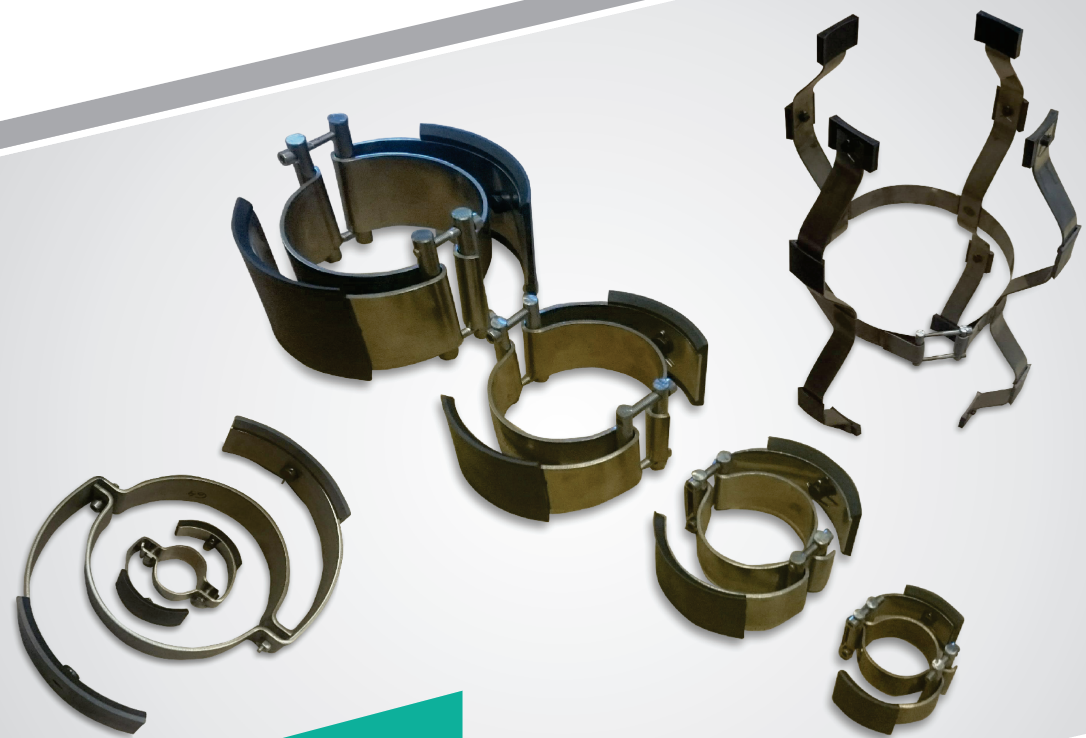


AF Flex©

FLEXIBLE DOUBLE WALL PIPE SUPPORTS

The inner pipe flexible support is designed to accommodate movement in the inner pipe of a double wall pipe in the axial and radial directions. Movement in the axial direction is unlimited due to the sliding action of the bearings, and movement in the radial direction is limited to the specified allowable elastic deformation of the supports themselves.

DESIGN CRITERIA

The principle design criteria for the supports are the dimensions of the inner pipe and outer pipe. The design is also made to ensure there is a good fit of the supports that are clamped around the inner pipe, and the slide bearings have permanent contact with the outer pipe inner surface in all scenarios. Designs are checked against pipe standard tolerances and manufacturing tolerances to ensure a good fit, and no metal-to-metal contact. The design is based on standard design criteria such as pipe dimensions and pipe masses, then design simulations are performed to optimise the stress distribution and deflection characteristics of the spring form itself. This is the first stage in the simulation process. Once a good spring form design is complete, then the entire flex support assembly is simulated in three stages:

1. The initial clamping of the assembly (this stage also determines fastener torques)
2. The assembly stage, once the assembled flex support is compressed
3. The behavior of the final assembly in the piping arrangement. The last stage of the process is particularly important as it determines the calculated maximum deflections, and stiffness properties of the flex support assembly.

TESTING

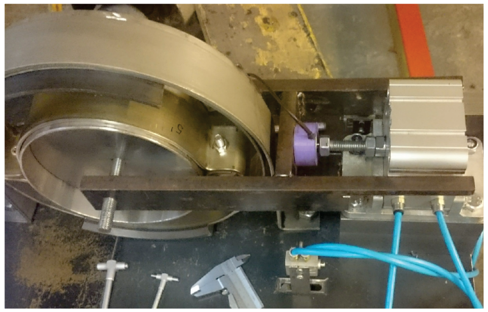
a. Design validation

The first series of tests are to confirm stiffness & maximum deflection properties of the flex support assembly, and allow for release of final specifications for the specific support. During the design phase design, simulations are performed to establish the maximum and minimum stiffness properties of the support. These characteristics form the basis for the installation recommendations regarding exact angular placement of the supports. Recommendations for design and installation can be found in our documentation, “AF Flex Design Guidelines” and “AF Flex Support Installation Procedure”.

a. Radial Stiffness & Deflections

In order to verify the design simulations the support is installed in a test rig, and tested for stiffness and deflection properties.

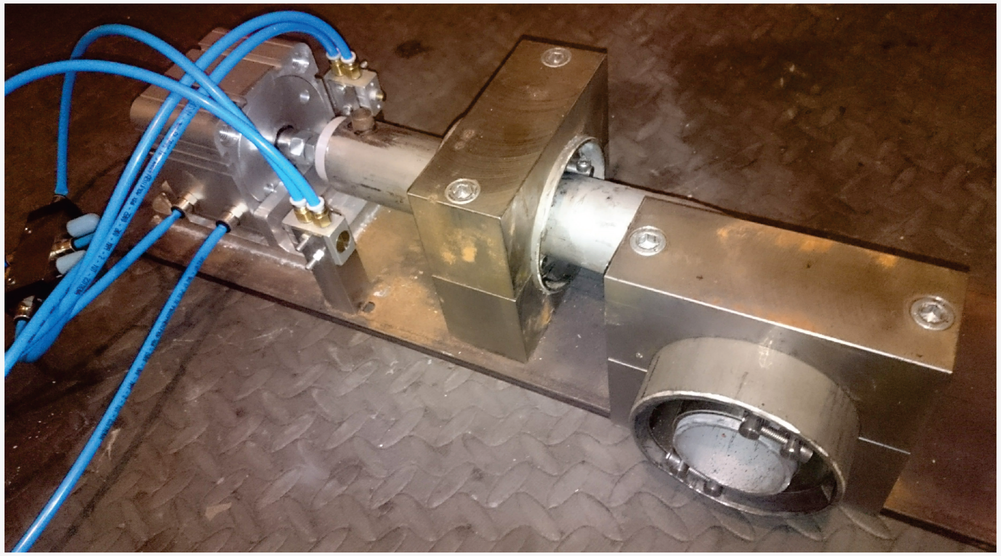
For stiffness testing a load cell is inserted in between the pneumatic cylinder and the test piece in order to directly measure the force exerted by the cylinder. The deflection is then set by adjusting the limit switches. This methodology allows for precise specification of stiffness properties.



Radial deflection and stiffness test

For durability testing a robust connection piece is used to run thousands of cycles at the specified maximum deflection until failure occurs. The principle for success of the test is based on the expected number of cycles during the lifetime of the piping system. The estimated number of cycles is based on twenty start-stops per week, over a fifty year period, equating to 104,000cycles. Minimum lifetime is typically specified to 150,000cycles to include a degree of safety in the system. In case of premature failure during testing, then then maximum deflection specification can be reduced.

Durability test



a. Flow testing

Before flow testing occurs, in the design phase, CFD simulation of the flow behavior is performed to make an estimate of the pressure loss across 1 support.

Validation of CFD simulation is then performed with a ventilation system set up for 5-6m of double wall piping. The output from the test is some flow versus pressure drop per support datapoints, that can then be used for HVAC calculations.

c. Additional tests

The additional tests are performed, but not necessarily specified on the product specification, or performed on batch level:

- Corrosion test: consists of addition of saturated salt water solution sprayed onto the flex support during durability testing. Also, long term salt water bath dip, to test applicability of materials.
- Wear test: consists of erosion allowance measurement of the bearings by measuring mass of axial bearing support pad before and after a specified number of cycles.
- Joint test: measurement of force required to remove pad from spring form.
- Low temperature test: bath of liquid nitrogen used to check thermal contractions and suitability of support in low temperature.

Common Specification

The flex supports are made up of a metallic spring form, with a bearing mounted on the spring form:

Spring Form Material*	Stainless spring steel, EN1.4301 or EN1.4310 work hardened
Bearing Material*	PEEK mixture with PTFE and Carbon Fibre
Temperature range	-220° to 100°C
Bearing Friction Co-efficient	0.21

*Special materials available on request.

QUALITY

All materials are batch traceable with 3.1 material certificates. AF Pipes maintains master records of production batch numbers, and quality control records for the standard 10% batch check of assembled components. Quality documentation is as standard made available on a protected shared drive for ease of sharing order documentation.

CLASSIFICATION

All AF Flex supports are designed and produced in conformance with Classification Society rules for piping systems.

COMPACT

The compact type of flex support can be used with smaller annular spaces, therefore smaller outer pipe sizes, thus allowing for a more economical double pipe installation with reduced weight of outer pipe. It can be used up with 1 ¼" to 6" diameter outer pipe, and is secured on the inner pipe using four bolts.

Dimensions

The dimensions of the inner and outer pipes are shown below, typically up to schedule 40 outer pipe.

Max inner pipe diameter		Min outer pipe diameter		Mass	k_{min}	$\Delta s_{radial, max}$	1st Harmonic	Pressure drop (Pa)			
NPS	DN	NPS	DN	Kg	N/mm	Mm	Hz	15m3/h	30 m3/h	60 m3/h	120 m3/h
3/8" , ½"	10,15	1 ¼"	32	0.06	50	4	8	**10**	24	78	-
3/4" , 1"	20,25	2 ½"	65	0.1	65	5	10	**7**	18	57	-
1 ¼" , 1 ½"	32,40	3"	80	0.3	85	5	15	-	4	13	30
2"	50	4"	100	0.3	58	8	13	-	2	8	27
2 ½" , 3"	65, 80	5"	125	0.6	105	8	15	-	2	6	16
4", 4 ½"	100,115	6"	150	1.5	190	8	11	-	2	4	11

Special dimensions available on request.

k_{min} = Stiffness , minimum. The actual stiffness is variable depending on mounting angle, please refer to individual support specification for stiffness chart.

$\Delta s_{radial,max}$= maximum allowable radial deflection.

1^{st} Harmonic = First order harmonic frequency, given 1m spacing of the flex support.

STANDARD

The standard type of flex support is based on the original double wall pipe design for the high pressure gas supply system. It is suitable for a comparatively larger annular space when compared to the compact version, and thicker pipe wall (schedule). There is therefore a larger radial deflection allowance with this type of support.

It can be used with 4" to 10" diameter outer pipe, and is installed simply using two bolts.

Dimensions

The dimensions of the inner and outer pipes are shown below, up to schedule XXS for the outer pipe.

Max inner pipe diameter		Min outer pipe diameter		Mass	k_{min}	$\Delta s_{radial, max}$	1st Harmonic	Pressure drop (Pa)		
NPS	DN	NPS	DN	Kg	N/mm	Mm	Hz	30 m3/h	60 m3/h	120 m3/h
1", 1 ¼", 1 ½"	32, 40	4"	100	0.3	70	6	12	1	2	5
2", 2 ½"	50, 65	5"	125	0.5	85	8	12	1	2	7
3, 3 ½"	80, 90	6"	150	0.9	110	10	16	1	3	6
4, 4 ½"	100, 115	8"	200	1.4	90	10	18	-	3	10
5, 6"	125, 150	10"	250	1.9	50 / 180	12	13	-	-	12

Special dimensions available on request.

K_{min} = Stiffness , minimum. The actual stiffness is variable depending on mounting angle, please refer to individual support specification for stiffness chart.

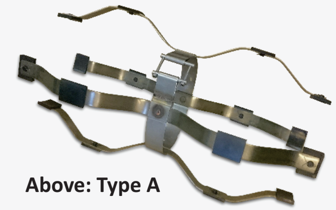
$\Delta s_{radial,max}$ = maximum allowable radial deflection.

1st Harmonic = First order harmonic frequency, given 1m spacings of the flex support.

CENTRALISER

The centraliser is typically used for larger diameter systems, and where there is a small annular space, and thereby a reduced possibility for radial deflection. The design allows for significantly higher stiffness of the support, whilst maintaining some degree of flexibility to absorb vibrations or limited expansions and contractions of the inner pipe. The centraliser can be used in conjunction with a standard or compact

There are two types of centraliser, type A for larger radial deflection, and type B, which is an economical version primarily designed for axial movement only



Above: Type A

Right: Type B

Dimensions

The dimensions of the inner and outer pipes are shown below, up to schedule 10 for the outer pipe.

Max inner pipe diameter		Min outer pipe diameter		Mass	k_{min}	$\Delta s_{radial,max}$	1st Harmonic	Pressure drop (Pa)		
NPS	DN	NPS	DN	Kg	N/mm	Mm	Hz	60 m3/h	120 m3/h	240 m3/h
6	150	8	200	0.5	400	3	280	2	8	18
6	150	10	250	1.8	260	18	150	2	9	20
8	200	10	250	0.7	425	3	300	3	10	30
8	200	12	300	2.1	295	26	170	3	12	40
10	250	12	300	1.0	475	3	350	1	2	8
10	250	14	350	2.4	330	32	200	1	3	15
12	300	14	350	1.4	550	3	400	-	1	4
12	300	16	400	2.6	380	40	250	-	1	5

Special dimensions available on request.

Type A: White background , Type B: Grey background

k_{min} = Stiffness , minimum. The actual stiffness is variable depending on mounting angle, please refer to individual support specification for stiffness chart.

$\Delta s_{radial,max}$ = maximum allowable radial deflection.

1st Harmonic = First order harmonic frequency, given 1m spacing of the flex support.

Patent pending.