JU Type Ball Joint

Flanged・Welded

for Building・Air-conditioning Equipments, Factory Equipments, and Earthquake-proof Buildings, etc.

Solutions for Preventing Expansion and Contraction of Pipelines, Earthquake-proof, and Ground Sinkage

Absorb expansion and contraction in axial direction of pipeline, shifting of axes, bending, twisting, and other displacement of pipeline due to ground sinkage or earthquake. Ideal for high buildings, area conditioning, plants, storage tanks and factories.

JU-3F, 4F Type

JU-3W, 4W Type

FEATURES

- Super packing allows high sealing performance.
- Large displacement in limited space.
- Low load on fixing point, allows utilization of small fixing point.
- Absorb thermal expansion of pipeline and the movement of pipeline due to ground sinkage.

SPECIFICATIONS

Model name	JU-3F	JU-3W	JU-4F	JU-4W
Code name	**JU3F-N**	**JU3W-N**	**JU4F-N**	**JU4W-N**
Applicable fluid	Steam, air, gases, cold or hot water & oils			
Fluid temperature	Max. 220℃			
Applicable pressure	Max. 1.0MPa		Max. 2.0MPa	
End connection	Flanged JIS 10KFF	Butt-weld	Flanged JIS 20KRF	Butt-weld
Materials	Ball(Stainless steel), End pipe(Carbon steel), Packing(Graphite compound)			
	Flange(Mild steel)	–	Flange(Carbon steel)	–
Pressure test	Hydraulic 1.5MPa		Hydraulic 3.0MPa	

＊All stainless material are also available upon request.

DIMENSIONS

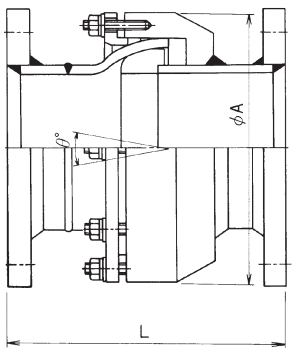
DIMENSIONS / Models / Size	L(mm) JU-3F JU-4F	L(mm) JU-3W JU-4W	A(mm)	Max. displacement angle(θ)	Mass (kg) JU-3F JU-4F	Mass (kg) JU-3W JU-4W	Torque(N・m) JU-3F JU-3W	Torque(N・m) JU-4F JU-4W
50(2″)	220	210	125	20	9(9.5)	5.5	200	200
65(2½″)	240	230	145	20	12(12.5)	7.5	300	300
80(3″)	270	260	160	20	16.5	11.5	400	500
100(4″)	295	280	195	20	23.5	17.5	700	800
125(5″)	315	300	220	15	33.5	23.5	900	1100
150(6″)	325	310	255	15	71	59	1300	1600
200(8″)	375	360	335	15	86	70	2400	3100
250(10″)	390	430	395	15	130	110	4000	5200
300(12″)	430	480	465	15	163	142	6000	8200

＊Figures in ( ) are for JU-4F Type.

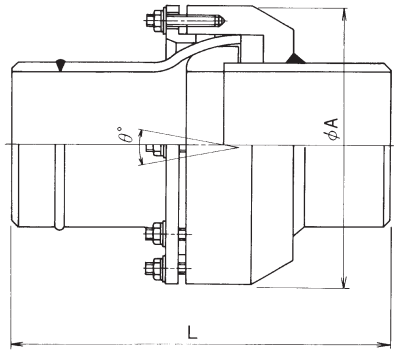
＊Flange type: Flange code JIS 10KFF, JIS 20KRF

CONSTRUCTION

JU-3F, 4F Type



JU-3W, 4W Type



DATA/JB Type Bellows Expansion Joint

■ ABOUT BELLOWS MATERIAL SUS316L (Stainless steel)

The JIS B 2352 Bellows Type Expansion Joint recommends SUS304, SUS304L, SUS316, SUS 316L, and others for making bellows. To ensure durability and corrosion resistance, which are extremely important parameters for high grade bellows, we selected SUS316L for making bellows and all parts that contact with fluid. With higher performance than SUS304, SUS316L is considered having the same or even higher characteristics than SUS304L. See the following table for characteristics of SUS316L and SUS304L.

■ COMPARISON BETWEEN SUS316L AND SUS304L

TABLE1. CHEMICAL COMPOSITION (%)

Type	Carbon C	Silicon Si	Manganese Mn	Phosphor P	Sulfur S	Nickel Ni	Chrome Cr	Molybdenum Mo
SUS316L	0.030 or less	1.00 or less	2.00 or less	0.045 or less	0.030 or less	12.00~15.00	16.00~18.00	2.00~3.00
SUS304L	0.030 or less	1.00 or less	2.00 or less	0.045 or less	0.030 or less	9.00~13.00	18.00~20.00	—

TABLE2. MECHANICAL PROPERTY

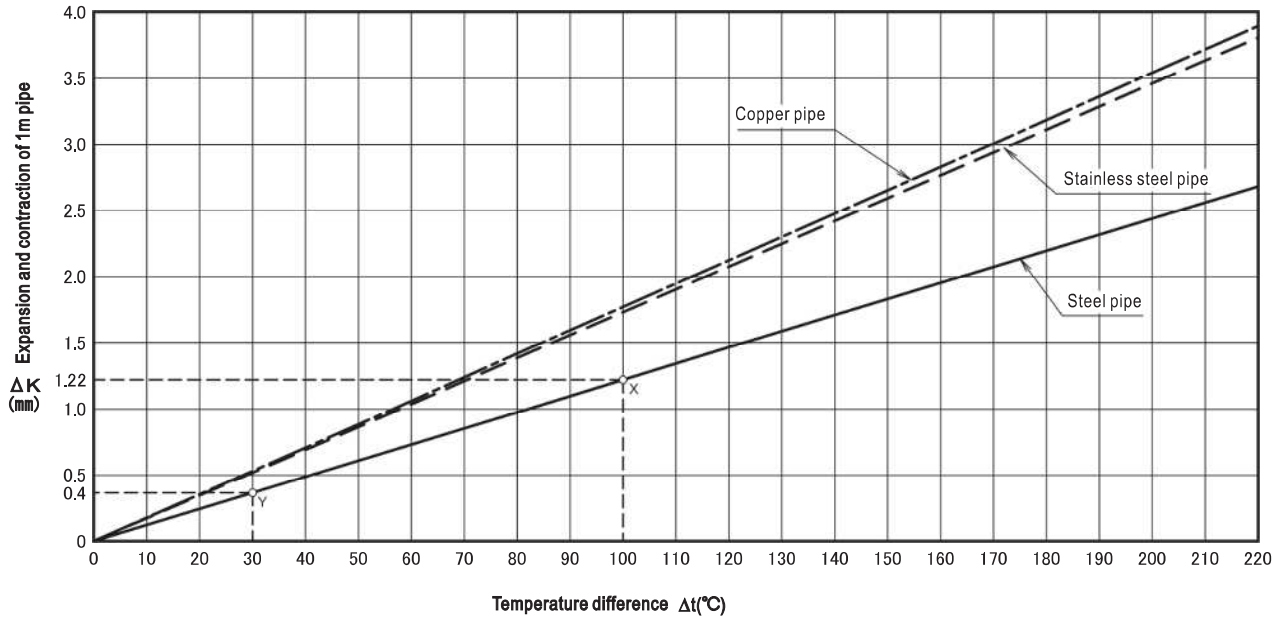
Type	Tensile test			Hardness test		
	Yield Strength N/mm²	Tensile N/mm²	Elongation %	HB	HRB	HV
SUS316L	175 or more	480 or more	40 or more	187 or less	90 or less	200 or less
SUS304L	175 or more	480 or more	40 or more	187 or less	90 or less	200 or less

TABLE3. ANTICORROSION

Type	All surface corrosion	Intercrystalline corrosion	Stress corrosion crack	Porous corrosion	Gap corrosion
SUS316L	○	○	◎	◎	◎
SUS304L	○	○	○	○	○

＊○:Superior ◎:Much superior

■ FIG.1 EXPANSION AND CONTRACTION OF 1m PIPE



■ SELECTING EXPANSION JOINT

Determine the type and number of expansion joints based on the material of pipe and change of temperature, which are factors affecting expansion/ contraction of pipe.

● Calculation $n = \frac{\Delta \ell}{\delta}$

$$\Delta \ell = \beta \times \Delta t \times \ell$$

n : number of joints
δ :max. expansion/contraction of joint (mm)
Δℓ : expansion/contraction of pipe (mm)
β : linear expansion coefficient of pipe (mm/m/℃)
Steel pipe (12.2×10^{-3})
Copper pipe (17.7×10^{-3})
Stainless steel pipe (17.3×10^{-3})

Δt : temperature difference (℃)
ℓ : length of pipe (m)

● Example

Under the following conditions:
Length of pipe (ℓ): 35m
Max. working temperature (t_1): 120℃
Min. ambient temperature (t_2): −10℃
Ambient temperature at the time of installation (t_3): 20℃
Determine the type and number of expansion joints.
The pipe is steel pipe and the joint is to be determined based on standard face-to-face dimensions.

DATA/JU Type Ball Joint

■ CALCULATING EXTENSION / CONTRACTION OF PIPELINE

$\delta = \beta \times \Delta t \times L$

δ: Expansion and contraction of pipe (mm)
β: Linear expansion coefficient of pipe
12.2×10^{-3}mm/m/℃ (steel pipe)
Δt: Temperature difference (℃)
L: Length of pipe (m)

The expansion/contraction of 1m pipe can be calculated using Fig.1 in Page 179.

In the case of earthquake-proof buildings and solutions for preventing ground sinkage and absorption of displacement between buildings, the expansion/contraction should be added with displacement.

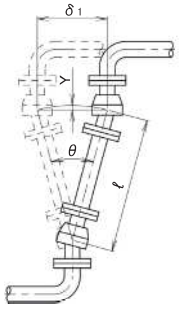
■ POSITIONS FOR INSTALLING BALL JOINT

Generally, ball joint can be installed at any position, provided it can absorb the expansion or contraction of pipe. However, in the case of absorption of displacement in axial direction, installing ball joint at the bending part or ascending/descending part of pipe can help saving space.

■ INSTALLING 2 BALL JOINTS
(Determining interval between ball joints)

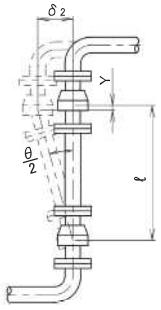
The interval between ball joints can be calculated using the following formula, where the interval is ℓ, expansion/contraction of pipe is δ, the displacement angle is θ, and safety factor is 1.5.

Fig.1



$$\ell \geqq \frac{\frac{\delta_1}{2}\times 1.5}{\sin\frac{\theta}{2}}$$

Fig.2



$$\ell \geqq \frac{\delta_2\times 1.5}{\sin\frac{\theta}{2}}$$

■ CALCULATING DEFLECTION OF PIPE

When two ball joints are used, deflection may occur when pipe expands. The deflection can be calculated using the following formula.

In Fig.1,

$$Y=\ell-\sqrt{\ell^2-\left(\frac{\delta_1}{2}\right)^2}$$

In Fig.2,

$$Y=\ell-\sqrt{\ell^2-\delta_2^2}$$

ℓ : Interval between ball joints (mm)
δ_1 : Expansion/Contraction of pipe (in the case of Fig.1) (mm)
δ_2 : Expansion/Contraction of pipe (in the case of Fig.2) (mm)
Y : Deflection of pipe (mm)
θ : Displacement angle of ball joint

The results of calculations are shown in Tab.1.

■ TABLE1. DEFLECTION OF PIPE "Y"

(mm)

Expansion of piping δ_1		40	60	80	100	150	200	300	400
Expansion of piping δ_2		20	30	40	50	75	100	150	200
The distance "ℓ" between ball joints	800	0.25	0.56	1.0	1.6	3.5	6.3	14.2	25.4
	1000	0.20	0.45	0.8	1.3	2.8	5.0	11.3	20.2
	1500	0.13	0.30	0.53	0.83	1.9	3.3	7.5	13.4
	2000	0.10	0.23	0.40	0.63	1.4	2.5	5.6	10.0
	2500	0.08	0.18	0.32	0.50	1.2	2.0	4.5	8.0
	3000	0.07	0.15	0.27	0.42	0.94	1.7	3.8	6.7
	4000	0.05	0.12	0.20	0.32	0.70	1.3	2.8	5.0
	5000	0.04	0.09	0.16	0.25	0.56	1.0	2.3	4.0

Deflection of pipe causes bending moment on pipe. Therefore, the distance to the first guide should be longer than the distance calculated using the following formula.

$$X=f\sqrt{\frac{3EYD}{2\sigma}}$$

X: Min. distance to the first guide (mm)
f: Safety factor (≧2)
E: Young's modulus (N/mm^2)
Y: Deflection of pipe (mm)
D: External diameter of pipe (mm)
σ: Allowable stress of pipe (N/mm^2)

In the case of steel pipes, the minimum distance "X" to the first guide is shown in TABLE 2. taking safety factor "f"=2
$E=191\times10^3 N/mm^2$,
"σ"=$70N/mm^2$ ※: 200℃

■ TABLE2. MINIMUM DISTANCE "X" TO THE FIRST GUIDE

(mm)

Y / Size	Deflection "Y" of pipe							
	1	2	4	6	8	10	12	14
25(1″)	800	1100	1600	1900	2200	2400	2700	2900
32(1¼″)	900	1200	1700	2100	2400	2700	3000	3200
40(1½″)	1000	1300	1900	2300	2600	2900	3200	3400
50(2″)	1100	1500	2000	2500	2900	3200	3500	3800
65(2½″)	1200	1700	2300	2800	3300	3600	4000	4300
80(3″)	1300	1800	2500	3000	3500	3900	4300	4600
100(4″)	1400	2000	2800	3400	4000	4400	4800	5200
125(5″)	1600	2100	3100	3800	4400	4900	5400	5800
150(6″)	1700	2400	3400	4100	4800	5300	5800	6300
200(8″)	2000	2700	3900	4700	5400	6100	6700	7200
250(10″)	2200	3000	4300	5200	6000	6800	7400	8000
300(12″)	2400	3300	4700	5700	6600	7400	8100	8700

＊In case of using 3 ball joints, there will be no deflection. So, the first guide should be installed at the nearest point of the ball joint.

■ THE DISTANCE "ℓ" BETWEEN BALL JOINTS

Max. Displacement angle of joint	Fig.1	Fig.2
θ=30° (JU-1 Type)	$\ell \geqq 3\delta_1$	$\ell \geqq 6\delta_2$
θ=20° (JU-3~4 Type Size 100mm and below)	$\ell \geqq 4.5\delta_1$	$\ell \geqq 9\delta_2$
θ=15° (JU-3~4 Type Size 125mm above)	$\ell \geqq 6\delta_1$	$\ell \geqq 12\delta_2$

DATA/JU Type Ball Joint

■ USING 3 BALL JOINTS

① One-way expansion

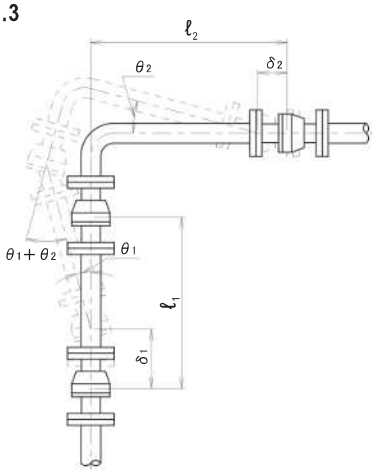
By using a combination of 3 ball joints, it is able to absorb deflection and bending stress that occur in the case of using 2 ball joints.

The interval (ℓ) can be calculated using the same formulas as those utilized in the case of using 2 ball joints.

② Two-way expansion

Using 3 ball joints can also absorb expansion of pipe in two directions. The interval (ℓ) can be calculated using the longer one of δ_1 and δ_2 and $\ell_1=\ell_2$. The total of θ_1 and θ_2 should not exceed allowable displacement angle($\frac{\theta}{2}$).

Fig.3



■ INSTALLING FIXING AND THE FIRST GUIDE

ⓐ Fixing point should be installed at the two ends and points that equally divide the extension of pipe.

ⓑ The first guide should be installed at a position as near as possible to ball joint. In the case 2 ball joints are used, see Tab.2 in Page 188.

ⓒ The load of fixing point and the first guide can be calculated using the following formulas. Fixing point and the guide must be strong enough to bear this load.

$$F_1=\frac{2T}{\ell}\times 1000$$

$$F_2=\frac{3EIY}{X^3}$$

$$F_T=\sqrt{F_1^2+F_2^2}$$

$$F_Z=\sqrt{F_A^2+F_B^2-2F_AF_B\cos\alpha}$$

$$F_Z=\sqrt{F_A^2+F_B^2}\quad(\alpha=90°)$$

F_1: The load of the first guide when fixing points and 3 ball joints are used (N)
See Tab.3 in Page 191.

F_2: The load of the first guide when fixing points and 2 ball joints are used (N)
See Tab.4 in Page 191.

F_T, F_Z: Combined load of fixing points (N)

F_A: Axial load of pipe A (N)
See Fig.8.

F_B: Axial load of pipe B (N)
See Fig.8.

α : Angle between pipe A and B (°)
ℓ : Interval between ball joints (mm)
T : Torque of ball joint (N • m)
See dimension table in Page 186, 187.
I : Inertia moment (mm^4)

$$I=\frac{\pi}{64}(D^4-d^4)$$

D : External diameter of pipe
d : Internal diameter of pipe
E : Young's modulus
Steel pipe (200℃): $191\times10^3 N/mm^2$
X : Distance to the first guide (mm)
Y : Deflection of pipe (mm)

■ PIPING EXAMPLE

Fig.4

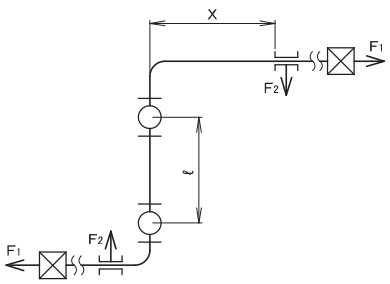


Fig.5

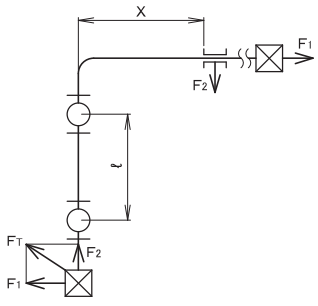


Fig.6

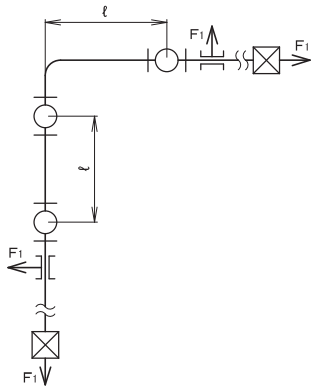


Fig.7

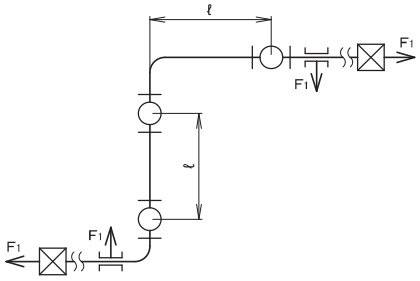
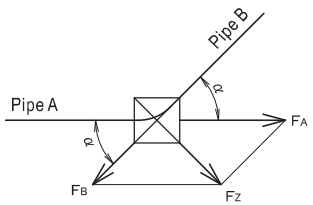


Fig.8



Ball joint

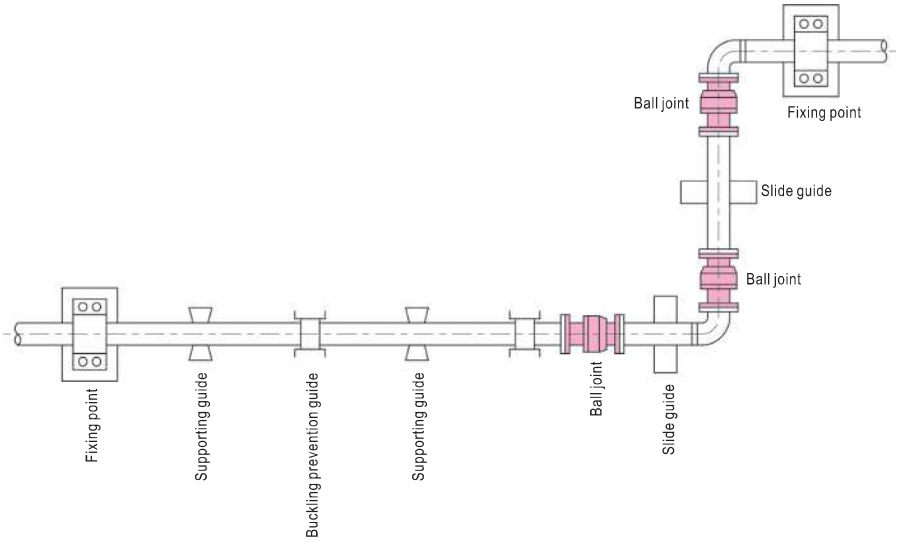
Anchor

The first guide

DATA/JU Type Ball Joint

■ PIPING EXAMPLE

● Horizontal piping



■ GUIDE

ⓐ Buckling prevention guide

To allow correct expansion of pipe, it is necessary to install guides for supporting pipe and preventing buckling. The interval between buckling prevention can be calculated using the following formula.

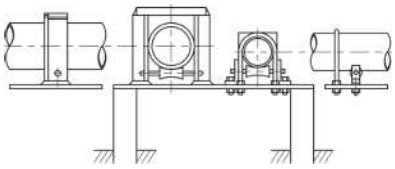
$$L=\sqrt{\frac{\pi^2 EI}{fF}}$$

L: Interval between guides	(mm)
F: Axial load of pipe	(N)
E: Young's modulus	(N/mm^2)
I: Secondary moment of cross section of pipe	(mm^4)
f: Safety factor	(≧3)

ⓑ Pipe supporting

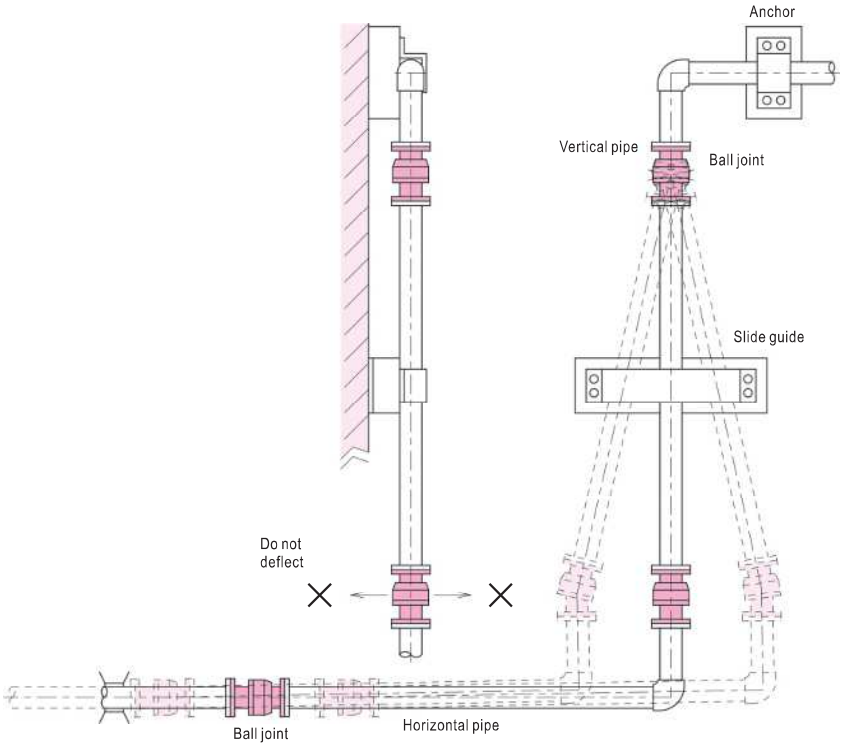
Pipe may bend due to its weight and the weight of fluid. To prevent pipe from bending, it is necessary to install roller, hanger and other guides. In addition, since the pipe between ball joints move in horizontal direction, it is also necessary to install slide joint on this section of pipe.

● An example of buckling prevention guide



● Vertical piping

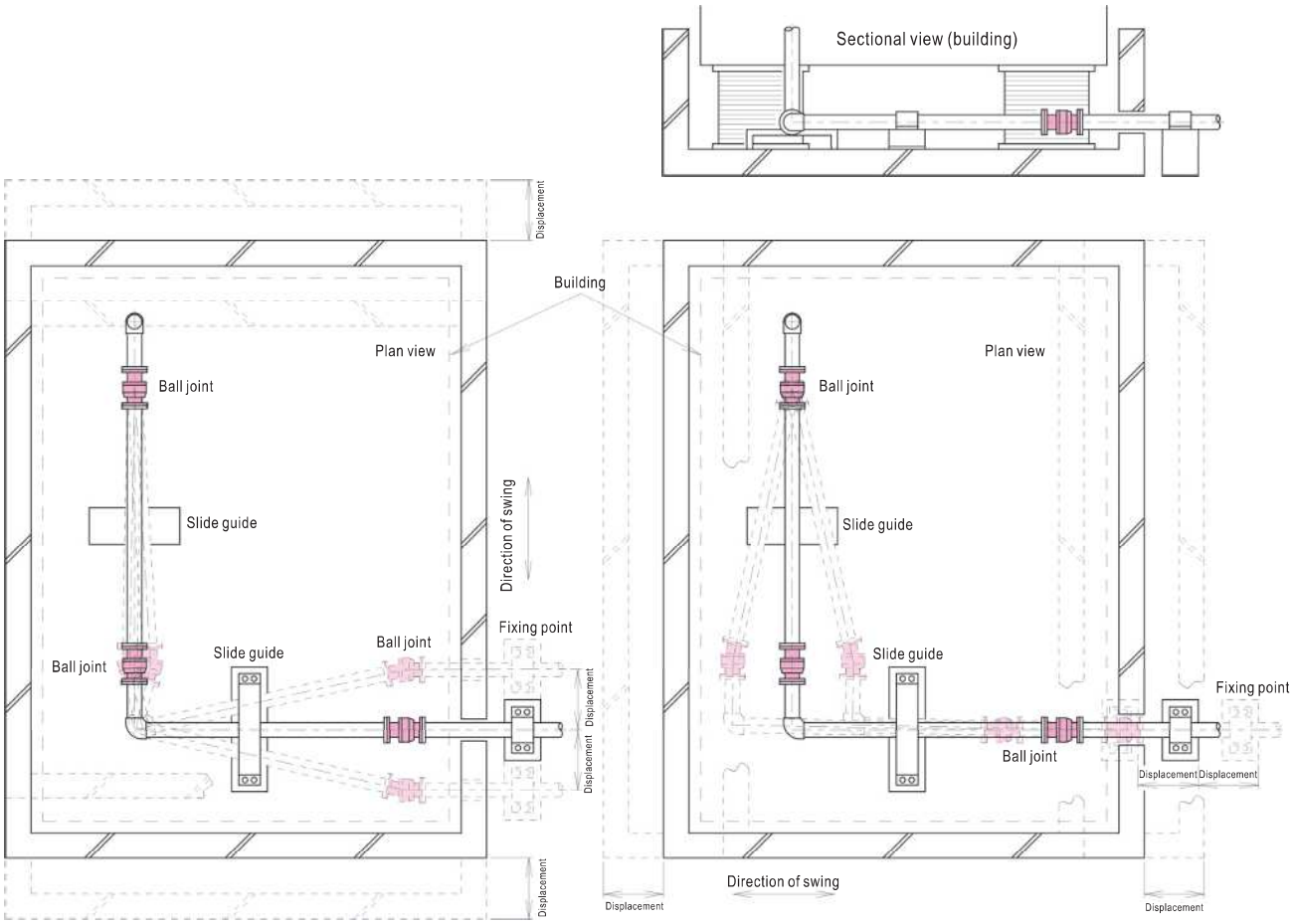
Make sure the ball joint in the middle does not deflect from the direction of sliding and clamp the pipe from both sides. Install slide guide on vertical pipe (as shown in the figure) or horizontal pipe.



DATA/JU Type Ball Joint

■ USING BALL JOINT IN EARTHQUAKE-PROOF BUILDING

Example (using 3 ball joints)



■ TABLE 3. F_1 at pressure 1.0MPa

(N)

Size	Distance between ball joints ℓ (mm)					
	1000	1500	2000	2500	3000	4000
50(2″)	400	270				
65(2½″)	600	400				
80(3″)	800	540	400			
100(4″)	1400	940	700			
125(5″)		1200	900	720		
150(6″)		1740	1300	1040		
200(8″)		3200	2400	1920	1600	
250(10″)			4000	3200	2670	2000
300(12″)			6000	4800	4000	3000

∗ This table is for JU-3F & JU-3W Types.

■ TABLE 4. F_2 at deflection Y=1mm

(N)

Size	Distance to first guide X (mm)						
	1000	2000	3000	4000	5000	6000	7000
50(2″)	170	21	6.1	2.6			
65(2½″)	430	54	16	6.8			
80(3″)	740	93	28	12			
100(4″)		220	65	28	14		
125(5″)		450	140	56	29		
150(6″)		810	240	110	52	30	
200(8″)			630	270	140	79	50
250(10″)			1360	580	300	170	110
300(12″)			2560	1080	560	320	210

(STPG Sch40)

∗ 1. Required load can be figured out by multiplying the actual distance mm with the above figures.
∗ 2. This table is for JU-3F, 4F & JU-3W, 4W Types.