



Water Closet Carrier System Anchor Pull-out Force Calculations

The intent of this document is to display calculated pull-out forces applied to anchors that are embedded in concrete and utilized in the installation of Zurn floor-affixed water closet carrier systems. Any calculated data contained within this document is specific to Zurn product design, and does not apply to any other carrier system manufacturer.

The tabulated calculation data contained within this document is independent of anchor manufacturer, anchor embedment depth, concrete manufacturer, concrete type, concrete depth, and installation practices. All data displayed is calculated with zero safety factor.

Carrier Design Background:

A Zurn floor-affixed water closet carrier system is a combination fixture support and waste fitting assembly that utilizes support components that provide a means of anchoring the carrier to a structural floor slab (Fig-1). These components are generally referred to as carrier feet and require one anchor per foot, in the rear slot or hole of each foot, to secure to the floor. Most Zurn water closet carriers also include a rear anchor foot assembly that attaches to the carrier fitting and is anchored to the floor in either one or two locations, depending on the type of carrier.

Calculation Parameters:

- Dimensional data, with respect to the Load placement, is taken from ANSI Standard A112.6.1M, entitled “Floor-Affixed Supports for Off-The Floor Plumbing Fixture For Public Use.”
- All calculations assume that the carrier is a completely rigid system (no deformation occurs within the components of the system).
- The carrier system is considered weightless in all calculations.
- **All calculations assume that identical anchors are being utilized to anchor the entire carrier. If anchor types or sizes differ within a carrier installation, the tabulated results displayed in this document will not be accurate.** If multiple types of anchors are to be used on one carrier system, it will require different calculations to determine the forces applied to each anchor.
- All calculations are subject to change as the design of the carrier system is changed, per manufacturer’s requirements.



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Sample Method of Calculations

$$\sum F_y = 0: \text{-(Load)} + F_a - F_b - F_c = 0$$

Equilibrium Equations:

$$\sum \tau_a = 0: (\text{Load})(x) - (F_b)(y) - (F_c)(z) = 0$$

Because there are three unknowns (F_a , F_b , and F_c) and only two equilibrium equations, the free-body diagram in Fig-2 is considered statically indeterminate. The deformations of the anchors can be used to provide the third additional equation necessary to solve for the unknown forces. As previously stated, the carrier is considered to be a completely rigid system.

The effect of a force applied to the system will be to elongate the carrier anchors at point B and point C and rotate the system counter-clockwise. Refer to Fig-3 for a free-body diagram showing the deformations in the anchors. A geometrical relationship between the deformation of the anchors can be established.

$$\tan \phi = \delta_b / (y) = \delta_c / (z)$$

$$\delta_b (z) = \delta_c (y)$$

In developing a relationship between stress, strain, and deformation of the anchors, the following equations can be expressed:

Stress: $\sigma = F / A$ (lb/in²)

Strain: $\varepsilon = \delta / L$ (no units)

Hooke's Law: $E = \sigma / \varepsilon$ (lb/in²)

Deformation: $\delta = FL / AE$ (in.)

Since $\delta_b (z) = \delta_c (y)$, and substituting (FL/AE) for δ , the relationship between deformation of the anchors now becomes:

$$(F_b L_b / A_b E_b) (z) = (F_c L_c / A_c E_c) (y)$$

F = Force on the anchor

L = Length of the anchor

A = Cross-sectional area of the anchor

E = Young's Modulus of the anchor



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From the calculation parameters, an assumption was stated that all of the anchors at points B and C are to be considered identical. If anchors are equal, then the properties of the anchors would also be equal at both points of the system. Therefore, the equation can be simplified as follows:

$$(F_b E_b / A_b E_b) (z) = (F_c E_c / A_c E_c) (y)$$

or, $(F_b) (z) = (F_c) (y)$

Looking back at the second equilibrium equation,

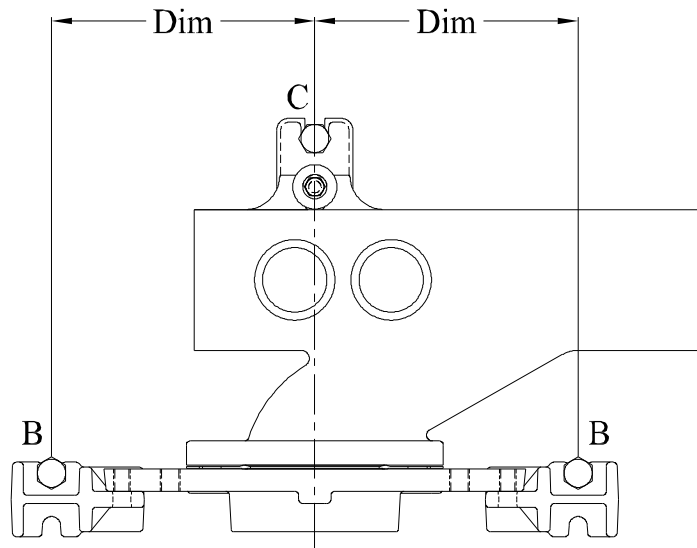
$$\sum \tau_a = 0: (\text{Load})(x) - (F_b)(y) - (F_c)(z) = 0 \quad \dots\dots\text{a substitution for } F_b \text{ can be made:}$$

$$\sum \tau_a = 0: (\text{Load})(x) - [(F_c)(y^2)] / (z) - (F_c)(z) = 0$$

After inputting the Load and dimensional data (x), (y), and (z) into this equation, F_c can be solved for. Once F_c is known, F_b can be determined by substitution into the equation:

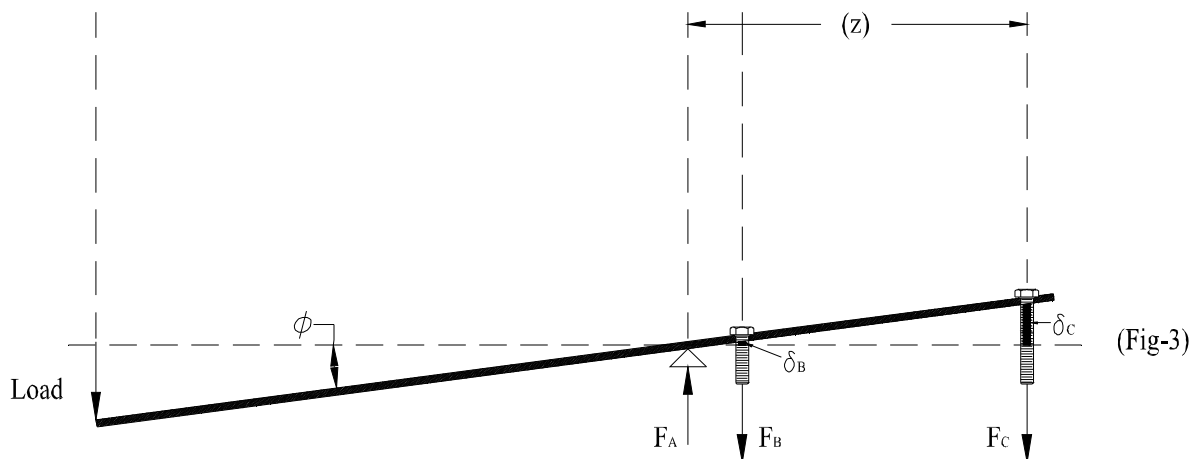
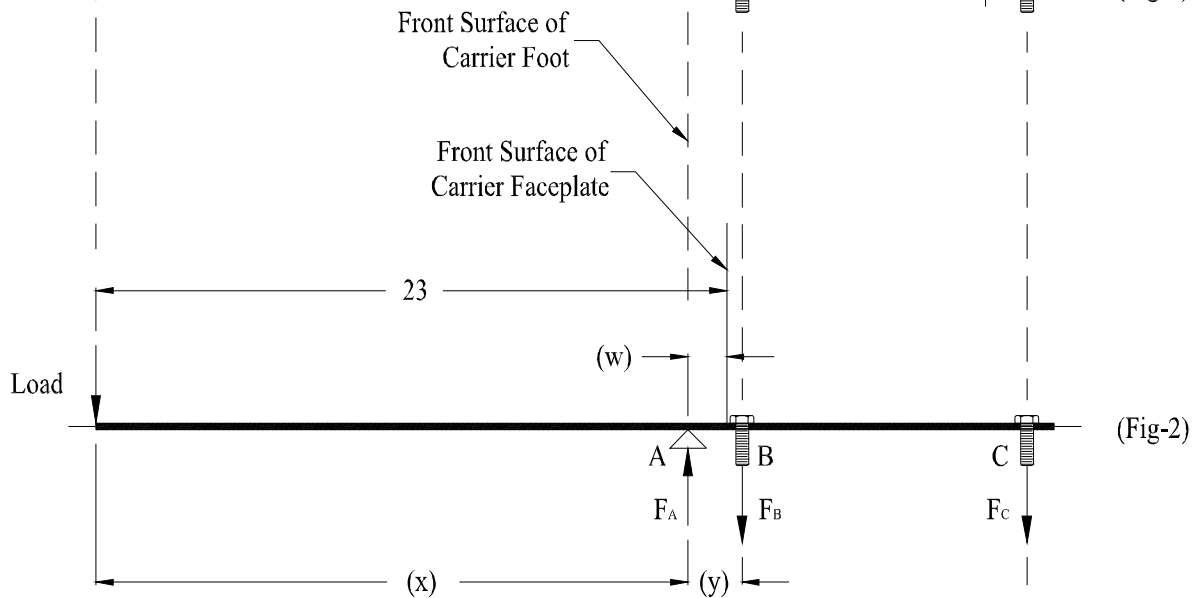
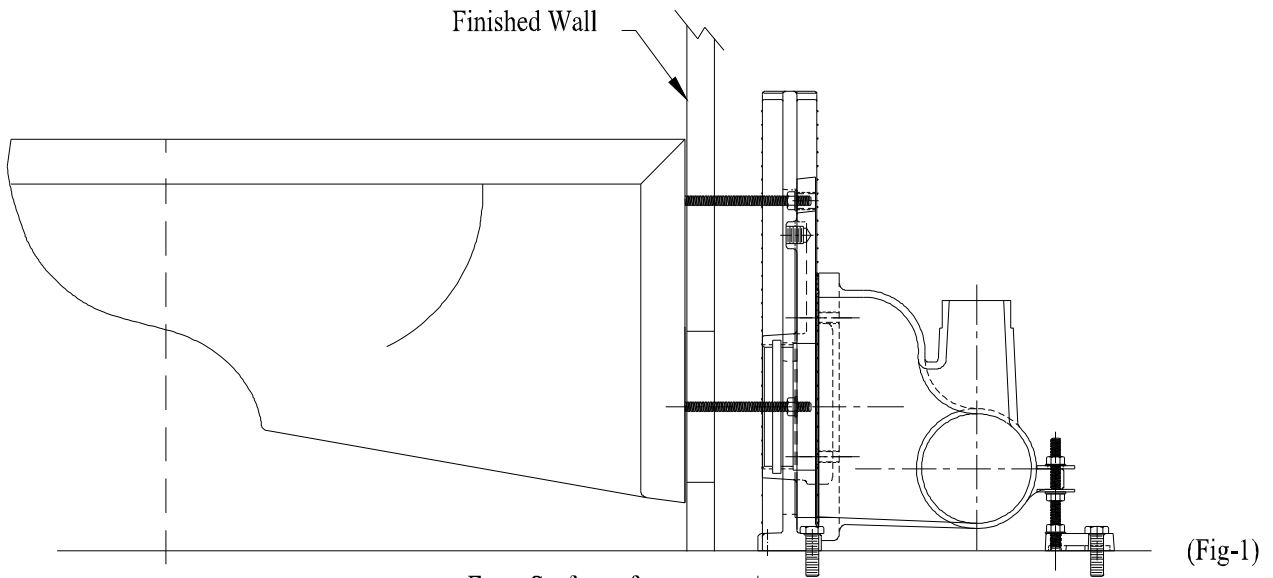
$$(F_b) = [(F_c) (y)] / (z)$$

Note: Because the carrier is symmetrical about its centerline when viewed from the top and also considered a completely rigid system, the value(s) calculated at point B (and point C in the case of a rear-anchor bar) may be divided by the number of anchors at that point to obtain the force applied on each anchor.





Water Closet Carrier System Anchor Pull-out Force Calculations





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Carrier Model	Calculation Dimensions (in)				Force	** Minimum Pull-out Force Per Anchor (lbs)	Depth (in)
	(w)	(x)	(y)	(z)	Load (lbs)		
Z1201-NL3, -NR3	1/4	22-3/4	13/16	9-57/64	500	1142	10-49/64
Z1201-NL4, -NR4	1/4	22-3/4	13/16	11-17/64	500	1005	12-9/64
Z1201-HL4, -HR4	1/4	22-3/4	13/16	11-17/64	500	1005	12-9/64

Carrier Model	Calculation Dimensions (in)				Force	** Minimum Pull-out Force Per Anchor (lbs)	Depth (in)
	(w)	(x)	(y)	(z)	Load (lbs)		
Z1202-N4	1/4	22-3/4	13/16	11-17/64	500	1005	12-9/64
Z1202-H4	1/4	22-3/4	13/16	11-17/64	500	1005	12-9/64

Carrier Model	Calculation Dimensions (in)				Force	** Minimum Pull-out Force Per Anchor (lbs)	Depth (in)
	(w)	(x)	(y)	(z)	Load (lbs)		
Z1203-NL3, -NR3	1-13/32	21-19/32	1-31/32	11-1/16	300	568	11-11/16
Z1203-NL4, -NR4	1-13/32	21-19/32	1-31/32	12-23/64	300	512	12-63/64
Z1203-HL4, -HR4	1-13/32	21-19/32	1-31/32	12-21/64	300	513	12-21/64
Z1203-HL5, -HR5	1-13/32	21-19/32	1-31/32	12-59/64	300	490	13-35/64
ZN1203-NL4, -NR4	1/16	22-15/16	3-7/16	N/A	300	1001	8-13/16
ZF1203-NL4, -NR4	0	23	1-27/64	10-29/32	300	623	11-17/32
Z1203-NL4-X, -NR4-X	1-13/32	21-19/32	1-31/32	10-51/64	500	484	11-35/64
Z1203-NL4-XH, -NR4-XH	1/16	22-15/16	3-7/16	9-29/64	750	804	10-13/64
Z1203-NL4-XB, -NR4-XB	2-1/32	20-31/32	5-13/32	11-27/64	1000	750	14-9/64

**** Note:** Minimum Pull-out Force Per Anchor is a calculated value with zero safety factor applied to it. Each anchor in a complete carrier system should be rated for the pull-out force value shown. Principles of good engineering practice should include a safety factor of four when choosing anchors for actual applications.



Water Closet Carrier System Anchor Pull-out Force Calculations

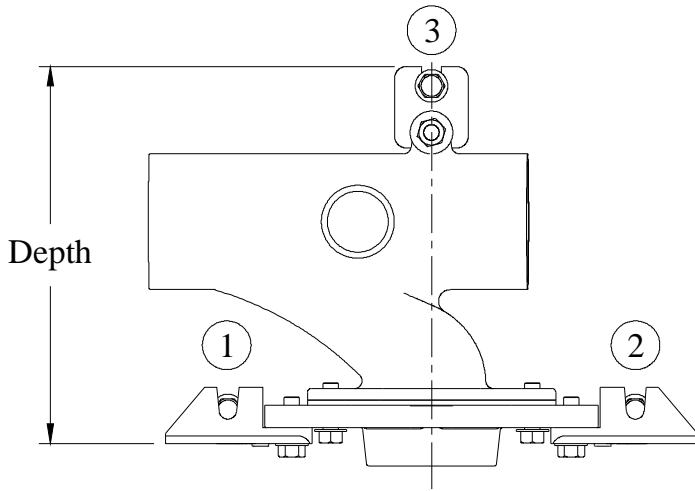
Carrier Model	Calculation Dimensions (in)				Force Load (lbs)	** Minimum Pull-out Force Per Anchor (lbs)	Depth (in)
	(w)	(x)	(y)	(z)			
Z1204-N4	1-13/32	21-19/32	1-31/32	12-23/64	300	512	12-63/64
Z1204-N5	1-13/32	21-19/32	1-31/32	12-53/64	300	494	13-29/64
Z1204-N6	1-13/32	21-19/32	1-31/32	13-53/64	300	460	14-29/64
Z1204-H4	1-13/32	21-19/32	1-31/32	12-21/64	300	513	12-15/16
Z1204-H5	1-13/32	21-19/32	1-31/32	12-59/64	300	490	13-35/64
Z1204-H6	1-13/32	21-19/32	1-31/32	13-53/64	300	460	14-29/64
ZN1204-N4	1/16	22-15/16	3-7/16	N/A	300	1001	8-13/16
ZN1204-N5	1/16	22-15/16	3-7/16	N/A	300	1001	9-5/16
ZN1204-N6	1/16	22-15/16	3-7/16	N/A	300	1001	10-15/16
ZF1204-N4	0	23	1-13/32	10-57/64	300	624	11-33/64
ZF1204-N5	0	23	1-13/32	11-23/64	300	599	11-63/64
ZF1204-N6	0	23	1-13/32	12-23/64	300	552	12-63/64
Z1204-N4-X	1-13/32	21-19/32	1-31/32	10-59/64	500	479	11-43/64
Z1204-N5-X	1-13/32	21-19/32	1-31/32	11-25/64	500	461	12-9/64
Z1204-N6-X	1-13/32	21-19/32	1-31/32	12-25/64	500	425	13-9/64
Z1204-N4-XH	1/16	22-15/16	3-7/16	9-37/64	750	796	10-21/64
Z1204-N5-XH	1/16	22-15/16	3-7/16	10-3/64	750	767	10-51/64
Z1204-N6-XH	1/16	22-15/16	3-7/16	11-3/64	750	710	11-51/64
Z1204-N4-XB	2-1/32	20-31/32	5-13/32	11-35/64	1000	745	14-17/64
Z1204-N5-XB	2-1/32	20-31/32	5-13/32	12-1/64	1000	726	14-47/64
Z1204-N6-XB	2-1/32	20-31/32	5-13/32	13-1/64	1000	687	15-47/64

**** Note:** Minimum Pull-out Force Per Anchor is a calculated value with zero safety factor applied to it. Each anchor in a complete carrier system should be rated for the pull-out force value shown. Principles of good engineering practice should include a safety factor of four when choosing anchors for actual applications.

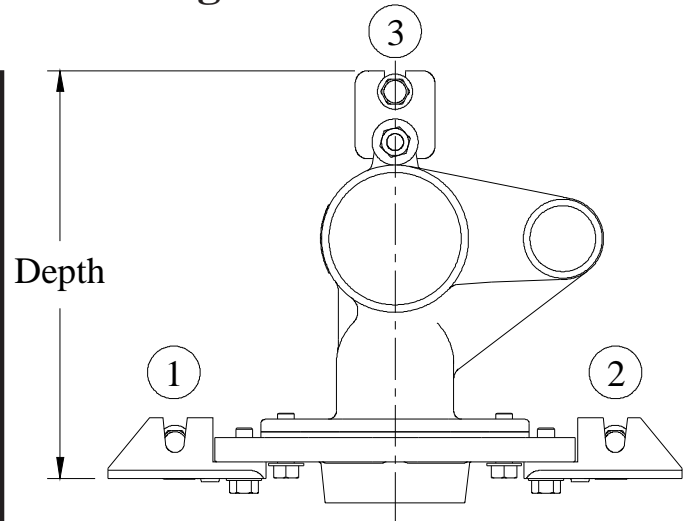


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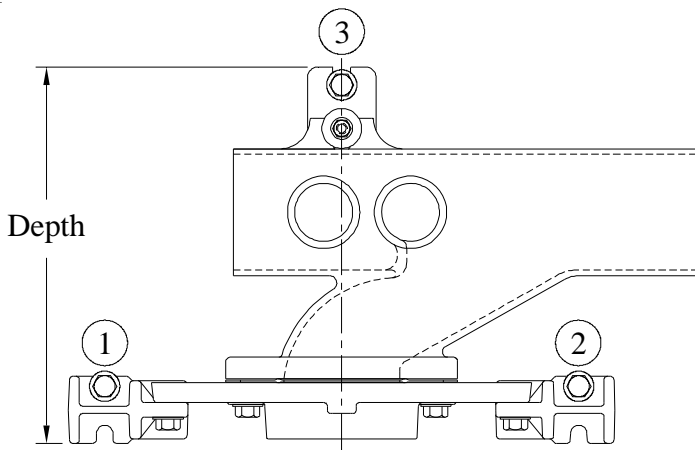
Water Closet Carrier Diagrams



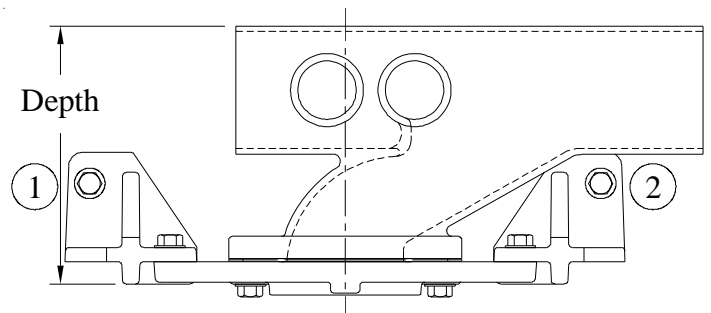
Adjustable Horizontal Siphon Jet
Z1201-NL3, -NR3, NL4, -NR4,
-HL4, -HR4
Anchors Required - 3
Maximum Load - 500 lbs



Adjustable Vertical Siphon Jet
Z1202-N4, H4,
Anchors Required - 3
Maximum Load - 500 lbs



Adjustable Horizontal Siphon Jet
Z1203-NL3, -NR3, -NL4, -NR4,
-HL4, -HR4, -HL5, -HR5
Anchors Required - 3
Maximum Load - 300 lbs

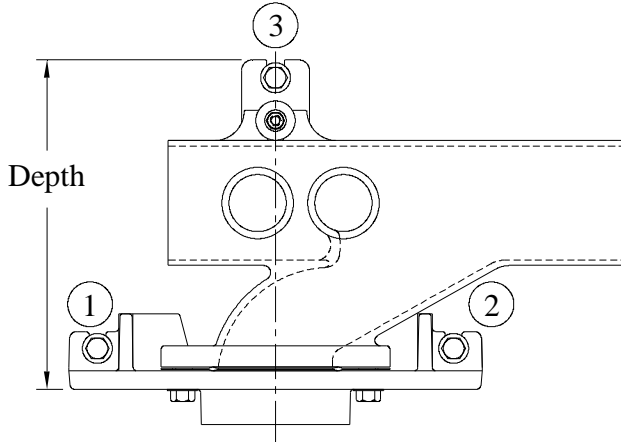


Adjustable Horizontal Siphon Jet
(Narrow-Wall Carrier)
ZN1203-NL4, -NR4
Anchors Required - 2
Maximum Load - 300 lbs

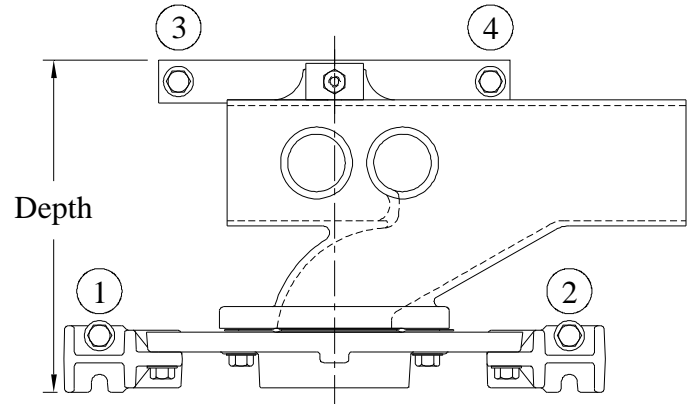


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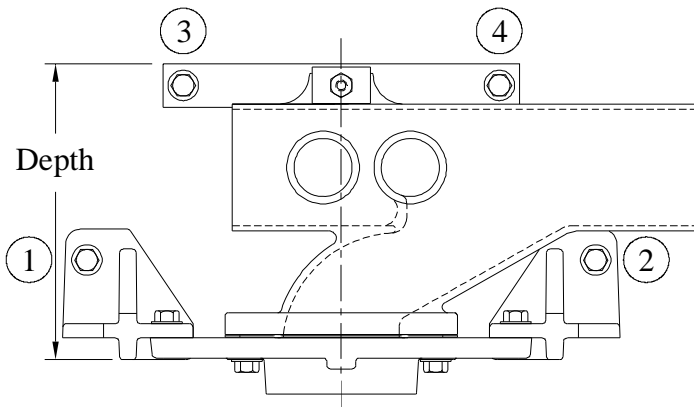
Water Closet Carrier Diagrams



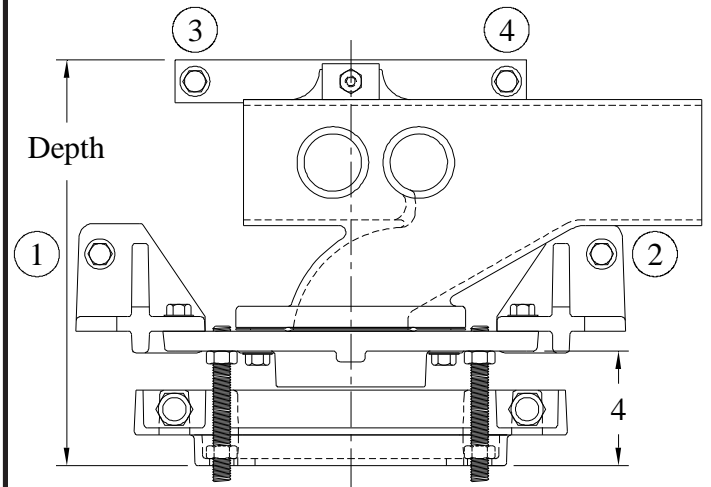
**Adjustable Horizontal Siphon Jet
(One-Piece Faceplate Carrier)**
ZF1203-NL4, -NR4
Anchors Required - 3
Maximum Load - 300 lbs



**Adjustable Horizontal Siphon Jet
(500-lb Load Rated Carrier)**
Z1203-X-NL4, -NR4
Anchors Required - 4
Maximum Load - 500 lbs



**Adjustable Horizontal Siphon Jet
(750-lb Load Rated Carrier)**
Z1203-XH-NL4, -NR4
Anchors Required - 4
Maximum Load - 750 lbs

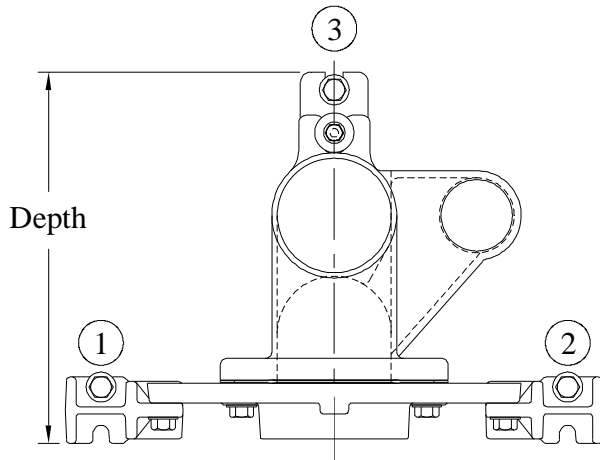


**Adjustable Horizontal Siphon Jet
(1000-lb Bariatric Carrier)**
Z1203-XB-NL4, -NR4
Anchors Required - 4
Maximum Load - 1000 lbs



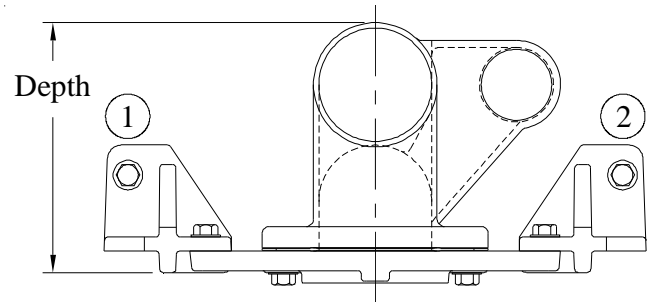
Water Closet Carrier System Anchor Pull-out Force Calculations

Water Closet Carrier Diagrams



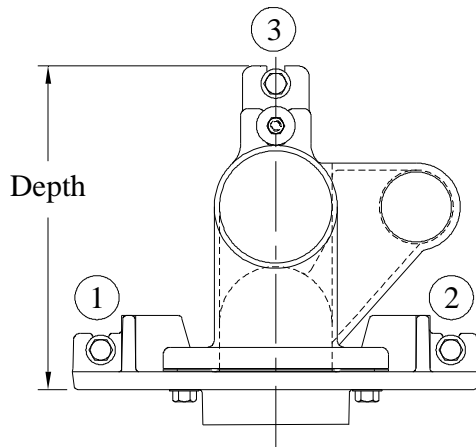
**Adjustable Vertical Siphon Jet
Z1204-N4, -N5, -N6, -H4,
-H5, -H6**

Anchors Required - 3
Maximum Load - 300 lbs



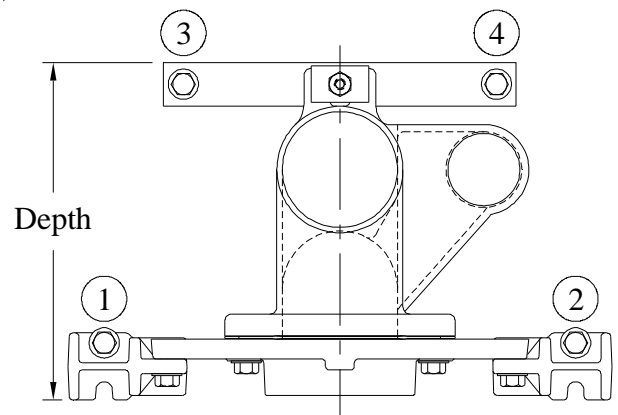
**Adjustable Vertical Siphon Jet
(Narrow-Wall Carrier)
ZN1204-N4, -N5, -N6**

Anchors Required - 2
Maximum Load - 300 lbs



**Adjustable Vertical Siphon Jet
(One-Piece Faceplate Carrier)**

ZF1204-N4, -N5, -N6
Anchors Required - 3
Maximum Load - 300 lbs



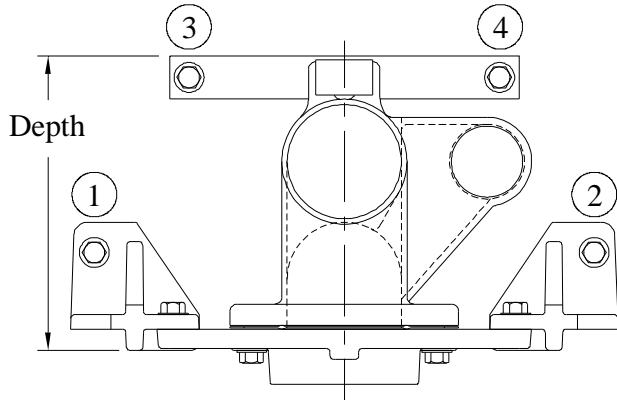
**Adjustable Vertical Siphon Jet
(500-lb Load Rated Carrier)**

Z1204-X-N4, -N5, -N6
Anchors Required - 4
Maximum Load - 500 lbs

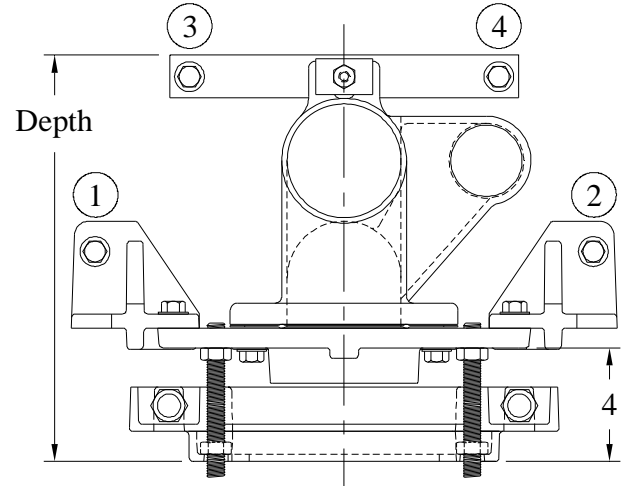


Water Closet Carrier System Anchor Pull-out Force Calculations

Water Closet Carrier Diagrams



**Adjustable Vertical Siphon Jet
(750-lb Load Rated Carrier)**
Z1204-XH-N4, -N5, -N6
Anchors Required - 4
Maximum Load - 750 lbs



**Adjustable Vertical Siphon Jet
(1000-lb Bariatric Carrier)**
Z1204-XB-N4, -N5, -N6
Anchors Required - 4
Maximum Load - 1000 lbs