RESTRAINT METHOD:

Underground Fire Service Utilities shall be restrained against movement at changes in direction and as required in other locations. The two approved methods are Thrust Blocks or Mechanical Restraint, which shall be designed and installed in accordance with NFPA 24, San Diego County Water Agencies standards, manufactures recommendations, and product listings. Additional requirements related to Thrust Blocks and Mechanical Restraints are listed below.

THRUST BLOCK RESTRAINT:

Calculations shall be submitted, and the resulting dimensions of thrust blocks shall be shown on the plans.
In areas of San Diego County where substandard soils (clay, sand, silt) exist, soil bearing strength shall be substantiated, via a geotechnical report, and shall be noted within the calculations. The San Diego County Fire Protection District's Thrust Block example calculations can be used if the design Engineer substantiates that the example Thrust Blocks are more conservative based upon known soil bearing capacity.

- Thrust blocks shall be installed on unrestrained pressure pipelines at all tees, wyes, reducers, horizontal bends, ascending vertical bends, and dead-ends, and shall bear directly against fittings and firm, wetted, undisturbed soil.
- Thrust blocks shall be located so that bearing areas on both fittings and soil are centered along the direction of thrust.
- For tees and wyes, the direction of thrust is along a line directly opposite the side outlet.
- For bends, the direction of thrust is along a line bisecting the outside angle formed by the adjacent pipe segments.
- For reducers, the direction of thrust is along the pipeline from the large end to the small end of the reducer.
- For dead-ends, including in-line valves, the direction of thrust is along the pipeline.
- Anchor blocks shall be located at all unrestrained descending vertical bends. Thrust blocks are not suited for such applications because excavation necessarily disturbs soil in the direction of thrust. Anchor blocks rely on the weight of the concrete used to restrain thrust. Anchor blocks must include as a minimum two (2) number four (#4) steel reinforcing bars with 2-inch minimum concrete embedment as directed design Engineer.
- To facilitate future removal of thrust blocks and line extension use cardboard separators between blocks, if needed.

Results of calculations for all Thrust Blocks and Anchor Blocks shall be individually noted in the plan presented in the form of a clear and complete "Thrust/Anchor Block Table." Thrust Block and Anchor Block information shall include pipe station, type of block, test pressure, total thrust, assumed or tested soil capacity, and area or volume of block(s) required.
All applications shall use a minimum of Class 560-C-3250 concrete (Cast-in-place piles), unless otherwise directed by the design Engineer.
** A notation below the Thrust/Anchor Block Table shall read "Concrete used for Thrust Blocks/Anchors to be a minimum of Class 560-C 3250 Concrete unless otherwise directed by the design engineer."

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When determining thrust at fittings, in the calculation of concrete blocks, a thrust pressure of 225psi shall be used.

MECHANICAL RESTRAINT:

When utilizing Restrained Joint Systems, one of the following shall be used:

- Locking mechanical or push-on joints,
- Mechanical joints utilizing setscrew retainer glans,
- Bolted flange joints,
- Pipe clamps and tie rods, or
- Other approved methods or devices.

NOTES / INFORMATION TO BE PLACED ON PLANS:

- Type of Restraint used.
- Results of calculations for all Thrust Blocks and Anchor Blocks shall be individually noted in the plan presented in the form of a clear and complete "Thrust/Anchor Block Table." Thrust Block and Anchor Block information shall include pipe station, type of block, test pressure, total thrust, assumed or tested soil capacity, and area or volume of block(s) required.
- The most conservative sizing specifications for Thrust / Valve supports. Either Valve support block and Thrust/Anchor Block box from regional standards drawings or calculated values clearly displayed on plans.
- Applicable diagrams of Thrust / Anchor blocks from Thrust block detail sheet.
- Underneath Thrust/Anchor Block table, print "Concrete used for Thrust Blocks/Anchors to be a minimum of Class 560-C 3250 Concrete unless otherwise directed by the design engineer."
- Soils information.
- Thrust block bearing faces shall be placed against undisturbed soil, approved compacted backfill, or Class 100-E-100 slurry.
- To facilitate future removal of thrust blocks and line extension use cardboard separators between blocks, if needed.

See the following pages from the San Diego County Water Agencies standards for Thrust Blocks.

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5.2.5 THRUST CALCULATIONS

Pipeline thrust shall be calculated using the following formulae. Calculations below use standard American units.

A. Pipeline thrust at tees, in-line valves, and dead-ends:

$$T = 0.25\pi p d^2$$

Where: T = resultant thrust force (lb),
p = internal pressure (lb/in^2), and
d = outside diameter of side (branch) outlet piping (for tees or wyes) or dead-end pipe (in).

B. Pipeline thrust at bends:

$$T = 0.50\pi p d^2 \sin(\Delta / 2)$$

Where: T = resultant thrust force (lb),
p = internal pressure (lb/in^2),
d = outside diameter of pipe adjacent to bend (in), and
Δ = true angle of bend (degrees).

C. Pipeline thrust at reducers:

$$T = 0.25\pi p(D^2 - d^2)$$

Where: T = resultant thrust force (lb),
p = internal pressure (lb/in^2),
D = outside diameter of pipe adjacent to the large end of the reducer (in), and
d = outside diameter of pipe adjacent to the small end of the reducer (in).

D. Pipeline thrust at crosses:

For the most conservative approach and due to the fact that valves can be placed at crosses on any leg and the valve then closed the designer should use the approach above in Item B. for pipeline thrust at bends. The only difference is the angle at a cross will always be 90°.

E. Resultant Thrust Force Table for C900/C905 PVC:

The following table shows the thrust, in pounds, resulting from the required hydrostatic test pressure upon various fittings and types of pipe. Values in the following table is identical to those derived from the formulae shown above and are listed for convenience. Refer to AWWA M23, PVC Pipe Design and Installation for more detail. Thrust values for all other pipe materials shall be calculated by the Engineer of Work.

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Table 1
RESULTANT THRUST FORCE

Pipe Size (In)	Outside Diameter (In)	Test Pressure (lb/in²)	Tee, Valve & Dead End	90° Bend	45° Bend	22.5° Bend	11.25° Bend
AWWA C900, Class 305 PVC Pipe							
			Thrust (lbs)				
4	4.8	250	4524	6398	3462	1765	887
6	6.9	250	9348	13220	7155	3647	1833
8	9.05	250	16082	22743	12308	6275	3153
10	11.1	250	24192	34213	18516	9439	4743
12	13.2	250	34212	48383	26185	13349	6707
AWWA C905, Class 165 PVC Pipe							
			Thrust (lbs)				
14	15.3	215	39529	55902	30254	15423	7749
16	17.4	215	51124	72301	39129	19948	10022
18	19.5	215	64209	90806	49144	25053	12587
20	21.6	215	78784	111417	60298	30740	15444
24	25.8	215	112400	158958	86028	43856	22034
AWWA C905, Class 235 PVC Pipe							
			Thrust (lbs)				
14	15.3	250	45963	65002	35179	17934	9010
16	17.4	250	59447	84070	45499	23195	11654
18	19.5	250	74662	105588	57144	29132	14636
20	21.6	250	91609	129554	70114	35744	17958
24	25.8	250	130698	184835	100032	50996	25621

* The outside diameter is the same for both Class 165 and Class 235 PVC pipe.

5.2.6 ALLOWABLE SOIL BEARING CAPACITY

Calculations to determine the size of thrust blocks or valve support blocks shall use the results of soil bearing capacity tests performed by a qualified geotechnical engineer when such test results are available. In the absence of such test results, allowable soil bearing capacity shall be determined by using the following table:

Table 2
ESTIMATED BEARING STRENTH (Undisturbed Soil)

Type of Soil	Allowable Soil Bearing Capacity
Muck, peat, etc.*	0 lb/ft²
Soft Clay	500 lb/ft²
Fine Sand	1,000 lb/ft²
Decomposed Granite (D.G.)	1,500 lb/ft²
Sandy Gravel	2,000 lb/ft²
Cemented Sandy Gravel	4,000 lb/ft²
Hard Shale	5,000 lb/ft²
Granite	10,000 lb/ft²

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5.2.7 THRUST BLOCKS

A. Thrust blocks shall be installed on unrestrained pressure pipelines at all tees, wyes, reducers, horizontal bends, ascending vertical bends, and dead-ends, and shall bear directly against fittings and firm, wetted, undisturbed soil. Thrust blocks shall be located so that bearing areas on both fittings and soil are centered along the direction of thrust. For tees and wyes, the direction of thrust is along a line directly opposite the side outlet. For bends, the direction of thrust is along a line bisecting the outside angle formed by the adjacent pipe segments. For reducers, the direction of thrust is along the pipeline from the large end to the small end of the reducer. For dead-ends, including in-line valves, the direction of thrust is along the pipeline.

B. The required minimum area, in square feet, that a concrete thrust block must bear against undisturbed soil shall be in accordance with the following formula:

$$A = \frac{T}{S_b}(SF)$$

Where: A = area of thrust block (ft^2),
T = resultant thrust force (lb),
S_b = allowable soil bearing capacity (lb/ft^2), see Chart 1 for values, and
SF = safety factor (Use 1.5)

A passive resistance thrust block design is required if the height of the thrust block is greater than 0.5 times the depth from finish grade to the bottom of the designed thrust block. The required thrust block area using this method can be calculated as follows:

$$A = \frac{T(SF)}{\gamma H_t N_d + 2C_s\sqrt{N_d}}$$

Where: A = area of thrust block (ft^2),
T = resultant thrust force (lb),
SF = safety factor (Use 1.5),
γ = unit weight of soil (lb/ft^3), use appropriate soil value,
H_t = total depth to bottom of block (ft),
$N_d = \tan^2(45^\circ + \Phi/2)$,
Φ = soil internal friction angle (degrees), use appropriate soil value,
C_s = soil cohesion (lb/ft^2), use appropriate soil value

Note: The thrust block area using the passive resistance thrust block design is generally larger than what is shown in Table 3. The engineer shall calculate thrust block sizes for this condition based upon each specific case. Refer to AWWA M23, PVC Pipe Design and Installation for more detail.

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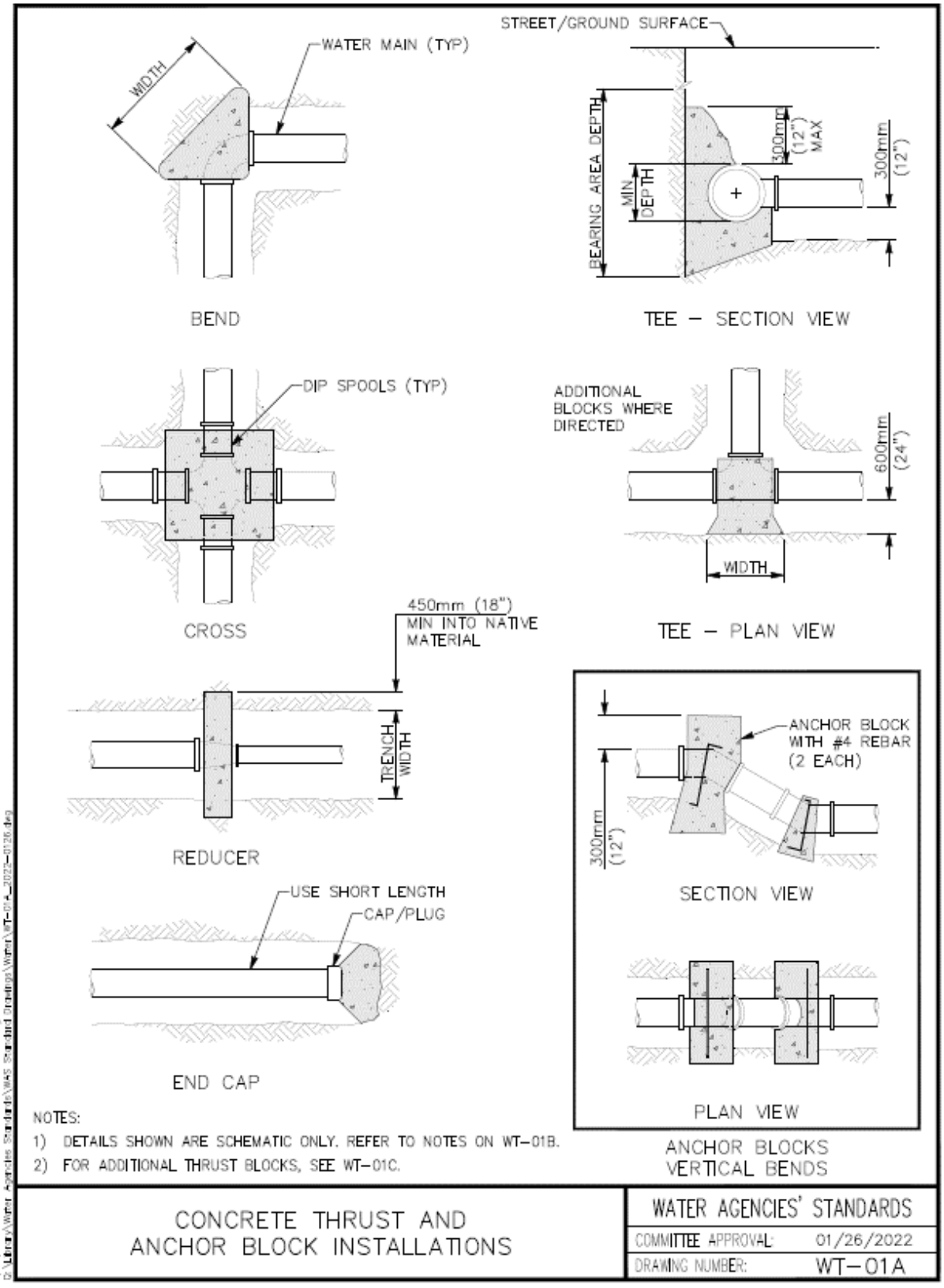

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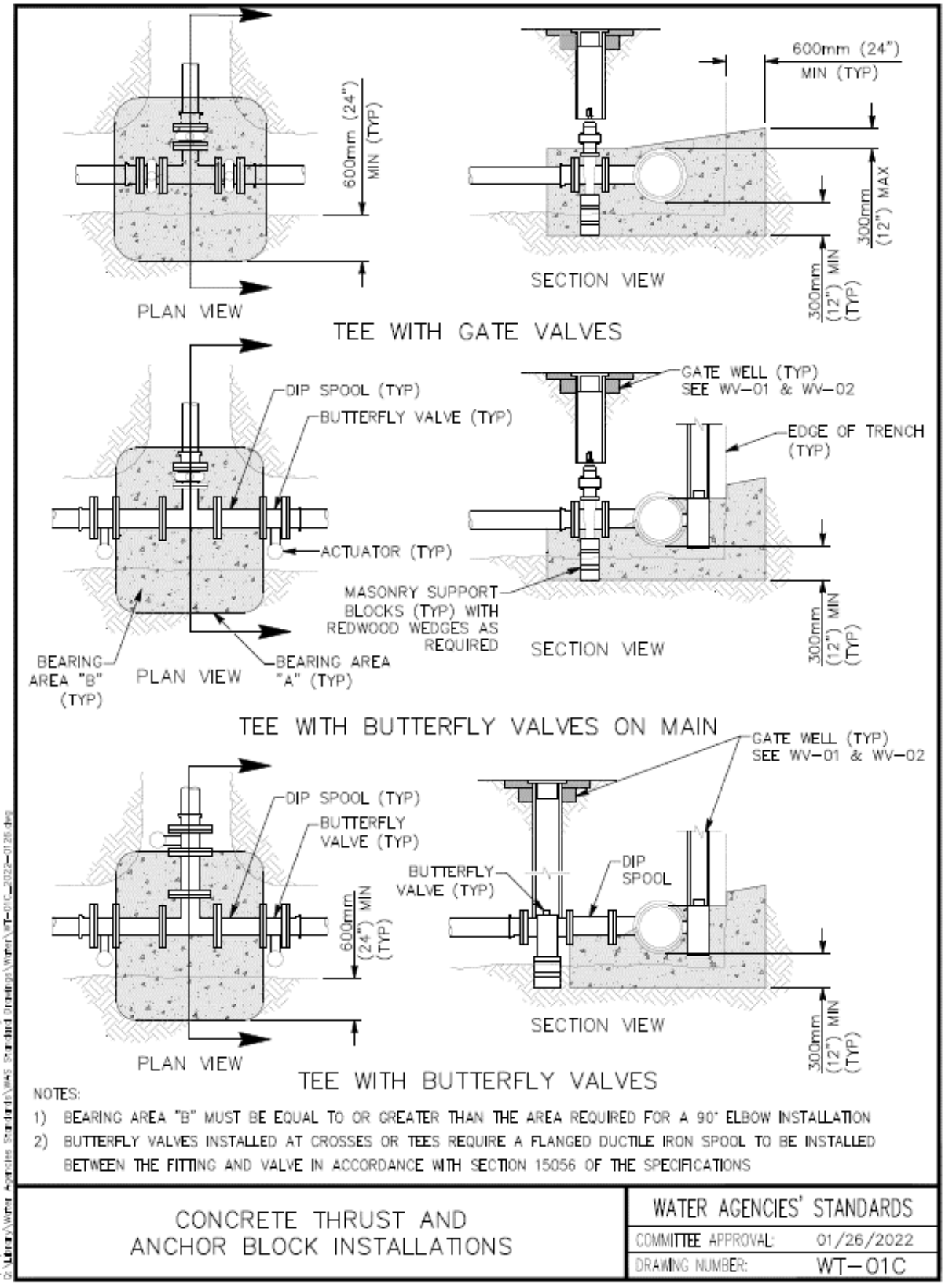
600mm (24") MIN (TYP)
PLAN VIEW
600mm (24") MIN (TYP)
300mm (12") MAX
300mm (12") MIN (TYP)
SECTION VIEW
TEE WITH GATE VALVES
DIP SPOOL (TYP)
BUTTERFLY VALVE (TYP)
ACTUATOR (TYP)
BEARING AREA "B" (TYP)
PLAN VIEW
BEARING AREA "A" (TYP)
GATE WELL (TYP) SEE WV-01 & WV-02
EDGE OF TRENCH (TYP)
MASONRY SUPPORT BLOCKS (TYP) WITH REDWOOD WEDGES AS REQUIRED
SECTION VIEW
300mm (12") MIN (TYP)
TEE WITH BUTTERFLY VALVES ON MAIN
DIP SPOOL (TYP)
BUTTERFLY VALVE (TYP)
600mm (24") MIN (TYP)
PLAN VIEW
GATE WELL (TYP) SEE WV-01 & WV-02
BUTTERFLY VALVE (TYP)
DIP SPOOL
SECTION VIEW
300mm (12") MIN (TYP)
TEE WITH BUTTERFLY VALVES
NOTES:
1) BEARING AREA "B" MUST BE EQUAL TO OR GREATER THAN THE AREA REQUIRED FOR A 90° ELBOW INSTALLATION
2) BUTTERFLY VALVES INSTALLED AT CROSSES OR TEES REQUIRE A FLANGED DUCTILE IRON SPOOL TO BE INSTALLED BETWEEN THE FITTING AND VALVE IN ACCORDANCE WITH SECTION 15056 OF THE SPECIFICATIONS
CONCRETE THRUST AND ANCHOR BLOCK INSTALLATIONS
WATER AGENCIES' STANDARDS
COMMITTEE APPROVAL: 01/26/2022
DRAWING NUMBER: WT-01C