DIPRA

1915

CIPRA

DIPRA Member Companies

AMERICAN CAST IRON PIPE COMPANY

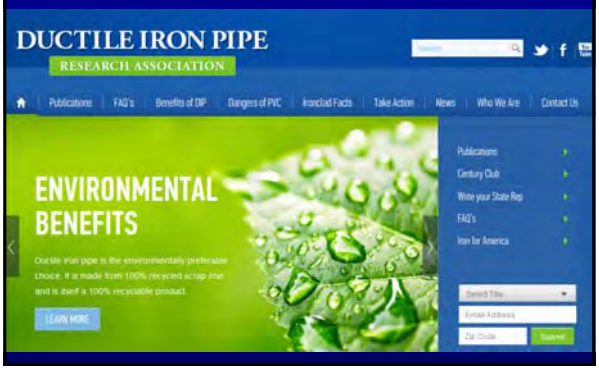
Canada Pipe Company Ltd.

U.S. PIPE

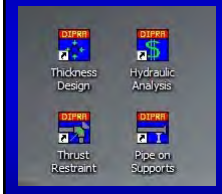
McWANE DUCTILE

GRIFFIN PIPE PRODUCTS CO.

DIPRA Website
(www.dipra.org)



DIPRA Computer Programs



- Thickness Design of Ductile Iron PIpe
- Hydraulic Analysis of Ductile Iron Pipe
- Thrust Restraint Design for Ductile Iron PIpe
- Design of Ductile Iron Pipe on Supports

AWWA Standards

ANSI/AWWA C104/A21.4	Cement-Mortar Linings
ANSI/AWWA C105/A21.5	Polyethylene Encasement
ANSI/AWWA C110/A21.10	Ductile-Iron and Gray-Iron Fittings
ANSI/AWWA C111/A21.11	Rubber-Gasket Joints
ANSI/AWWA C115/A21.15	Flanged Ductile-Iron Pipe
ANSI/AWWA C116/A21.16	Fusion-Bonded Epoxy Coatings for Fittings
ANSI/AWWA C150/A21.50	Thickness Design
ANSI/AWWA C151/A21.51	Ductile-Iron Pipe, Centrifugally Cast
ANSI/AWWA C153/A21.53	Ductile-Iron Compact Fittings
ANSI/AWWA C600	Installation of Ductile-Iron Water Mains
AWWA Manual M41	Ductile-Iron Pipe and Fittings

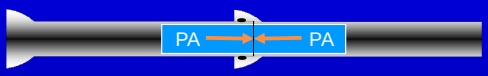
Restraining Thrust Forces

Forces Causing Thrust

- Static forces
  (Internal pressure)
- Dynamic forces
  (Fluid velocity)

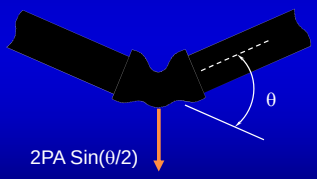
Thrust Force

Straight Run



Thrust Force

Bend



Resultant Thrust: 90° Bend

Pressure at 150 psi

Nominal Pipe Size (in)	Thrust Force (lbs)
6	7,932
12	29,030
24	110,901
36	244,396
48	429,956
64	718,506

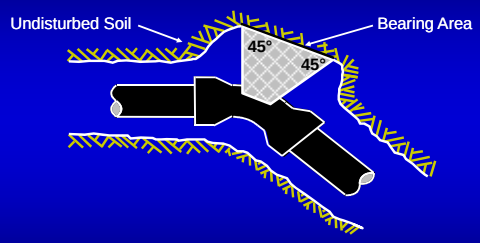
Restraining Techniques

- Thrust blocks
- Restrained joint system
- Tie rods
- Combined systems

Types of Thrust Blocks

- Bearing
- Gravity

Bearing Thrust Block

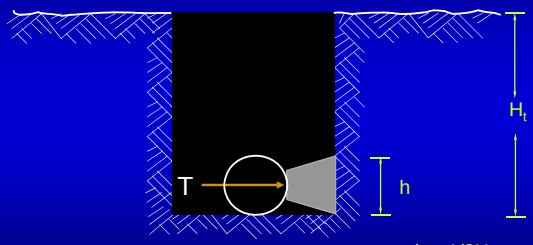


$$\text{Bearing Area (ft}^2\text{)} = \frac{\text{Safety Factor} \bullet \text{Thrust Force (lbs)}}{\text{Bearing Capacity of Undisturbed Soil (lbs/ft}^2\text{)}}$$

Soil Bearing Strength S_B

Soil	S_B (lb/ft^2)
Muck	0
Soft clay	1,000
Silt	1,500
Sandy silt	3,000
Sand	4,000
Sandy clay	6,000
Hard clay	9,000

Bearing Thrust Block

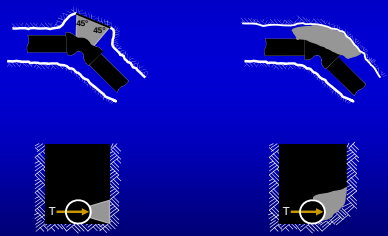


$h \le 1/2H_t$

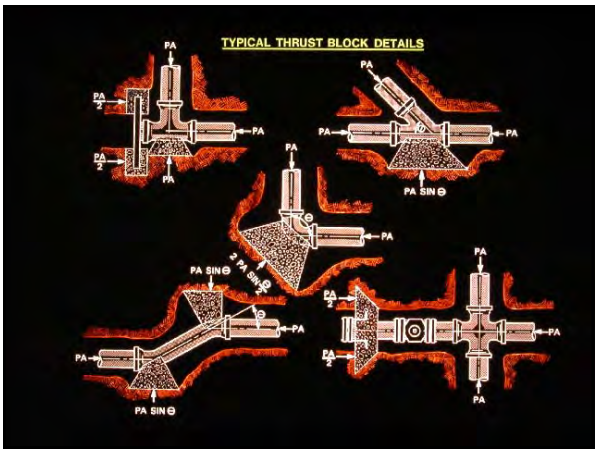
$$A = hb = \frac{T}{S_B}(S_f)$$

Bearing Block Construction

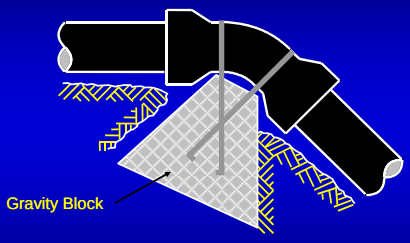
Right Wrong



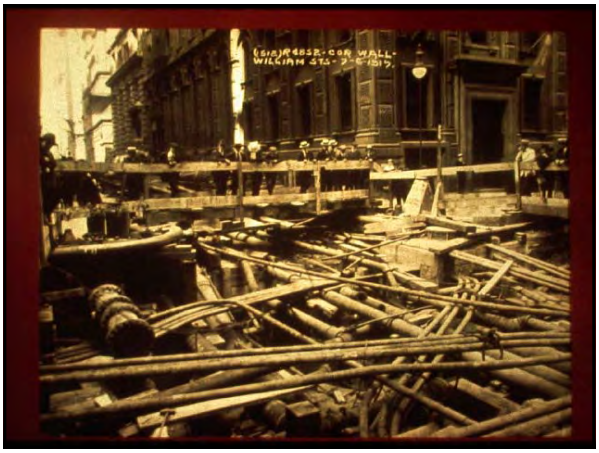
Thrust Restraint



Gravity Thrust Block

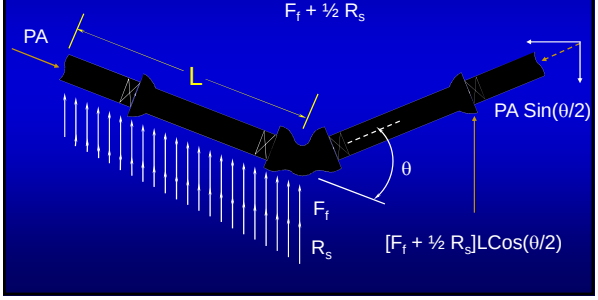


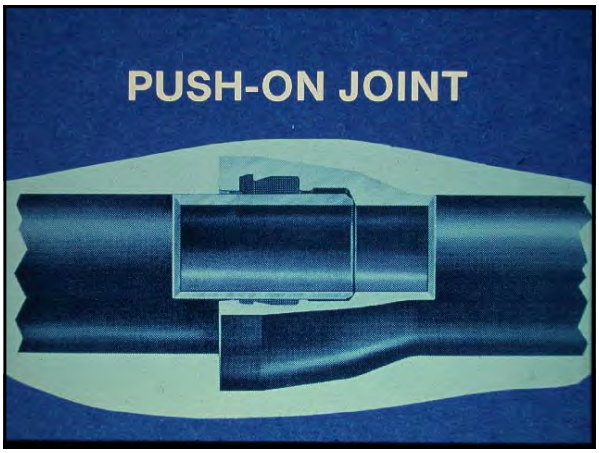
$$\text{Gravity Block Size (ft}^3\text{)} = \frac{\text{Safety Factor} \bullet \text{Thrust Force (lb)}}{\text{Density of Block Material (lb/ft}^3\text{)}}$$



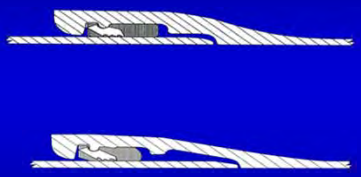
Restrained Joint Force System

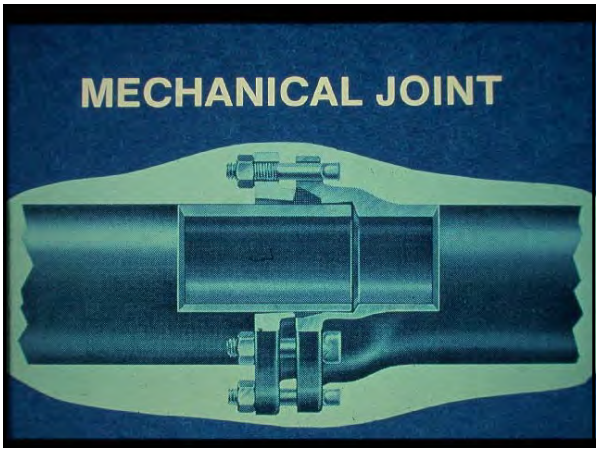
$$L = \frac{PA\ Tan(\theta/2)}{F_f + \frac{1}{2} R_s}$$





Restrained Joints



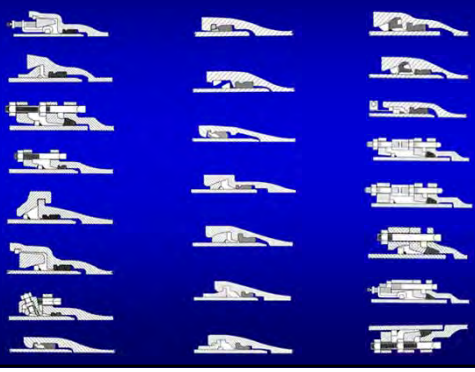


Mechanical Joint Retainer Glands

Set-Screw
Mechanical Joint
Retainer Gland

Wedge-action
Mechanical Joint
Retainer Gland

Restrained Joints



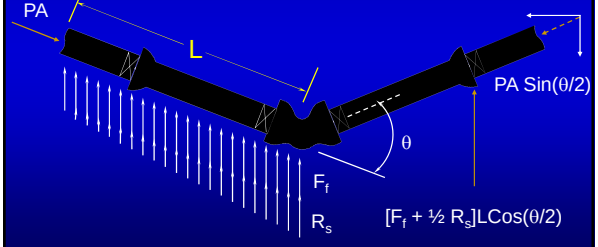
Designing Thrust Systems

Thrust Restraint Brochure

A brochure outlining design theory and a design aid of restrained joint systems for ductile iron pipe.

Restrained Joint Force System

$$L = \frac{PA\ Tan(\theta/2)}{F_f + \frac{1}{2} R_s}$$



Restrained Length Dependant Upon

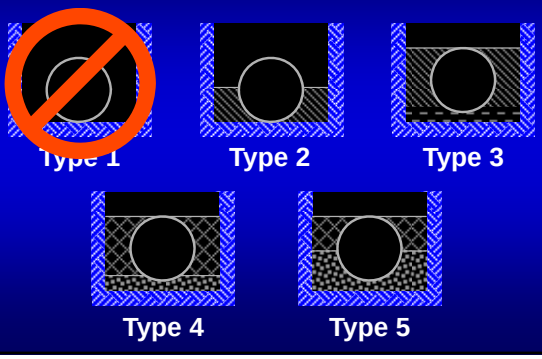
- Pipe size
- Type of fitting
- Internal pressure
- Depth of cover
- Soil characteristics
- Laying conditions

Suggested Values for Soil Properties and Reduction Constant

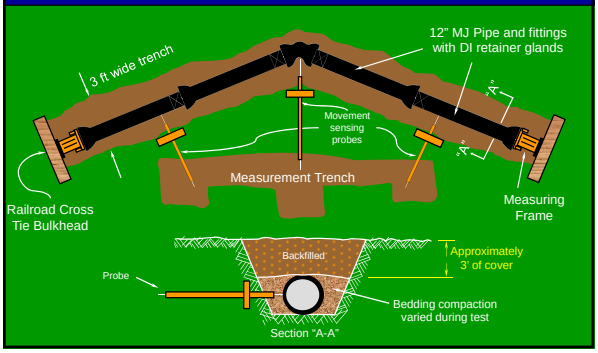
Soil Designation	Soil Description	ϕ (deg)	f_ϕ	C_s (psf)	f_c	γ (deg)	K_n A21.50 Laying Condition 2*	3	4	5
Clay 1	Clay of medium to low plasticity, LL<50, <25% coarse particles [CL & CL-ML]	0	0	300	.50 .80	90	.20	.40	.60	.85
Coh-gran	Cohesive granular soils, > 50% coarse particles [GC & SC]	20	.40 .65	200	.40	90	.40	.60	.85	1.0
Sand Silt	Sand or gravel w/silt, > 50% coarse particles [GM & SM]	30	.50 .75	0	0	90	.40	.60	.85	1.0
Good Sand	Clean sand, >95% coarse particles, [SW & SP]	36	.75 .80	0	0	100	.40	.60	.85	1.0

Consult Table 3 of thrust brochure for pertinent notes.

Laying Conditions



Thrust Restraint - Research



Designing Thrust Systems

Thrust Restraint Computer Program

A computer program to aid in the design of restrained joint systems for ductile iron pipe.

Table B-5

Soil Type: Coh-gran
Soil Parameters

ϕ = 20 degrees
C_u = 200 psf
γ = 90 pcf

A21.50 – Laying Conditions

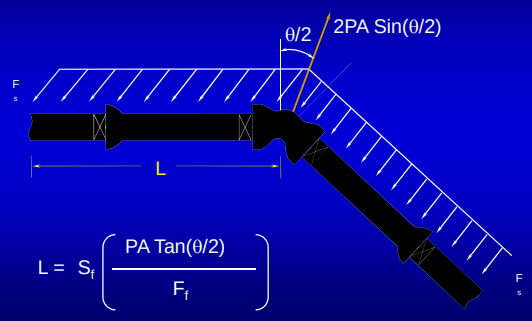
	2	3	4	5
f_s	0.40	0.65	0.65	0.65
f_c	0.40	0.40	0.40	0.40
K_u	0.40	0.60	0.80	1.00

Size (in)	Depth (ft)	A21.50 – Laying Conditions 2 Restrained Length (ft)	3 Restrained Length (ft)	4 Restrained Length (ft)	5 Restrained Length (ft)
30	2.5	97 (112)	69 (79)	56 (62)	50 (55)
30	3.0	91 (105)	65 (74)	52 (58)	47 (51)
30	4.0	81 (93)	57 (65)	46 (51)	41 (45)
30	6.0	66 (76)	46 (52)	37 (41)	33 (36)
30	8.0	56 (64)	38 (44)	31 (34)	28 (30)
30	10.0	48 (56)	33 (38)	26 (30)	24 (26)

Horizontal Bend Multiplier

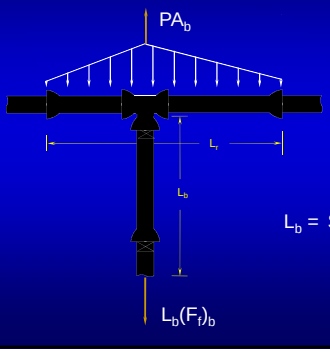
θ	Tan(θ/2)
90°	1.000
45°	0.414
22½°	0.199
11¼°	0.098

Vertical Down Bend



$$L = S_f \left(\frac{PA \tan(\theta/2)}{F_f} \right)$$

Tee

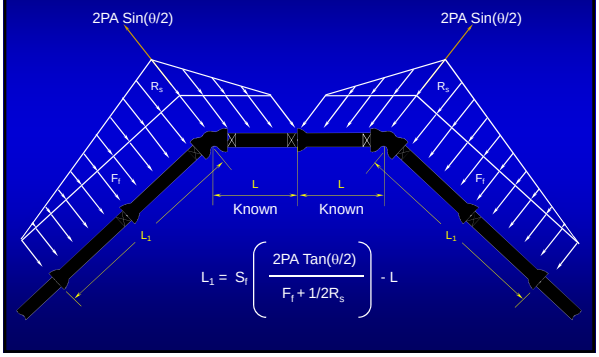


$$L_b = S_f \left(\frac{PA_b - 1/2\ R_s L_r}{(F_f)_b} \right)$$

Extend Restrained Joints at:

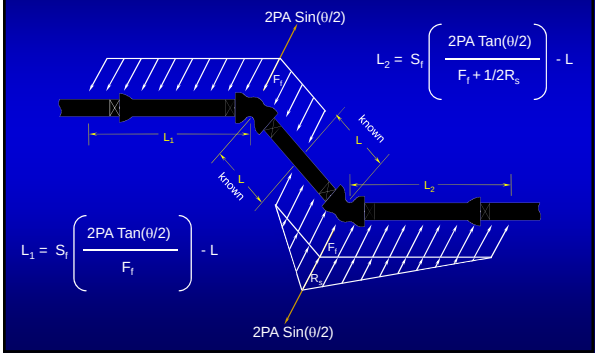
- Casings
- Bridge crossings
- Aboveground applications
- Poor soil conditions
- Closely located fittings

Combined Horizontal Bends

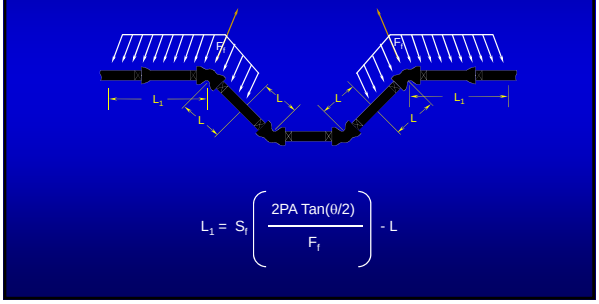


$$L_1 = S_f \left(\frac{2PA \tan(\theta/2)}{F_f + 1/2R_s} \right) - L$$

Vertical Offset

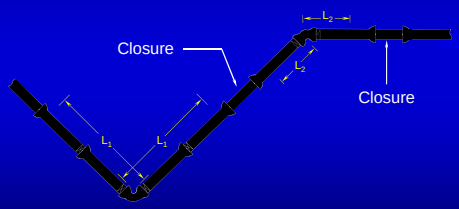


Combined Vertical Equal Angle Offsets

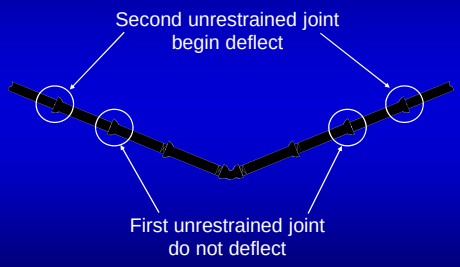


$$L_1 = S_f \left(\frac{2PA \tan(\theta/2)}{F_f} \right) - L$$

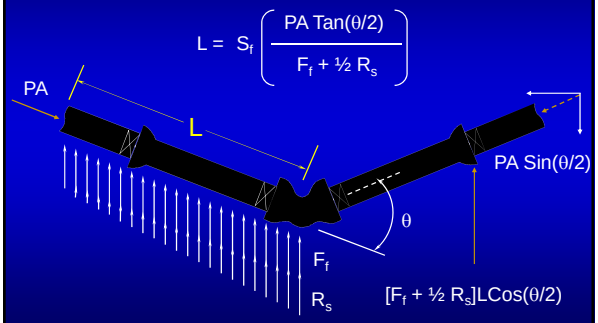
Thrust Restraint - Closures



Thrust Restraint – Deflected Joints



Horizontal Bend / Vertical Up Bend



Tie Rods

Calculating Number of Tie Rods

$$F = SA$$

$$N = \frac{S_f T_{(X \text{ or } Y)}}{F}$$

Where:

F = Force Developed per Rod (lbs.)

S = Tensile Strength of Rod Material (psi)

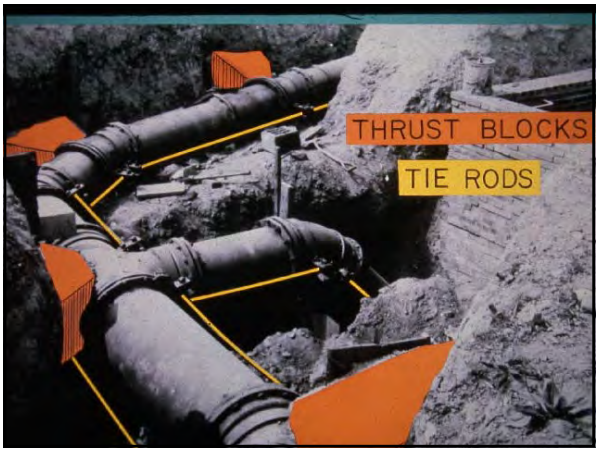
A = Cross Sectional Area of Rod ($in.^2$)

N = Number of Rods Required

$T_{(X \text{ or } Y)}$ = Thrust Force Component (lbs.)

S_f = Safety Factor (usually 1.5)

Combined Systems



Installation

DUCTILE IRON PIPE
THE RIGHT DECISION