Pipeline Design Considerations to Increase Seismic Resilience for Ductile Iron Pipe Applications

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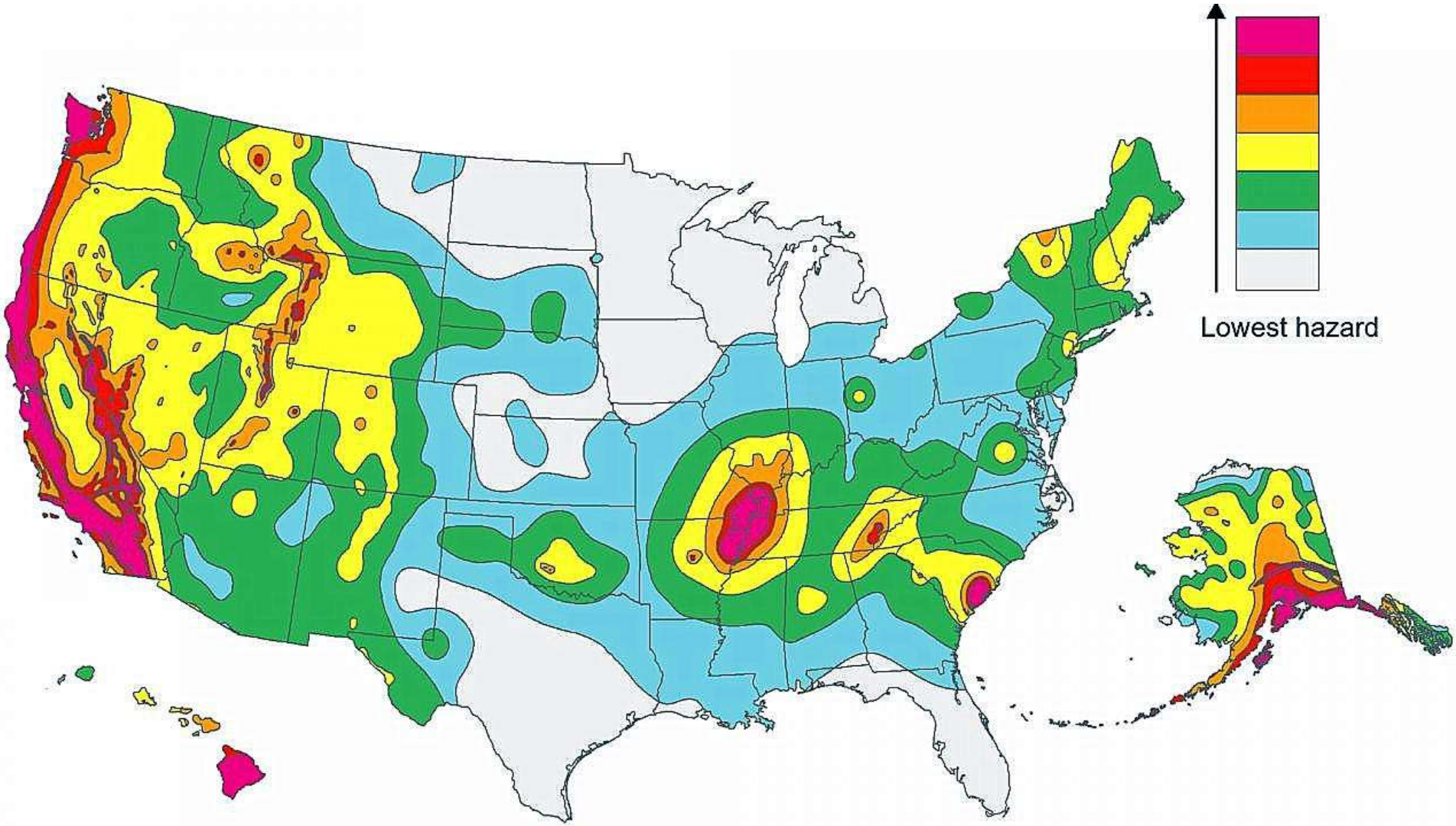
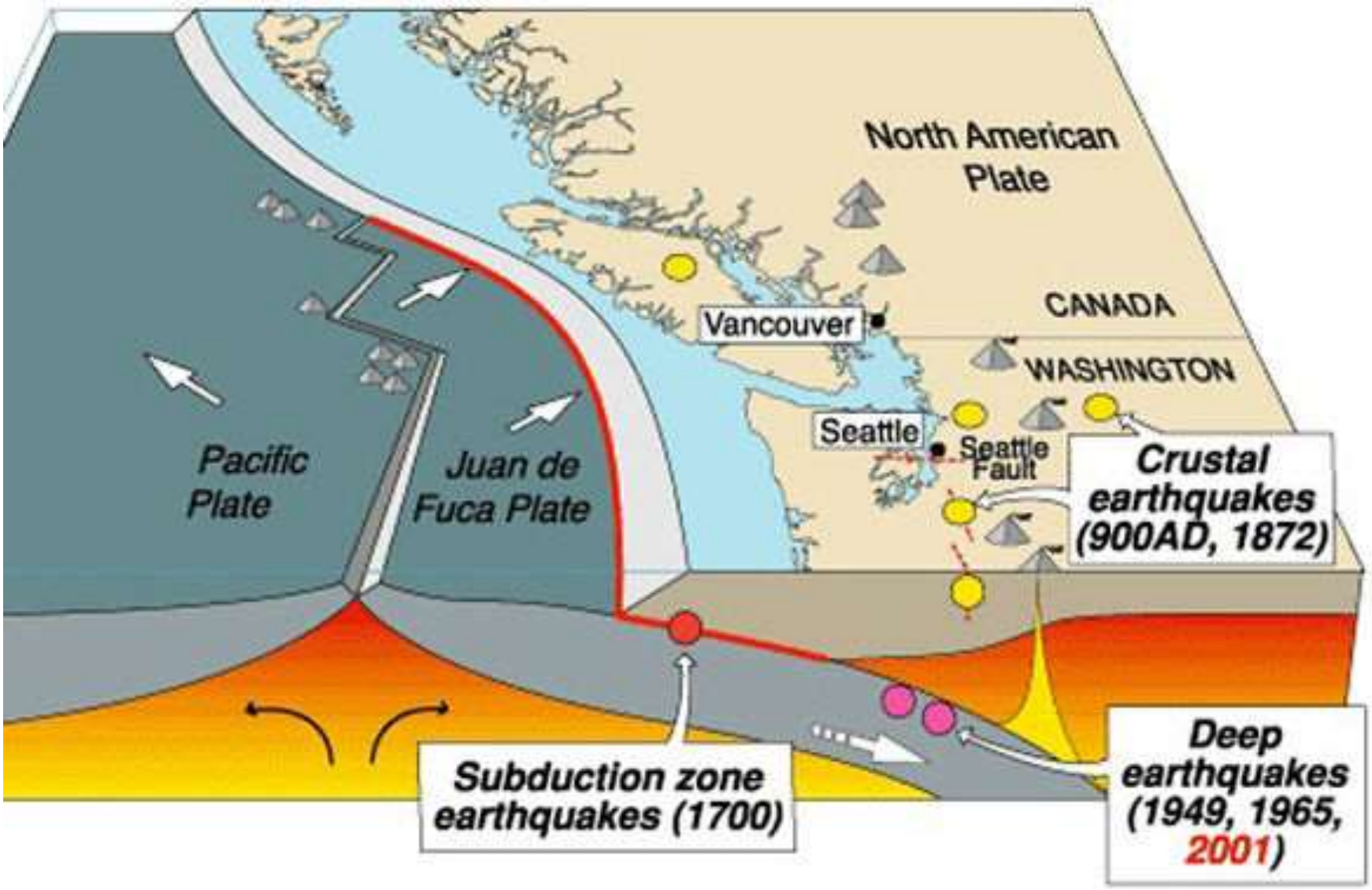
McWane Ductile

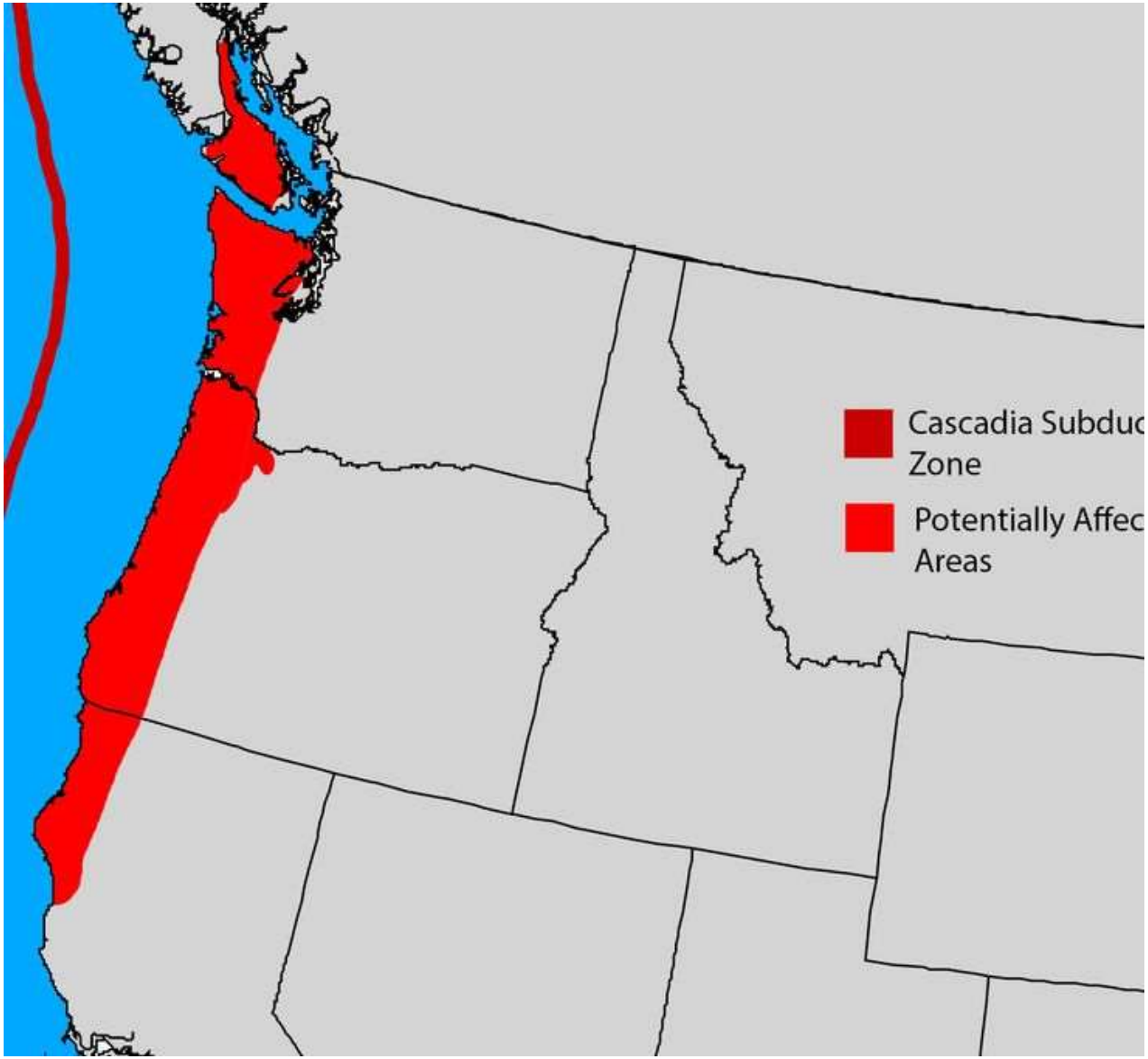
Seismic Potential



Seismic Potential



Seismic Potential



SEISMIC DESIGN CONSIDERATIONS

When designing to prevent pipe lines from damage due to seismic hazards there are many effects to consider:

- **Seismic Wave Ground Displacement**
- **Liquefaction**
- **Permanent Ground Deformation**
- **Surface Crack**
- **Ground Subsidence etc.**

Ductile Iron pipelines are naturally resistant to damage in earthquake prone areas due to its inherent strength and flexible joints. This inherent ability can **be significantly augmented** with the installation of a Seismic Coupling to further improve the lines ability to withstand significant ground displacements.

Additional areas that would benefit from additional protection are:

- **Soft or disturbed earth**
- **Reclaimed ground**
- **Slopping grounds**
- **Near revetments**
- **Areas prone to seismic events**

Seismic Pipe Performance Parameters

- **Ruggedness**
- **Resistance to Bending**
- **Joint Flexibility**
- **Joint Restraint**

FOR NEW or RETRO-FIT PIPELINE APPLICATIONS

Types of Seismic Hazards

Hazard Category	Subcategory/Description	
A. Ground Shaking	Transient ground motions	
B. Permanent Ground Deformation	1. Liquefaction	a. Settlement
		b. Lateral Spreading
	2. Soft or weak soils below pipe	
	3. Seismically induced landslides	
	4. Abrupt Offsets	a. Differential Movement
		b. Soil Transitions
		c. Fault Ruptures
C. Nearby infrastructure by others designed to lessor standards		
D. Other applicable hazards		

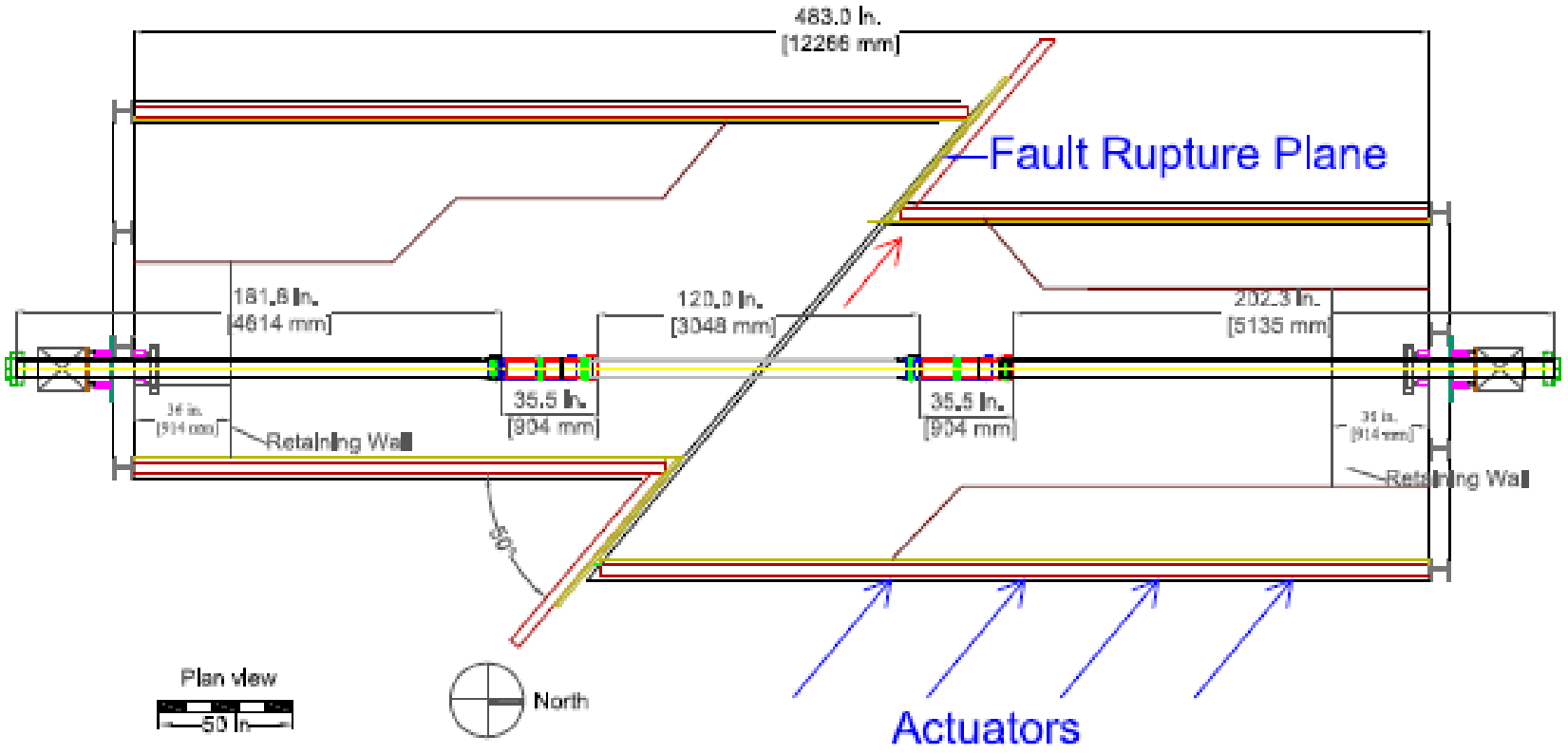
ISO 16134 REQUIREMENT SUMMARY

Parameter	Class	Component performance
Expansion/contraction performance	**S-1**	**± 1 % of L or more**
	S-2	± 0,5 % to less than ± 1 % of L
	S-3	Less than ± 0,5 % of L
Slip-out resistance	**A**	**3 d kN or more**
	B	1,5 kN to less than 3 kN
	C	0,75 kN to less than 1,5 kN
	D	less than 0,75 d kN
Joint deflection angle	M-1	± 15° or more
	M-2	**± 7,5° to < 15°**
	M-3	Less than ± 7,5°

L is the component length, in millimeters (mm), d is the nominal diameter of pipe, in millimeters (mm)

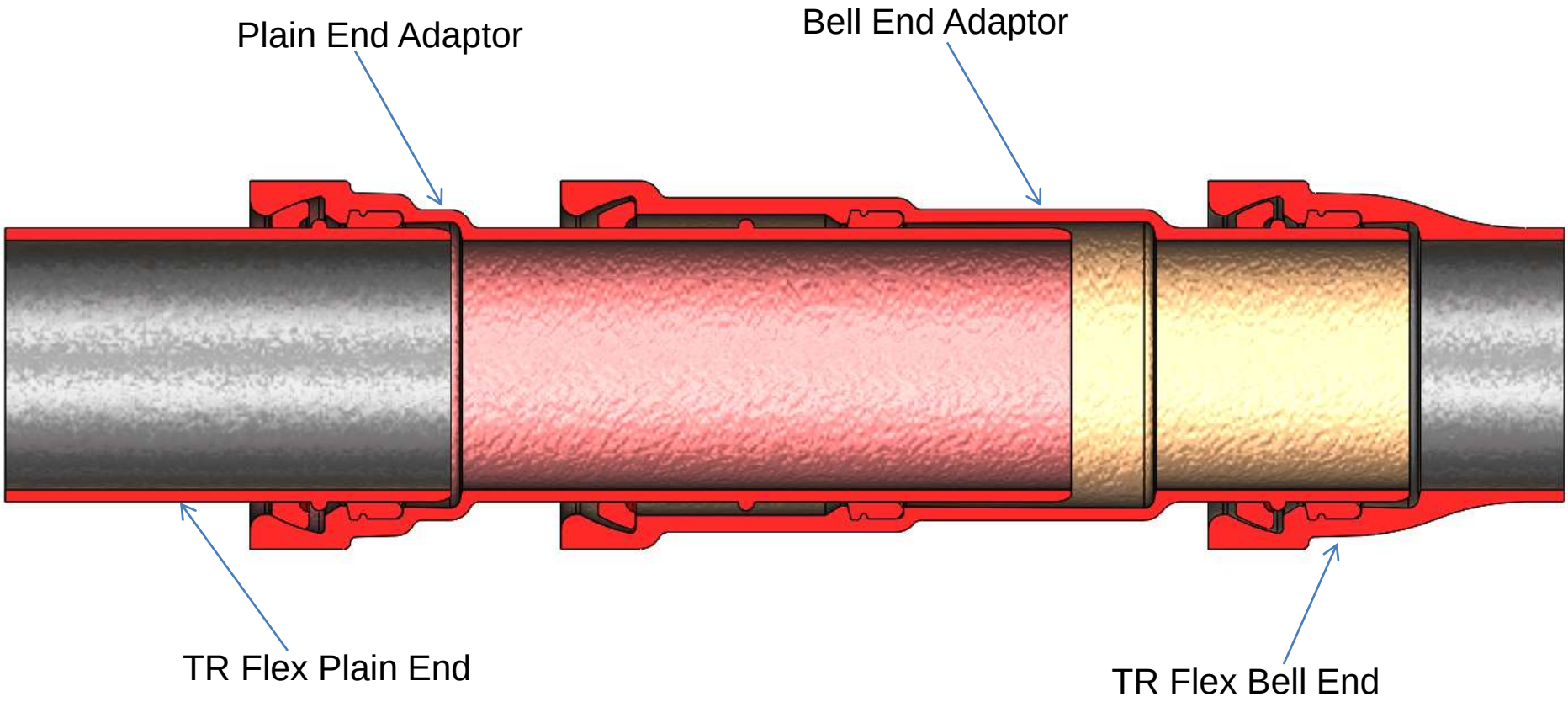
Load condition	Criterion	
Load in earthquake motion and normal load	Pipe body stress	≤ Allowable stress (proof stress) of ductile iron pipe
	Expansion/contraction value of joint	≤ Allowable expansion/contraction value of ductile iron pipe joint
	Deflection angle of joint	≤ Allowable deflection angle of ductile iron pipe joint

Option 2: 3 Pipe Segments with 2 SFCs



CORNELL UNIVERSITY

SEISMIC COUPLING

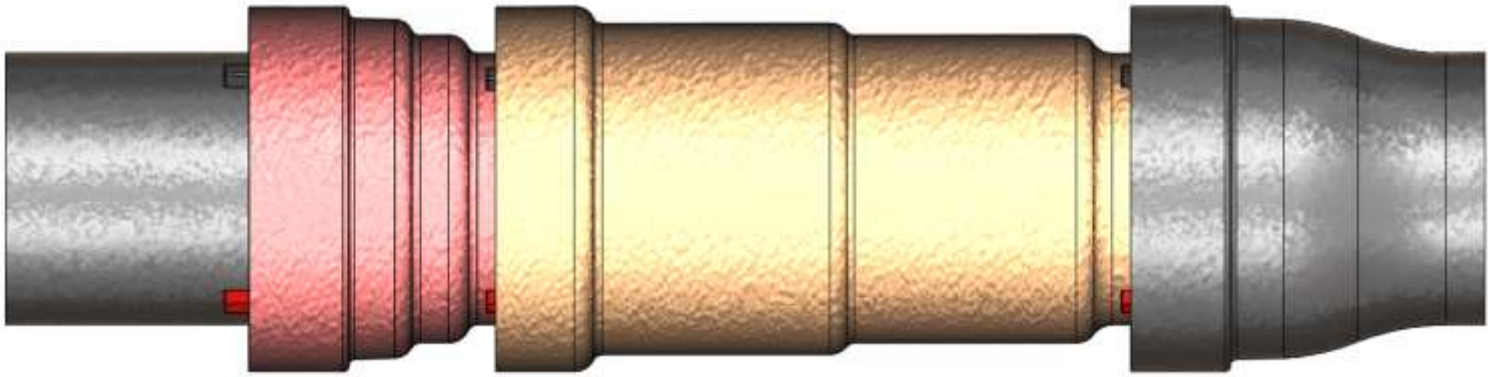


SEISMIC COUPLING

How the system works

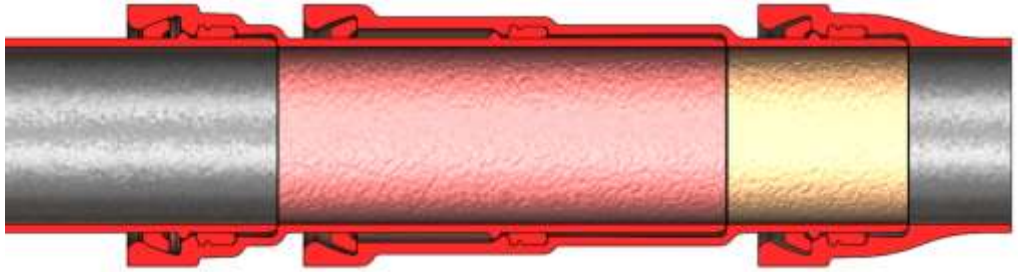
The Seismic Coupling system consists of two adaptors (Extreme Bell End and Extreme Plain End), Locking segments and Gasket. The Plain End Adaptor has a regular TR Flex bell profile at one end and extreme plain end feature at the other end. The Bell End Adaptor has regular plain end feature at one end and extreme bell end at another end.

The assembled Seismic Coupling has regular TR Flex bell at one end and TR Flex plain end at another end for easy integration into any new or existing TR Flex pipeline.

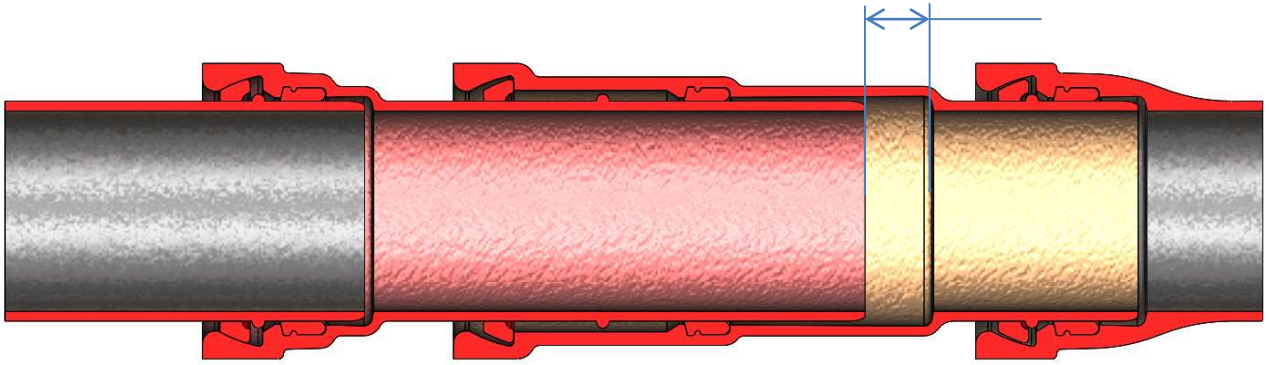


FULLY COLLAPSED VIEW

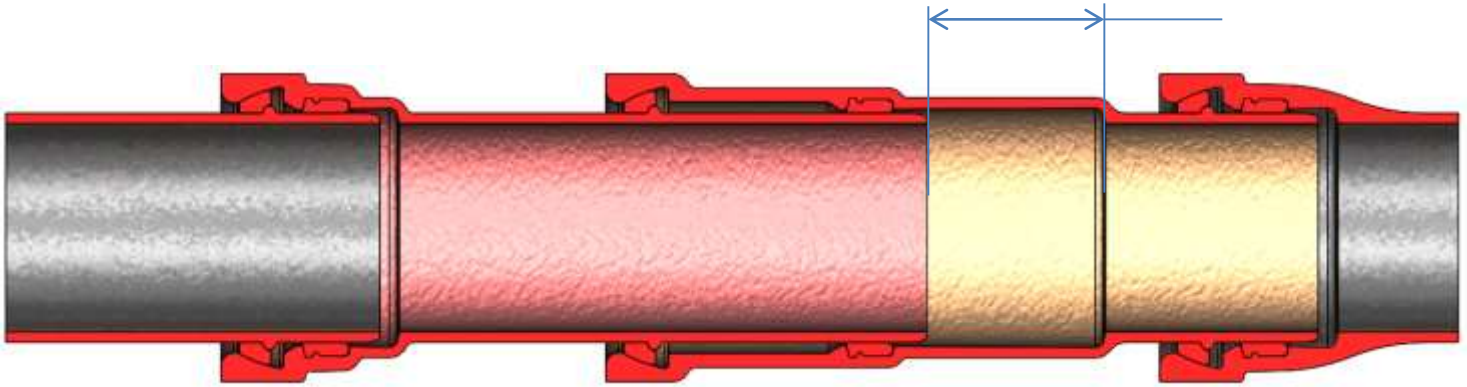
EXPANSION & CONTRACTION – Current Design



FULLY COLLAPSED VIEW

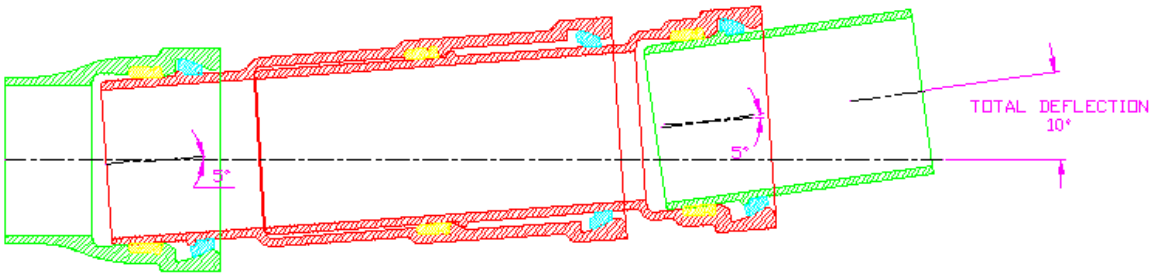


MID POSITION – Recommended Installation Position **± 5.25”**

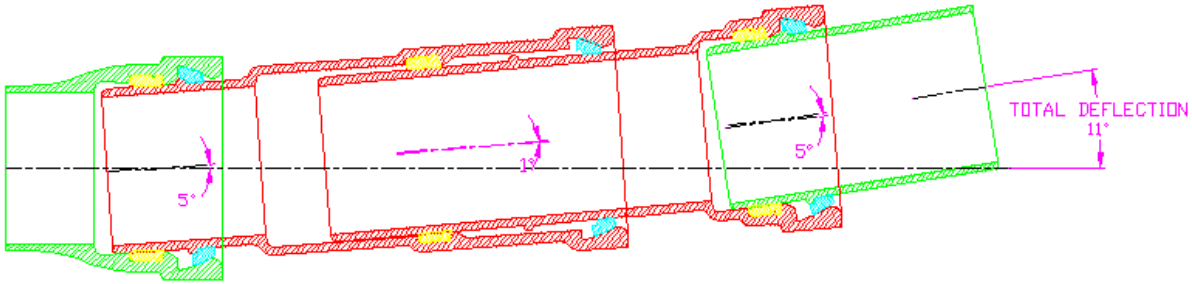


FULLY EXTENDED VIEW **10.50”**

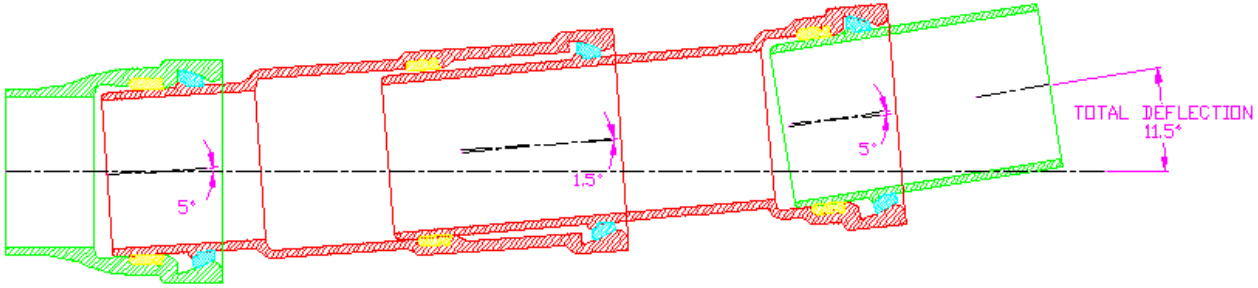
DEFLECTION 4” to 12”



FULLY COLLAPSED VIEW

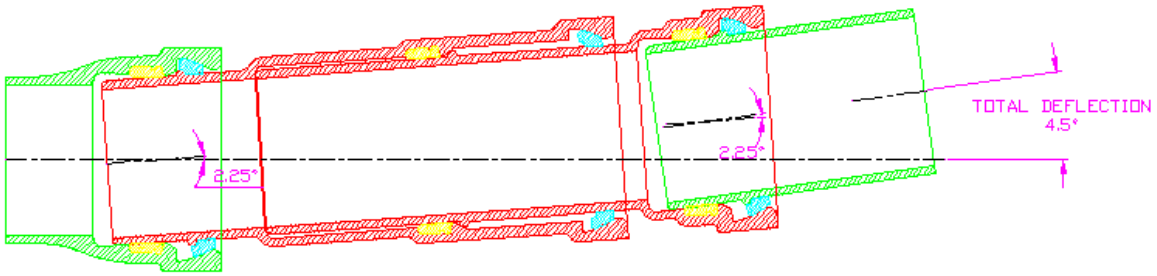


MID POSITION

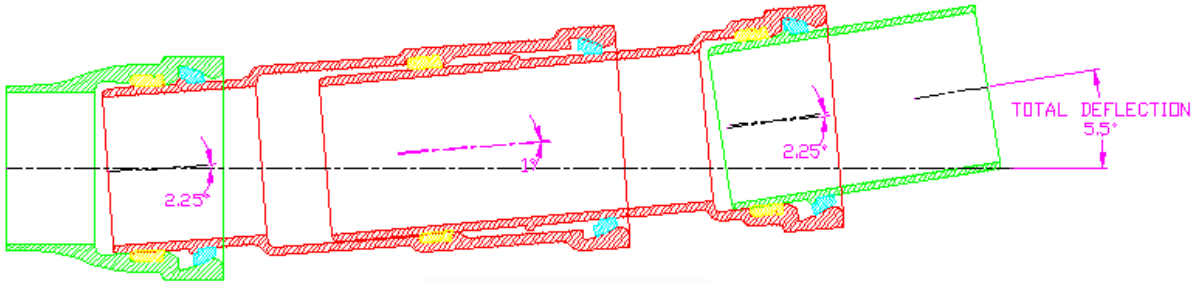


FULLY EXTENDED VIEW

DEFLECTION 24”



FULLY COLLAPSED VIEW



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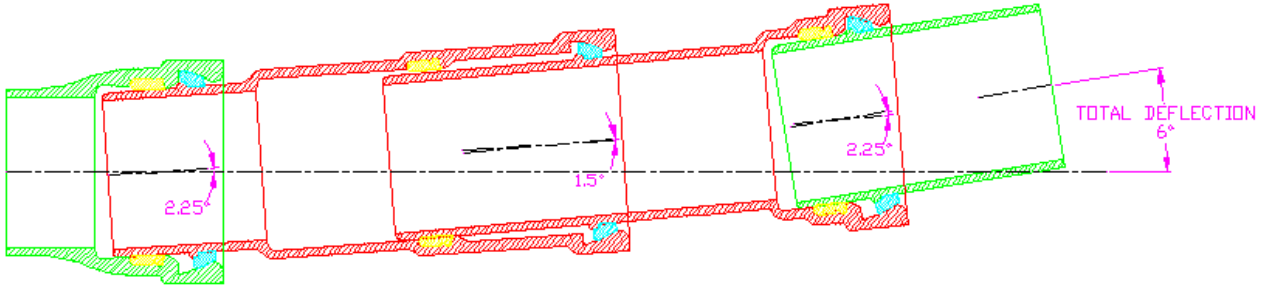
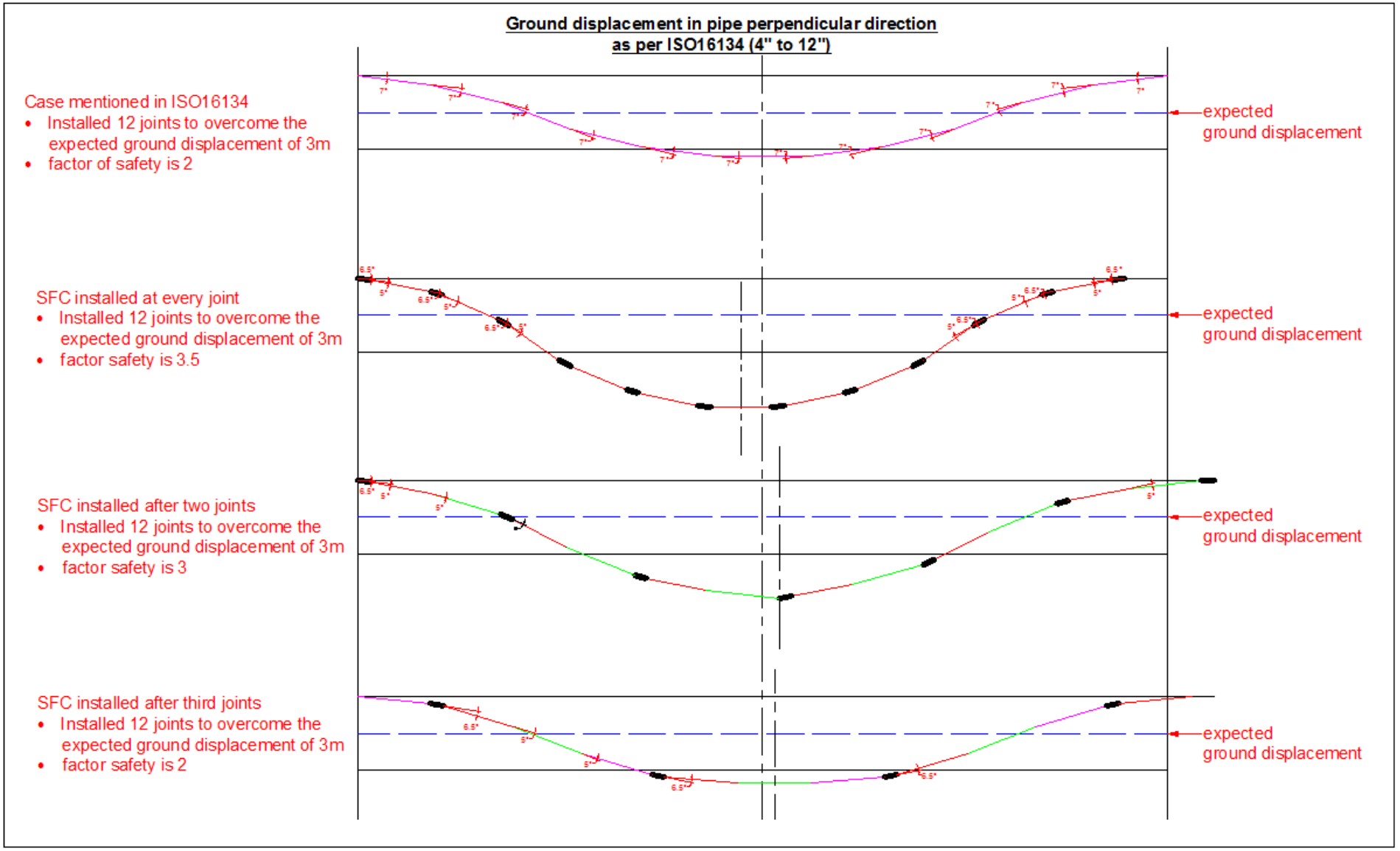


FULLY EXTENDED VIEW

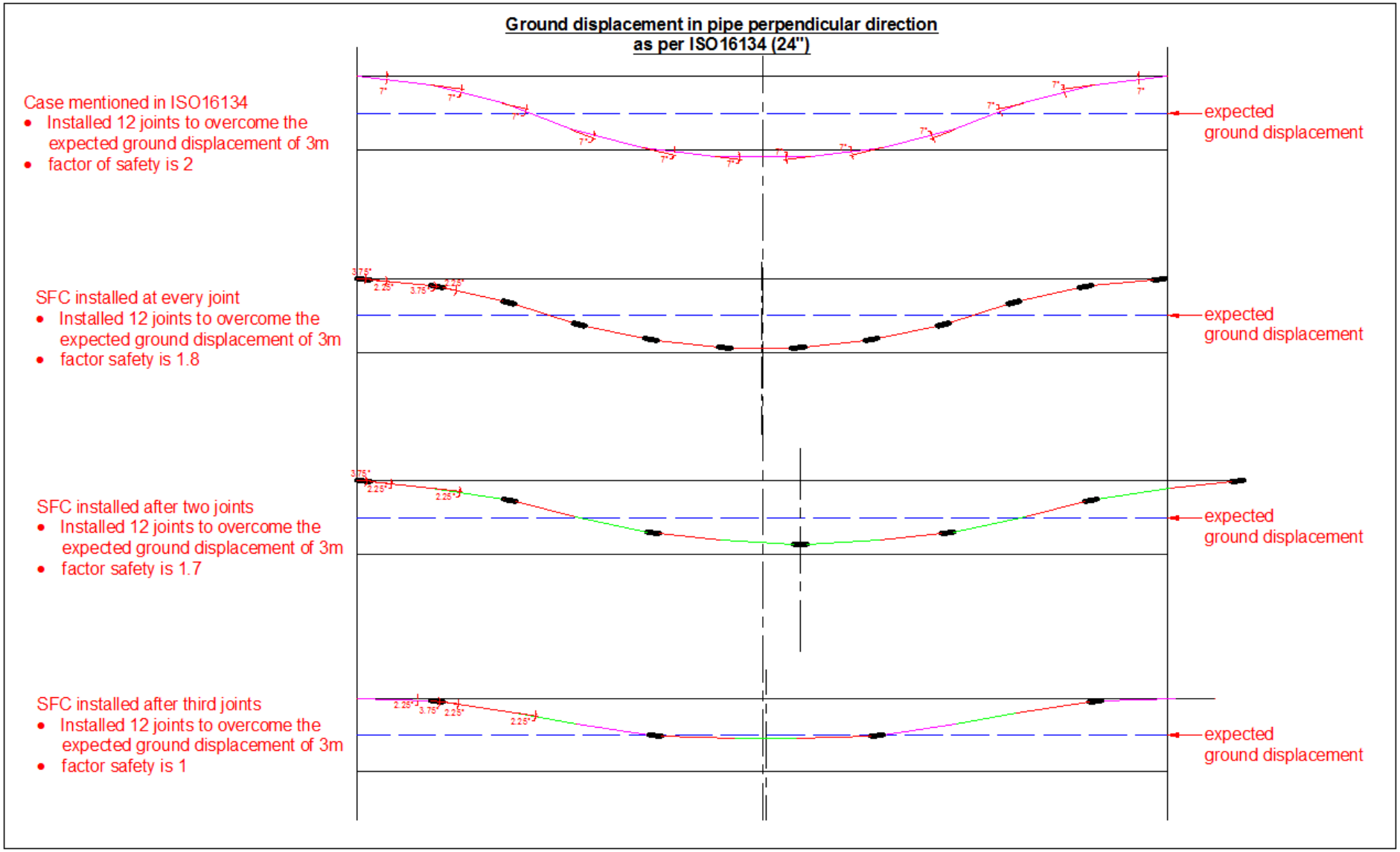
SEISMIC FLEX COUPLING

Description	AT EVERY JOINT	AT EVERY 2nd JOINT	AT EVERY 3rd JOINT
Number of Couplings used	12	7	4
Expansion / Contraction of a coupling	±5.25	±10.5	±15.75
Total length of a coupling(b/w pipes) inch	33.13	47.87	57.97
Weight of single coupling (lb)	103	155	190
Total weight of couplings (lb)	1236	1085	760

4-12” Case Study of SFC on Ground Displacement



24” - Case Study of SFC on Ground



International Standard – ISO 16134
Improved Laying Conditions

3.2.1 General

To increase the resistance of ductile iron pipeline to seismic hazards, the following qualitative design measures should be taken into consideration.

a) Provide pipelines with expansion/contraction and deflection capability.
   EXAMPLE Use of shorter pipe segments, special joints or sleeves and anti-slip-out mechanisms according to the anticipated intensity or nature of the earthquake.
b) Lay pipelines in a firm foundation.
c) Use smooth back fill materials.
   NOTE Polyethylene sleeves and special coatings are also effective cases.
d) Install more valves.

Advantages

- ***Has an Expansion / Contraction capability of MORE than one percent of pipe length – exceeds the standards set by ISO 16134***
- ***Has a cumulative deflection up to 11.5deg***
- ***Being a self contained coupling it can be installed in any existing or new TR-Flex pipe line installation***
- ***Easy Installation, requires no special tools or practices***
- ***McWane's seismic coupling comes preassembled, only insertion into the line is required by the installer***
- ***Less expensive by design since it is a stand alone coupling, it may be used where necessary, not necessarily at every joint***

SEISMIC FLEX COUPLING ASSEMBLY WITH LAND SUBSIDENCE