ASCE Manual and Reports on Engineering Practice No. 79

Steel Penstocks

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MOP 79 Steel Penstocks
Current Status

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Design Considerations

Table 3-1 Load Combinations for Service Conditions

LOAD	NORMAL 1	NORMAL 2	NORMAL 3	INTERMITTENT 1	2	3	4	5	6	7	8	9	10	11	EMERGENCY 1	2	3	EXCEPTIONAL 1	2	CONSTRUCTION 1	HYDROTEST 1
P_{N1}	•			•															•		
P_{N2}		•			•	•															
P_{N3}			•					•													
P_{I1}									•	•											
P_{I2}											•	•									
P_{I3}													•	•							
P_{EM1}															•	•	•				
P_{EX1}																		•			
P_{T1}																					•
DL1	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
DL2	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•
DL3	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
DL4													•	•						•	
DL5	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
LL1					•		•		•		•		•			•				•	
LL2	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		
LL3	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		
EQ1				•		•		•		•		•		•						•	
EQ2																			•		
DS1															•						
TL1	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
TL2													•	•							
EJL	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•
SFL	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•
P_{C1}																				•	
P_{C2}																				•	
P_{C3}																				•	

Table 3-2 SI Classifications for Typical Parts Found in Penstocks and Tunnel Liners

CASE	SI CATEGORY
RING GIRDER SUPPORTS AND STIFFENER RINGS	
RIM BENDING	Q
LOCAL MEMBRANE HOOP STRESS IN THE PENSTOCK IN THE CIRCUMFERENTIAL DIRECTION	P_L
BENDING STRESSES IN RING GIRDER AND/OR STIFFENERS ACTING ACROSS THE DEPTH OF THE GIRDER	P_m
BENDING + AXIAL SI IN RING	P_m
RIM BENDING IN THE PENSTOCK SHELL PLUS DIRECT/AXIAL LOAD	$(Q+P_m)$
SADDLES (PENSTOCK SHELL IMMEDIATELY ABOVE HORN OF SADDLE)	
HORN BENDING	Q
HORN HOOP MEMBRANE LOAD	P_L
SHEAR IN SHELL ADJACENT TO HORN	0.6S
BEARING OR COMPRESSION FROM BEARING LOADS	P_m
BENDING IN BASE PLATES AND SADDLE PLATES ACROSS THICKNESS OF ELEMENT	P_b
LOADED ATTACHMENTS AND NOZZLES	
MEMBRANE SI IN SHELL OF PENSTOCK DUE TO THE LOADS	P_L
BENDING SI IN SHELL OF PENSTOCK DUE TO THE LOADS	Q
NOZZLE NECKS	
NOZZLE NECKS OUTSIDE LIMITS OF REINFORCEMENT FROM EXTERNAL LOADS AND MOMENTS, AND PRESSURE	P_L
NOZZLE NECKS WITHIN LIMITS OF REINFORCEMENT FROM EXTERNAL LOADS AND MOMENTS, AND PRESSURE	P_m
BIFURCATIONS	
MEMBRANE STRESS INTENSITY AWAY FROM REINFORCING GIRDERS AND AWAY FROM CHANGES IN DIRECTION	P_m
MEMBRANE STRESS INTENSITY ADJACENT TO REINFORCING GIRDERS AND CHANGES IN DIRECTION	P_L
BENDING STRESS ACROSS THICKNESS OF SHELL	Q
MAXIMUM STRESS INTENSITY IN REINFORCING GIRDERS	$P_b + P_L$
MISCELLANEOUS	
MEMBRANE HOOP STRESS FROM INTERNAL PRESSURE IN CYLINDRICAL AND CONICAL PENSTOCK SECTIONS AND FOR FORMED SHELLS AWAY FROM DISCONTINUITIES	P_m
MEMBRANE SI IN THE VICINITY OF ATTACHMENTS UNDER LOAD, HORN AREA OF SADDLE SUPPORTS, CONICAL-TO-CYLINDRICAL INTERSECTIONS, AND PENSTOCK SHELLS ADJACENT TO NOZZLES	P_L
BENDING SI IN FLAT HEADS AND COVERS	P_b
TEMPERATURE SI	Q

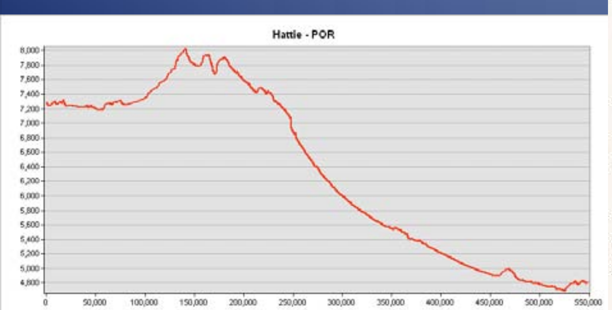


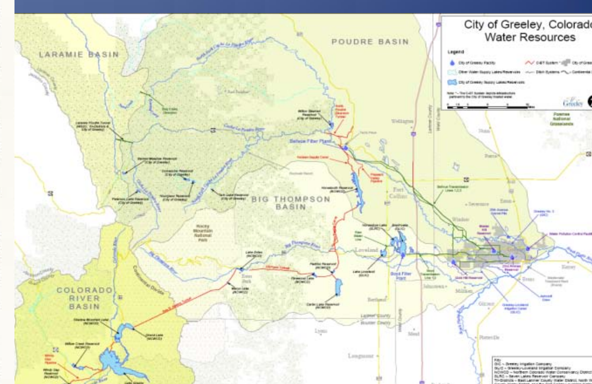
Table 3-3 Weld Joint Reduction Factors

Exposed Penstocks and Tunnel Liners

CATEGORY	TYPE	100% RT or UT	SPOT RT[1]	NO RT OR UT[2]
LONGITUDINAL BUTT WELDS CIRCUMFERENTIAL BUTT WELDS SPIRAL (HELICAL) BUTT WELDS	DOUBLE-WELDED BUTT JOINTS	1.00	.85	.70
	SINGLE-WELDED BUTT JOINTS WITH BACKING STRIPS	.90	.80	.65
	SINGLE-WELDED BUTT JOINT WITHOUT BACKING STRIPS (CIRCUMFERENTIAL ONLY, ≤5/8 in. THICK AND ≤24 in. O.D.[4])	NA[3]	NA	.60
DOUBLE FULL-FILLET LAP	LONGITUDINAL t_{max} = 3/8 in.	NA	NA	.55
	CIRCUMFERENTIAL t_{max} = 5/8 in.	NA	NA	.55
SINGLE FULL-FILLET LAP JOINTS WITH PLUG WELDS	CIRCUMFERENTIAL ONLY, FOR ≤24 in. O.D. t_{max} = 1/2 in.	NA	NA	.50

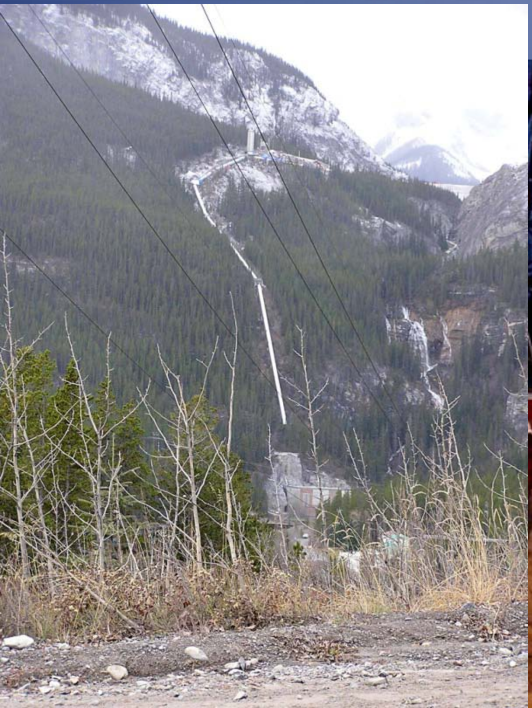
Buried Penstocks

CATEGORY	TYPE	100% RT OR UT	SPOT RT[1]	NO RT OR UT[2]
LONGITUDINAL BUTT WELDS CIRCUMFERENTIAL BUTT WELDS SPIRAL (HELICAL) BUTT WELDS	DOUBLE-WELDED BUTT JOINTS	1.00	.85	.70
	SINGLE-WELDED BUTT JOINTS WITH BACKING STRIPS	.90	.80	.65
	SINGLE-WELDED BUTT JOINTS WITHOUT BACKING STRIPS (CIRCUMFERENTIAL ONLY, ≤5/8 in. THICK AND ≤24 in. O.D.)	NA	NA	.60
DOUBLE FULL-FILLET LAP	LONGITUDINAL tmax = 3/8 in.	NA	NA	.55
	CIRCUMFERENTIAL t_{max} = 5/8 in.	NA	NA	.55
SINGLE FULL-FILLET LAP JOINTS WITH PLUG WELDS	CIRCUMFERENTIAL ONLY, FOR ≤ 24 in. O.D. t_{max} = 5/8 in.	NA	NA	.50
BELL-AND-SPIGOT JOINTS	SINGLE FILLET LIMITED TO t_{max} = 5/8 in.	NA	NA	.45
	DOUBLE FILLET t_{max} = 5/8 in.	NA	NA	.55



Intended Use of MOP 79

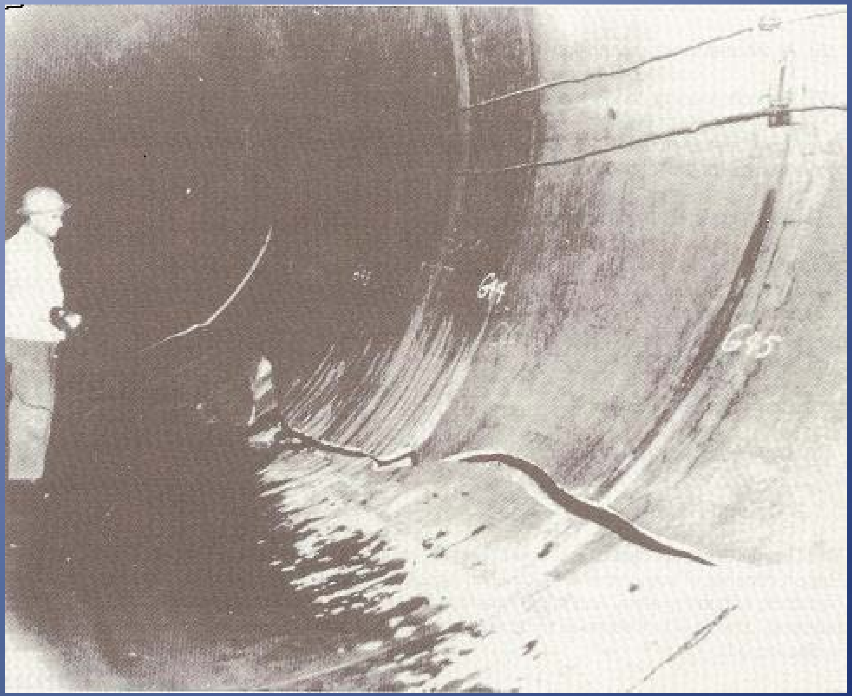
A Penstock is defined in MOP 79 as a pressurized, closed water conduit located between the first free water surface and a hydroelectric power/pump station.



Risk Assessment

- Chapter 16 -Maintenance

  An estimate of the potential risks associated with penstock failure mechanisms must be developed. This type of assessment is site dependant and must include, but not be limited to, estimating potential failure modes, assessing the probability or likelihood of such an event, and assessing the potential for loss of life and damage associated with each identified failure mode.



Engineering VS Operation

- Safety
- Operating efficiency
- Cost
- Installation restraints
- Repair and maintenance
- Environmental concerns