PIANC Workshop
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Innovation in Lock Filling and Emptying Systems

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PIANC
Setting the course

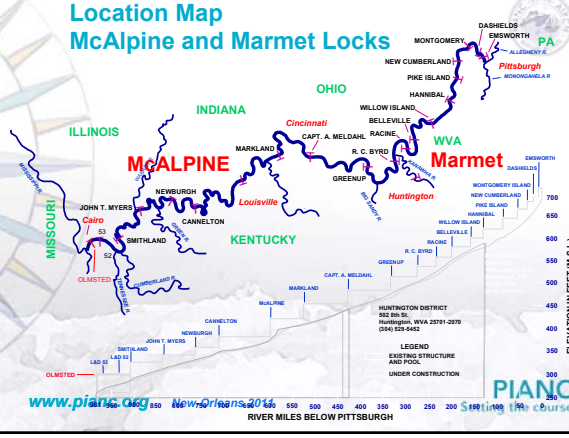
Background

- New lock designs are being considered to save construction, and operation and maintenance costs
- 2 newest locks have used innovative designs
  - New McAlpine Lock, Ohio River
    (11.3m, 37' lift)
  - New Marmet Lock, Kanawha River
    (7.3m, 24' lift)

In-Chamber Longitudinal Culvert System (ILCS)

- ILCS design was briefly mentioned at the last PIANC workshop by Mr. Jerry Webb (Paper 5, Part A)
- Today's presentation will
  - Provide details of ILCS design
  - Describe project features found on Marmet and McAlpine ILCS Locks

Location Map McAlpine and Marmet Locks

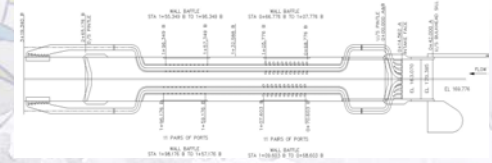


Planned Marmet Lock

Completed Marmet Lock

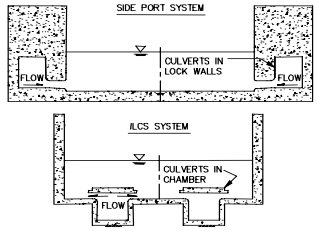
ILCS Design Philosophy

- Develop a system nearly as efficient as the side-port filling and emptying system
- Culverts in the chamber walls are replaced by culverts in the chamber floor



Marmet Lock

ILCS Offers Potential Cost Savings in Wall Construction



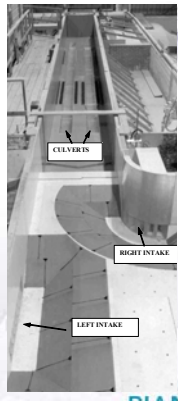
Culvert Locations for the Side-Port and ILCS Filling and Emptying Systems

Side-Port System

In-Chamber Longitudinal Culvert System

Intake Manifolds McAlpine Lock

Layout Fit Existing Conditions



Intake Manifolds Marmet Lock

Through-the-Sill Design Reduced Cofferdam Size

Hydraulic Efficiency: Lock Coefficient

$$C_L = \frac{2A_L\left(\sqrt{H+d}-\sqrt{d}\right)}{A_C\left(T-Ut_v\right)\sqrt{2g}}$$

Where:

C_L = lock coefficient
A_L = plan area of lock chamber
H = initial head (i.e. lift)
d = lock chamber water level over-travel (or under-travel)
A_c = sum of culvert area at each operation valve
T = operational time required to fill (or empty) the lock
t_v = valve operation time
U = valve coefficient ($0.45 \le U \le 0.55$)

Lock Coefficients - Previous Model Studies

Filling: Side Port = 0.73, ILCS = 0.64

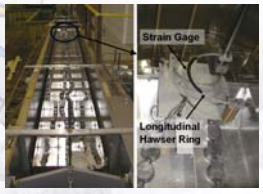
Project	Filling and Emptying System	Initial Head, m	Lock Coefficient		Reference
			Filling	Emptying	
Cannelton Model Type 45 Port Arrangement	Side Port	6.1	0.74	0.57	Ables and Boyd (1966a)
		7.9	0.74	0.60	
		9.1	0.73	0.61	
		12.2	0.74	0.60	
Cannelton Model Type 100 Port Arrangement	Side Port	6.1	0.71	0.56	Ables and Boyd (1966a)
		9.1	0.73	0.56	
		12.2	0.74	0.56	
Arkansas River Model	Side Port	3.0-15.2	0.73	0.67	Ables and Boyd (1966b)
Marmet Model Type 5 Chamber Design	ILCS	4.3	0.63		Hite (1999)
		7.3	0.63		
		10.4	0.63		
McAlpine Model Type 1 Chamber Design	ILCS	11.3	0.63	0.56	Hite (2000)
McAlpine Model Type 11 Chamber Design	ILCS	11.3	0.65	0.57	Hite (2000)

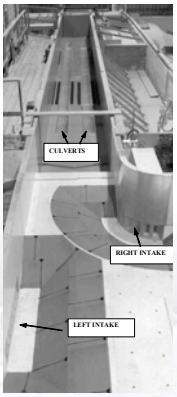
ILCS Manifolds

- Allow for alternative lock wall construction, such as RCC or in-the-wet construction
- Port extensions and wall baffles provide uniform distribution of flow and dissipate energy

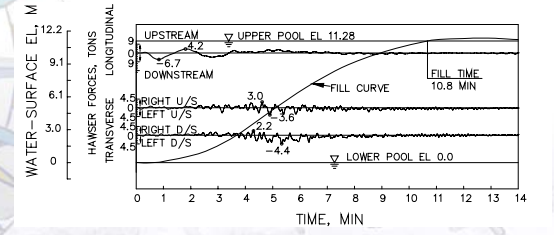
ILCS Research

1:25-Scale Hydraulic Model
- Hawser Forces
- Filling & Emptying Times



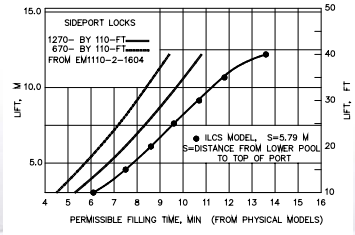


ILCS – Filling Characteristics



11.28-m lift, 5.79-m submergence, 5-min normal valve

Permissible Filling Times

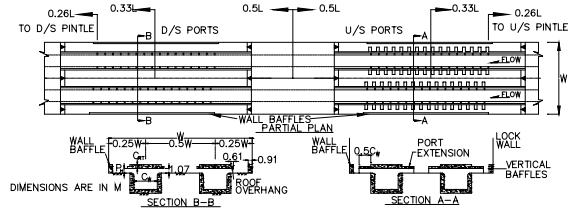


Side-Port System Allows Faster Filling than ILCS

ILCS Design Guidance

Ports:
- Spacing – chamber width dependent (~ 12m)
- Number – port-to-culvert ratio about 0.96
- 2 Groups – at 1/3 points of chamber length
- Extensions – needed on upstream group

Wall Baffles: diffuse port jets near lock floor and inhibit upwelling along walls



Questions?

Marmet Lock, Kanawha River