

**PIANC Workshop**  
**13-14th September 2011**



**Introduction to PIANC Report 106**  
**INNOVATION IN NAVIGATION LOCK DESIGN**

**Ph RIGO** Univ of Liege- ANAST, Belgium

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**PIANC WORKSHOP**

—  
**What's new in the design of  
navigation locks?**

—  
**13 -14 September 2011**  
**New Orleans**



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## WG29: Lock Innovations



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US, NL, BE, Fr, Brazil

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## LOCK INNOVATIONS



The PIANC report n° 106 (2009):

- Complements the PIANC 1986 report.
- Targets innovations and changes occurring since 1986

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# LOCKS: INNOVATIVE TOPICS



Hydraulics (filling and emptying),  
Operations and Maintenance,  
Environmental,  
Design (concrete, foundations, gates, etc.),  
Construction Methods,  
Equipment,

.....

Design concept : Cost-Effective, Reliable,....

## WG29 – Navigation Locks



- Locks are key structures for the development of commercial and leisure navigation in rivers and canals.
- Locks are also strategic infrastructure for seaport development.
- In low-lying countries, locks have an important function in flood defence.

## Innovation applies to the big and fast...



GERMANY

PANAMA



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## ... and the small and slow...



UK (in 1720!)



FR

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## WG29 LOCK INNOVATIONS



Major changes in design since 1986 concern:

- Maintenance and Operation aspects,
- New goals at the conceptual design stages of a lock
  - → RELIABILITY , LIFE CYCLE COST, ...
- Renovation and rehabilitation of existing locks are also key issues for the future.

## DESIGN AND OPTIMIZATION GOALS



- Reliability - system, structures and operations,
  - Reduced duration of a lock cycle times,
  - Reduced water motions and mooring forces
- Minimum water use → Water Saving Basins
- Reduced saltwater intrusion
- Minimum life cycle cost
- Minimum energy use
- Minimum negative impacts – environment, navigation and local community
- Safety and Security

## Early design stage



Key points at Early Design Stage are:

- Lock layout & Lock dimensions ,
- Life cycle of a lock ,
- Construction Methods,
- Layout of hydraulic system,
- Lock structure concepts ,
- Salt water intrusion, Ice Control,
- Communication,
- Security and Safety

## DESIGN PRINCIPLES



“Risk based design” versus “Deterministic approach”

“Life cycle cost optimisation” versus “Least construction cost”

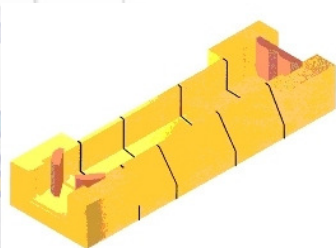
Use of “Numerical Modelling” as design tool  
(combined with physical model)

## Complementarities between modeling

| STEP | PHYSICAL MODEL   | NUMERICAL MODEL                   |
|------|--|-----------------------------------|
| 1    | Definition of the problem:<br>Identify essential acting forces               |                                   |
| 2    | Formulate similarity requirements  | Formulate sets of equations       |
| 3    | Formulate boundary conditions  |                                   |
| 4    | Construct model  | Develop numerical solution scheme |
| 5    | Calibrate model  |                                   |
|      | Variation of roughness   | Variation of coefficients         |
| 6    | Measurements & solution  | Calculation and solution          |
| 7    | Optimize solution according to problem formulation                           |                                   |
|      | Model geometry variations  | Variation of input data           |
| 8    | Transfer results from model to prototype<br>and verify by field measurements |                                   |

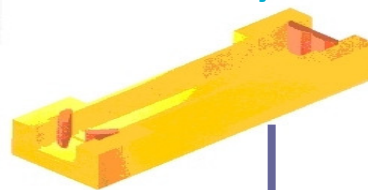
## Monolith Locks

**Standard Concept  
With dilation joints**



**No internal longitudinal stresses**

**Monolith Concept  
Without dilation joints**



**Internal longitudinal stresses**



# LAYOUT OF HYDRAULIC SYSTEM



Hydraulic systems for filling and emptying locks can be divided into two types:

- ➔ Through the heads
- ➔ Through longitudinal culverts

# LAYOUT OF HYDRAULIC SYSTEM



Typical layouts of Longitudinal culvert system:

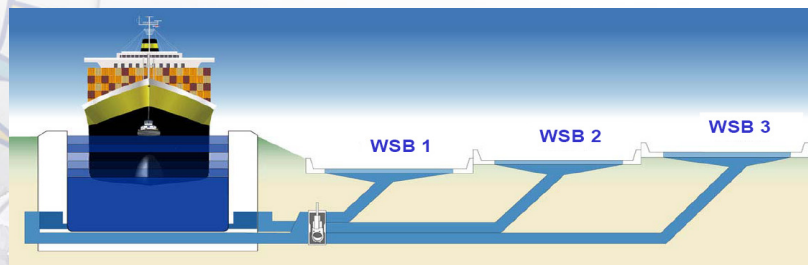
- Wall culvert side port system
- Wall culvert bottom lateral system
- In-Chamber longitudinal culvert system (ILCS)
- Longitudinal culverts under the lock floor
- Dynamically balanced lock filling system
- Pressure chamber



## Water Saving Basins (WSBs) (Standard Concept)



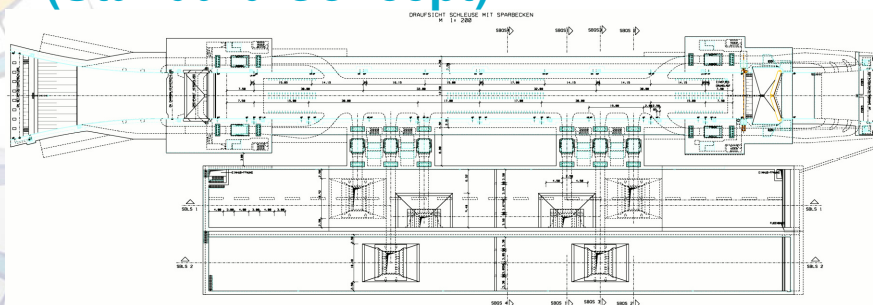
Locks with separated WSBs  
(located on one side or both sides of the lock,  
on a series of steps)



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## Water Saving Basins (WSBs) (Standard Concept)

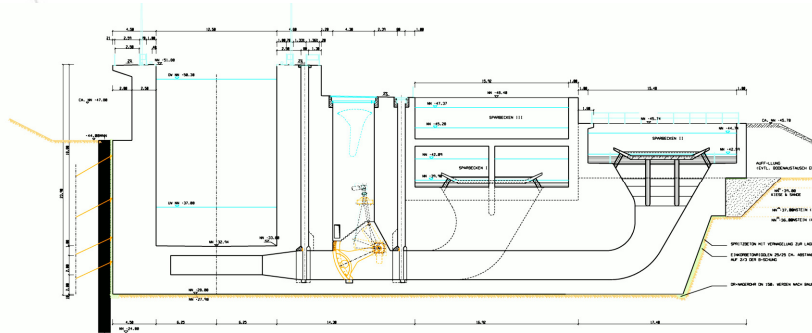


Lock with Water saving basins located on  
the side of the lock  
- Standard concept

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# NEW LAYOUTS OF HYDRAULIC SYSTEMS



Connection of pressure chamber to WSBs basins  
(upper) and to main chamber (lower) → Germany

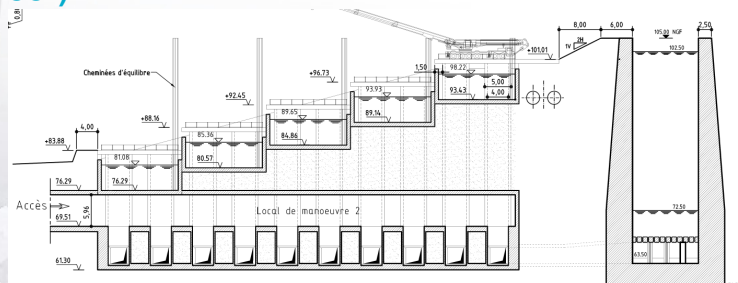
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## Water Saving Basins (WSBs)



Cross-sections in a lock with 5 standard laterally  
located Water saving basins  
(filling through the pressure chamber in the lock  
floor)

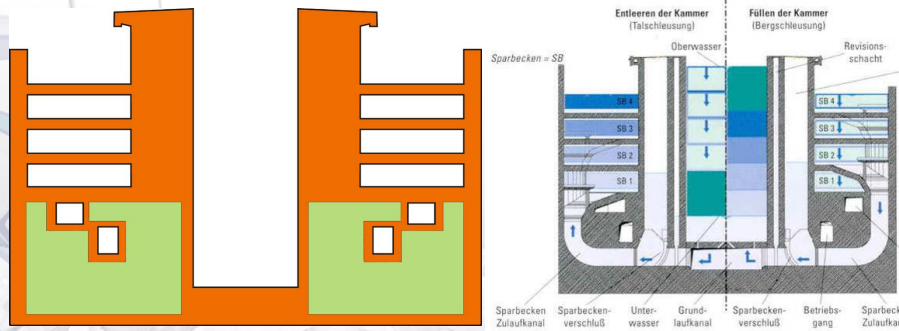


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# Integrated WSBs

The integrated system which integrates the WSBs in the two side walls, and makes the lock structure more stiff, compact and less land consuming.

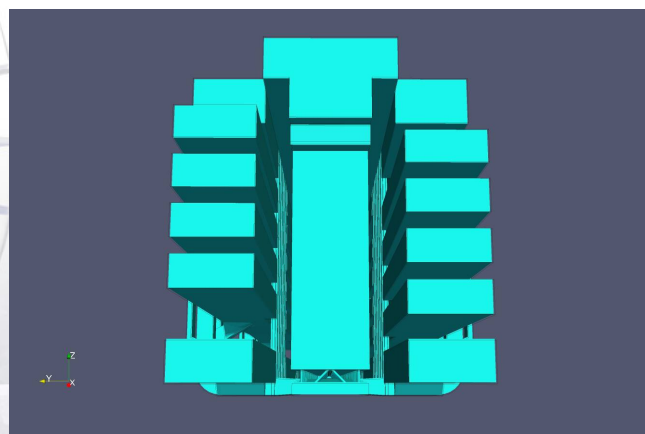


Lock sidewalls with integrated WSBs

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# New Lock Concepts

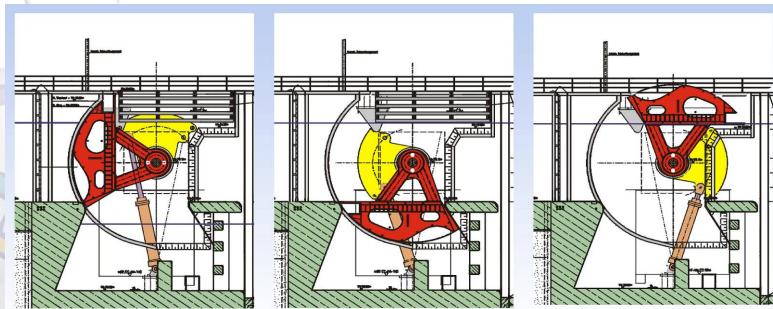


BAW – By C Thorenz

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# GATES AND VALVES



## INNOVATION IN LOCK GATES

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# Filling & Emptying System



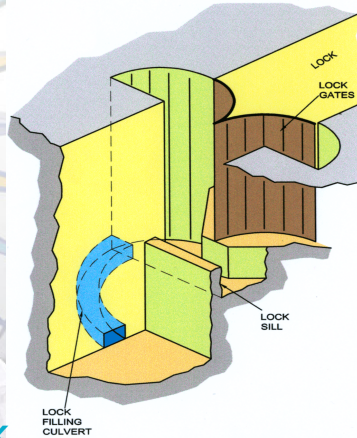
Upper gate at lock Lisdorf (D)

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## Innovative F/E Systems



UK



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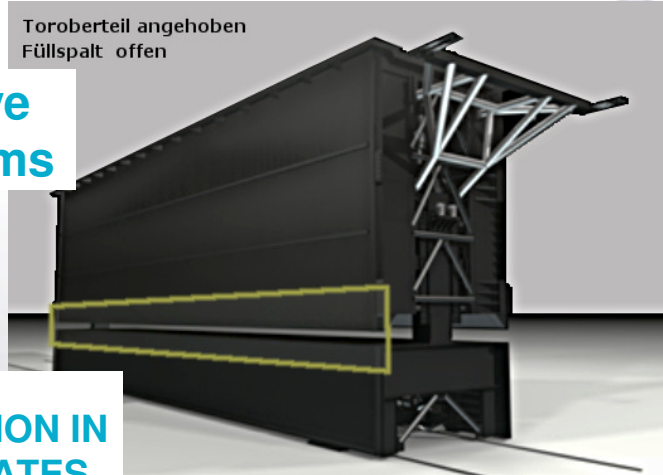
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## Kaiser lifting and sliding lock gate



Toroberteil angehoben  
Füllspalt offen

**Innovative  
F/E Systems**



**INNOVATION IN  
LOCK GATES**

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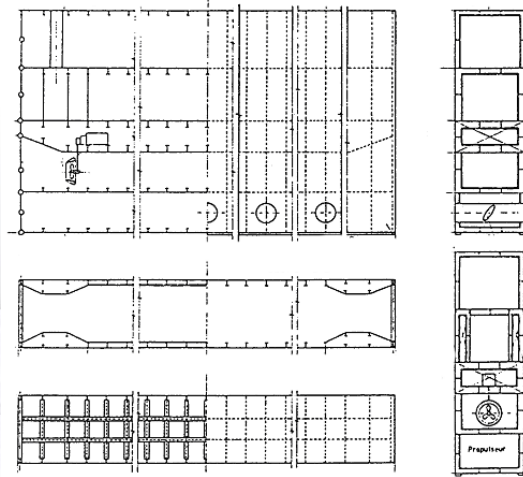
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# Self-Propelled Floating Lock Gate (up to 70 m long)



INNOVATION IN  
LOCK GATES

ANAST  
ULG  
(Belgium)



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# CURVED GATES



An innovative concept for a  
special requirement : SPACE

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# GATES AND VALVES



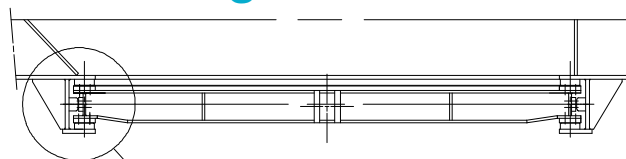
## MITER GATES

- Folded plates (low Cost)
- Support on 4 edges
- Cylinder on the downstream side
  - Protected against shock
  - In the dry

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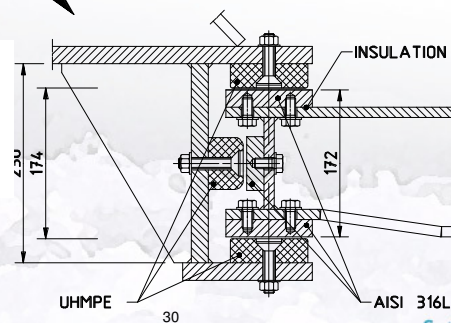
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## UHMPE sliding Gate/ Valves



**A-A**

**INNOVATION IN  
LOCK GATES**



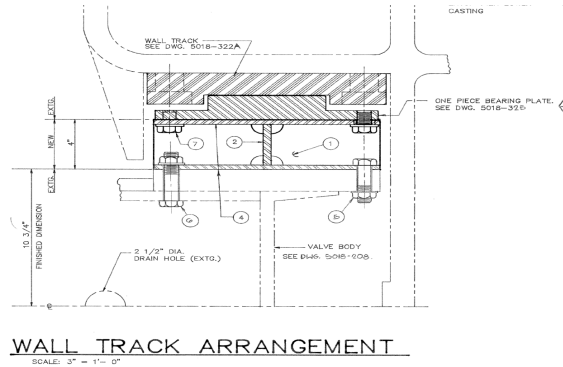
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# Mechanical devices



Sluice : Sliding vertical lift gate  
**UHMWPE** : Ultra-high molecular weight polyethylene



**WALL TRACK ARRANGEMENT**  
 SCALE: 3" = 1'-0"

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## Vacuum Mooring System

- Canada -  
 Welland Canal



**INNOVATION IN  
 MOORING  
 DESIGN**

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## SHIP POSITIONING SYSTEM (Canada – Welland Canal)



3D laser scanner  
invisible Class 1 eye-  
safe laser beam

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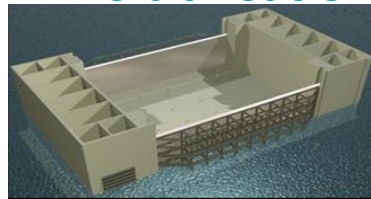
## Construction Methods



The lock chamber is constructed on the ground surface.

When completed the soil is removed beneath the lock chamber and it is lowered into its final position.

➔ **Prefabrication**



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# InCom WG 29 CONCLUSIONS



## Current Trade off problems in Lock Design:

→ **HIGH RELIABILITY** is often associated with **“PROVEN TECHNOLOGIES”** (in lock design)

If true → Is it a the place for innovation in lock?

**WG29 → Yes. Innovation** is required to reach highly reliable infrastructures, to reduce cost (construction mode), fulfil new requirements (fast locking), non standard dimension,...

**Do not be afraid by innovation.**

→ **Promote innovation.**

→ **RELIABILITY** versus **“COST”** (in lock design)

Lock design is highly **“Project Dependent”**.

Ex: **“Panama Canal”** versus the **“Renovation of a small pleasure lock in Finland”**

# INNOVATIONS IN LOCK DESIGN



→ **Some more  
EXAMPLES**

# Experiences of Innovation



- Mooring
- Fendering
- Lock Chambers - structural design
- Lock Gates
- F/E Systems
- Automation, self-operation
- Life Cycle Management
- Safety

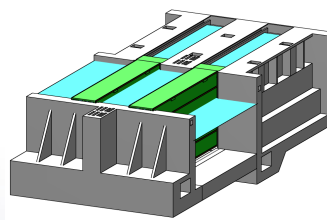
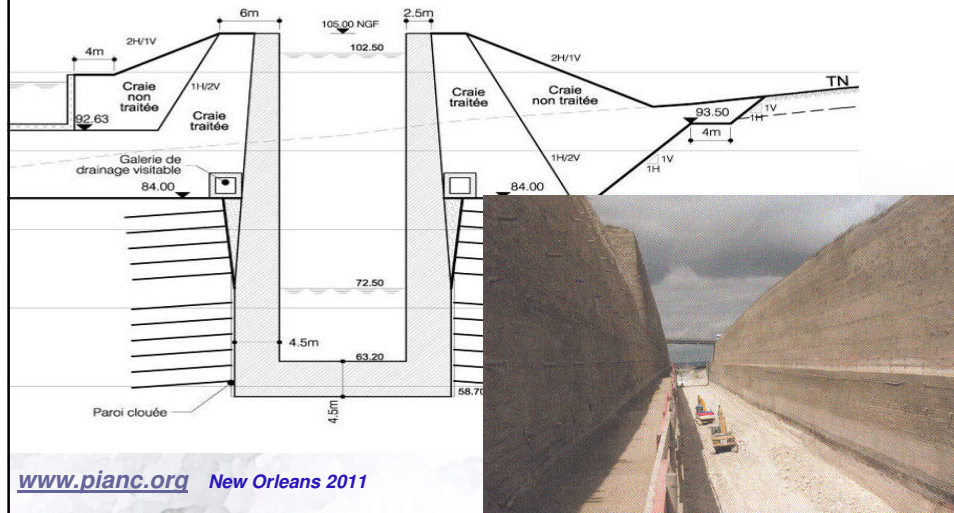
## Floating Mooring Pontoons



### INNOVATION IN MOORING & FENDER DESIGN







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## Experiences with Giant Gates

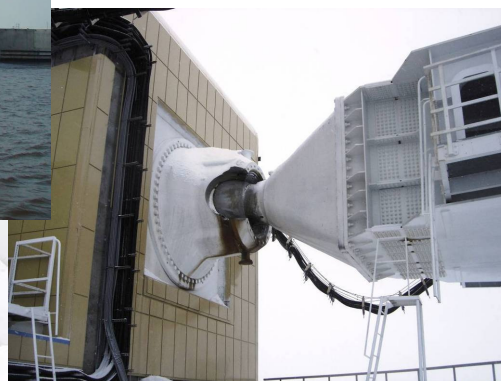


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## Experiences with Giant Gates



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## Experiences with Giant Gates



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## Experiences with Giant Gates



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# Life Cycle Management



LCM is aimed at providing minimum Whole Life Costs. dealt with in MarCom-WG42  
Life Cycle Management of Port Structures (August 2007)

[www](http://www.pianc.org)



MarCom

Report WG42 – August 2007



Life Cycle Management of Port Structures  
Recommended Practice  
for Implementation

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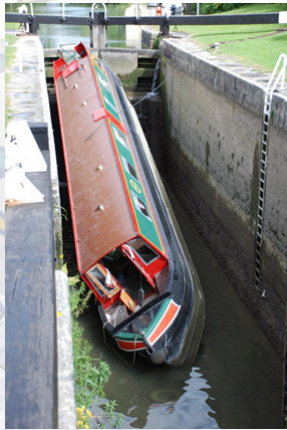
## Life Cycle Management



- Design for minimising operating & maintenance costs
- Design for minimising downtime
- Design for minimising whole life costs
- Maintenance Management

# SAFETY

Locks are safety-critical structures



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# Safety

Safety in design is increasingly important.

We are all more risk conscious, and are in a more litigious society.

The Report discusses protection of

- People (users, operators, bystanders)
- Locks
- Ships



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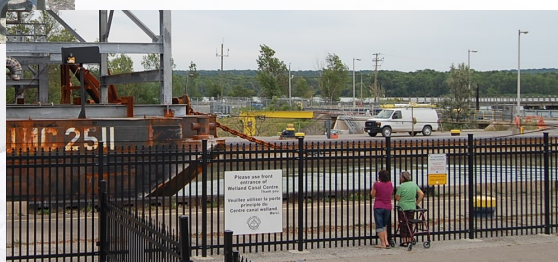


# Safety

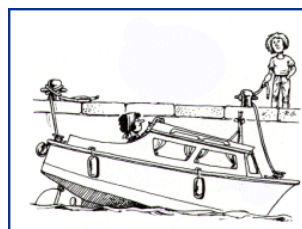


Standards of yesterday  
might not be sufficient  
today

Public access  
– or not?



# Safety



Prevent Accidents





## SAFETY



**Safety in design is increasingly important.**

**We are all more risk conscious,  
and are in a more litigious society.**

**The Report discusses protection of**

- **People (users, operators, bystanders)**
- **Locks**
- **Ships**

## Water Edge Safety Classification



**The Report includes**

- **Classification of types  
of water edge  
structure**
- **guidelines for suitable  
safety treatment for  
each category**



# PIANC Report No 106 Innovation in Navigation locks



## The 2009 report...

- Described lock innovations since 1986
- Recommended good practice
- Provided a basis for future innovations

## This Workshop ...

- Describes and develops further innovations
- ...

# NEW and FUTURE PIANC WGs



## 1) WG 154

“ Miter Gate Design and Operation

## 2) WG 155

“Ship behaviour in locks and lock approaches” , Chairman C Thorenz

## 3) Any ideas ?



## STATE OF ART OF THE NEW SLIDING GATE USING UHMWPE

**UHMWPE :**  
Ultra-high molecular weight  
polyethylene



## Salt Water Intrusion

1) Need system to avoid/reduce salt water intrusion

→ From low cost (air screen, ...)

→ High efficiency (Full salt water exchange system)

→ Need for innovative filling and emptying systems

2) HOW TO ASSESS (forces on gates, on ship, current, manoeuvrability, ...)