DJW Consulting Ltd

European Machine Safety Requirements & Hydraulic Design Specialist.

InCom WG 138
M&E Lessons Learnt

The Group is supported by members in:-

- Belgium
- Canada
- Germany
- Ireland
- Netherlands
- United Kingdom
- USA

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The WG have met on 6 occasions since Feb 2010

- Brussels
- Nuremburg
- Dublin
- Bristol
- Minneapolis Saint Paul
- Maastricht

With 3 further meetings planned in 2012

- Antwerp
- Toronto
- Bremen Ports

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- Meeting 1 – Introduction, getting to know, policy of the task
- Meeting 2 – first reports from collections of materials of each different responsibility, policy of verification for each area of investigation
- Meeting 3 – final collection of experiences, mistakes and mismanagements
- Meeting 4 – investigation, verification and evaluation for the area of hydraulic equipment
- Meeting 5 - investigation, verification and evaluation for the area of electro-mechanical equipment
- Meeting 6 - investigation, verification and evaluation for the area of electrical control systems
- Meeting 7 - investigation, verification and evaluation for the area of operational systems
- Meeting 8 - investigation, verification and evaluation for the area of maintenance systems
- Meeting 9 - policy and structure for the final report, review of issues for that report
- Meeting 10 - final review and approval of the final report

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Objective & core elements of purpose:-

- Provide a comprehensive summary of lessons learned of mechanical, electrical and operational experiences at navigation locks
- Provide future design of locks and operational elements with proposals free of mistakes and mismanagements
- Provide a guidance on a choice of systems to use in future navigation structures
- Investigation of special issues.

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Investigate & include for the following areas:-

- Hydraulic Equipment
- Electro-Mechanical Equipment
- Electrical Control Systems
- Operational Systems
- Maintenance Systems

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Special issues to be reviewed & recorded

- Troubleshooting – Difficult for lock personnel to troubleshoot, programming of PLC is complicated.
- Exterior mounted components – Vulnerable to Sun, Water, and Flooding.
- Custom designed cylinders and other components with long lead times for service and delivery.
- Possibility of impact damage on machinery connections to the gate
- PLC versus hardwire systems, Use of Programmable Logic Controller replaces many parts and flexible for adopting changes.
- Hydraulic components provide for fewer moving parts, centralized HPU, accurate control of speed, shock absorbing, smooth operation and fewer installation/alignment issues and less pivot points for wear.
- Labour intensive maintenance.

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The content of our report is now formulated into the following chapters:-

1 Introduction

2 General issues

1. Specific objectives
2. Research Methods
3. Case Studies
4. Systemizing the Lessons Learnt
5. Prioritising Areas of Concern

3 Electro Mechanical Drives for - Mitre Gates, Sector Gates, Filling/Emptying Valves, Vertical Lift Gates, Dam Gate Hoists & Bulkhead Cranes/Emergency Gate Hoists.

Mechanical Components – Linear Actuators, Gears, Greaseless Bearings, Lift Chains, Wire Rope, Shaft Couplings, Brakes, Lubrication & Mitre Gate Strut Springs.

4 Hydraulic Drives, Open & Closed Systems, Actuators, Seals, Cylinder Rods, Supports, position indicators, Hydraulic Fluids, Pumps, Reservoirs, Accumulators, Valves, Manifold Assemblies, Pipe work (flexible & rigid), Filtration & filters, Heaters, Compact Drives & Electrical Equipment.

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The content of our report is now formulated into the following chapters (cont'd):-

5 Other Drives & Systems – Manual Drives Systems, Inflatable Dams, Other systems, Air Bubbler De-Icing, Floating Bollards/Mooring Bitts, Standby Emergency Power Systems, Winch / Tow Haulage Systems, Ship Arrestors/Collision Protection Systems.

6 Power & Control Systems – Motor Starters, Electric Motors, Variable Speed Drives Systems, Sensors, Control Systems (Hard Wired / Emergency Control System), PLC's, HMI interfaces, Safety Interlocking systems, Arc Flash Protection, Modernisation & standardisation, Testing & Commissioning.

7 Maintenance – Criteria for Maintenance Strategy, Self Sufficiency or contracting out ?, Condition Monitoring, Service Levels, Concepts to Maintenance, Diagnostics, Developments in Maintenance.

8 Conclusions & Recommendations – general, mechanical, electrical & software engineering.

9 References / Appendices

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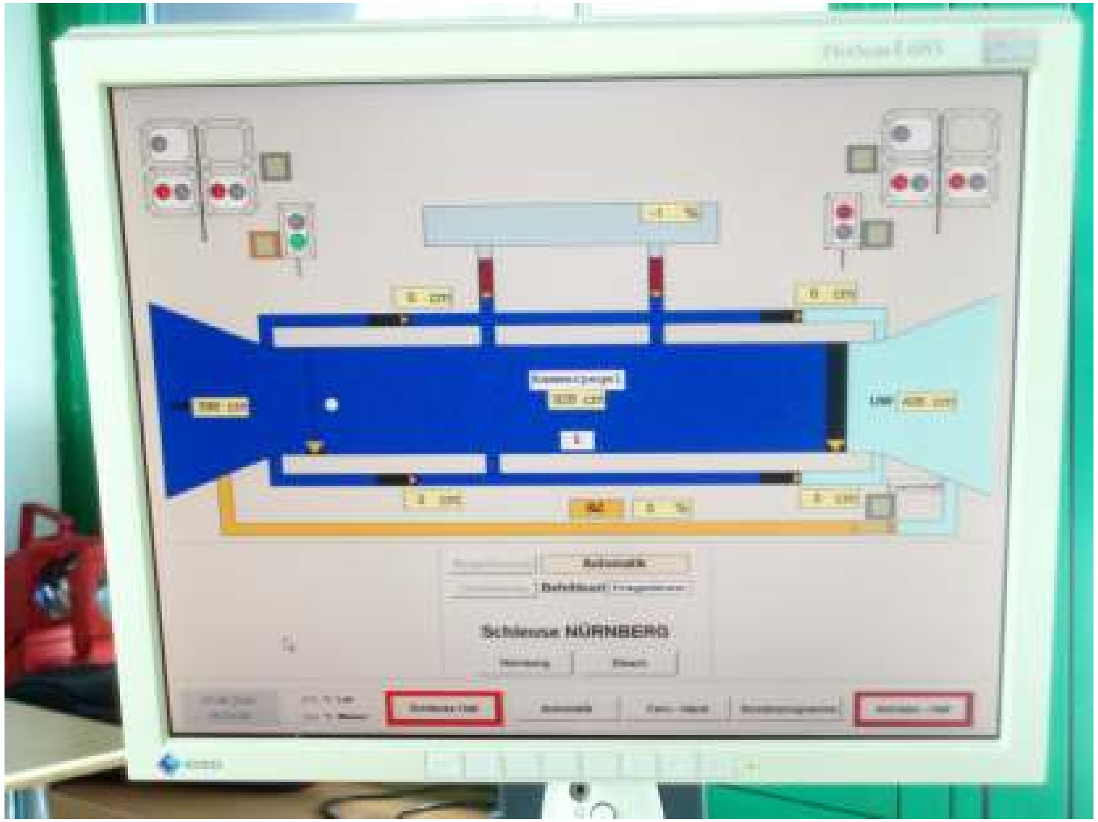

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Chapter 5

Electro-Mech

Drives

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Chapter 5

Electro Mech

Drives

5 ELECTROMECHANICAL DRIVES

5.1 Introduction

5.2 Systems

5.2.1 Mitre/Sector Gate Drives

5.2.1.1 Description

5.2.1.2 Issues/Best Practices

5.2.1.3 Lessons Learned

5.2.2 Filling/Emptying Valve Drives

5.2.2.1 Description

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Chapter 4

Hydraulic

Drives

evident that the ceramic coatings are more porous than originally believed. This is particularly true of rods subject to intermittent use and/or exposure to the weather allowing the evaporation of the protective oil from the pores of the coating. An example of a failed coating with the subsequent corrosion underneath is shown in Fig. 8.

Fig. 8: Ceramic coated cylinder rod with corrosion

Ceramic coatings have been found to be susceptible to impact damage where small pieces of the coating are completely removed. Impact has been noted to occur either from contact with debris in the water or from the inadvertent dropping of material or tools on the rods particularly during construction. Subsequent generations of the ceramic coatings incorporate a metal matrix and are applied with the High Velocity Oxygen Fuel (HVOF) process and are reported to have improved resistance to corrosion and higher impact and wear resistance. Nevertheless, these coatings are not guaranteed to be completely non porous. Ceramic coatings are applied on degreased, sand-blasted rods via a numerically controlled spraying process. After the adhesion layer is applied pore sealing is not permitted. Ceramic coatings should be at least 250 µm (average), with no value below 200 µm.

Chrome Coating
Chrome plating is not recommended on steel in waterside applications. Stainless steel rods should be protected with a chrome coating of 35-50µm when in a corrosive environment. The chrome coating is applied by electrolytic means. The thickness of the chromium coating after finishing (polishing) is minimum 50 µm.

Nickel Coating
The nickel coating is applied by electrolytic means. The minimum thickness of the nickel coating is 60 µm and a maximum of 150 µm.

Some promising alternatives have been developed that apply a corrosion and wear resistant coating to a carbon steel rod by a weld overlay process or laser cladding. Experience with these coatings in navigation environment is limited but worthy of further study.

Coating quality control methods include each cylinder rod extended by an additional test rod, which is treated same as the rod itself. The test rod has a length of 150 mm and has the same diameter as the rod itself. After chrome / ceramic coating, the cylinder rod is brought to size by grinding or polishing. The final diameter of the cylinder rod is located within the tolerance zone that was chosen for the rod diameter in function of the seals used.

Recent lessons learnt in the USA concerning hydraulic power systems on inland navigation projects have been derived from experiences with materials and coatings for hydraulic cylinder rods, cylinder sealing technologies, alternatives for position sensing, and cylinder mounting and configuration. The cylinder rod coating lessons have come about as the result of efforts to enable the use of corrosion susceptible materials for the rod base metal. These lessons have gone hand in hand with the efforts to find the optimum position sensing systems since some of the state of the art systems are integral to the rod coatings.

__Best Practices__
Generally selection of rod material and coating is very dependent on application and environment. A rule of thumb that may be used assuming corrosion is a factor can be rod diameter; rod diameters of less than 150 mm should use stainless steel and over 150mm carbon steel (or also stainless steel) with chrome or nickel coating.

The preferred rod material and coating combination is a stainless steel rod with chromium plating. Corrosion resistance of the stainless steel is good while the plating provides a smooth hard surface for sealing and exhibits good wear properties. While this may be the most costly initial alternative, it is a proven design and may be found to have minimal increase to the overall project lifecycle cost. Stainless steel alloys such as the precipitation hardening 17-4ph or Type 630 (DIN 1.4542) have been found to provide a high strength and good corrosion resistance in a relatively wide range of stock sizes.

4.3.4 Supports

__Description__
Supports are used throughout hydraulic systems, this section discusses, internal guides, as well as mounts for components. Calculation on the most extreme permissible conditions should be the foundation for support design.

When polymer guides are used, the deflection under operating conditions is verified by a calculation note.

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Chapter 4

Hydraulic

Drives

The rod guide is provided with helical grooves, the piston guide, however, has one or more circular oil grooves.

The guide bushes are mechanically locked in axial direction.

Fig. 9: Gate drive cylinder

4.3.5 Position Indicators

Description
Modern control systems have necessitated the accurate

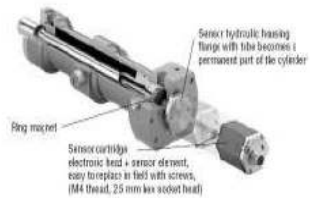

Fig. 10: Magnetostrictive system

Feedback from gate or valve position. Generally, position sensing systems are either integral with the cylinder or are external to the cylinder and sense either the cylinder or the gate or valve directly. Integral systems include the ❶ magnetostrictive (**Error! Reference source not found.**) and ❷ magneto resistive systems (Fig. 11).

Fig. 11: Magneto Resistive Position Sensor on Rod End Gland

Fig. 12: String pot encoder

External systems include ❶ electro mechanical position switches ❷ rotary encoder or driven encoder ❸Cable and rope length transducer (Fig. 12) ❹ externally driven directly linked to driven component.

Advantages
Systems integral with the cylinder are currently the most popular and require little or no design effort for external mechanisms or linkages. They also offer the advantage of being included with the cylinder as a turnkey product. Magnetostrictive systems offer reliability, absolute measurement in case of loss of power. External systems offer independance of cylinder when repairs or work is required and therefore a greater likelihood of the gate or valve remaining in service while repair is being made.
To be discussed: When the cylinder is removed the object (gate, valve) cannot be moved so the measurement system connected to the gate has no function. When the cylinder is replaced, it can be replaced by a cylinder with integral measurement system.

Disadvantages
Magnetostrictive systems are limited because of the

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Chapter 8
Maintenance

rijkswaterstaat / bremenports	Corrective	Preventive	Lifetime [yr]
Mechanical components:			
Panama and other large gear wheels	90	10	75
Pinions, shafts, other midsize parts	70	30	35
Racks, chains, winches, transmissions	70	30	25
Bearings of gates and their drives	40	60	30
Gate support rollers, wagons	60	40	30
Gate support wheels	40	60	35
Gate rails, slide tracks and buffers	90	10	70
Ropes, rope couplings, sheves	30	70	20
Gate slide pads, post linings and seals	60	40	25
Culvert/sluice gate drives if 6 or more	70	30	25
Culvert/sluice gate drives if less than 6	30	70	25
Hydraulic components:			
Hydraulic drive cylinders, weight > 1.0 ton	80	20	25
Hydraulic drive cylinders, weight < 1.0 ton	20	80	20
Integrated hydraulic drive units, fixed	80	20	35
Pumps, oil tanks, hydraulic motors, loose	20	80	15
Manifolds, valves, fixed piping	70	30	25
Culvert/sluice gate jacks if 6 or more	70	30	25
Culvert/sluice gate jacks if less than 6	30	70	25
Pressure control appliances	30	70	10
Filters, hoses, hydraulic couplings	10	90	10
Oil seals, gaskets, other small items	70	30	10
Electrical components:			
Main power supply facilities	10	90	30
Emergency power supply facilities	40	60	30
Fixed electric engines of gate drives	70	30	35
Removable electric gate drive engines	30	70	35
Culvert/sluice electric drives if 6 or more	70	30	25
Culvert/sluice electric drives if less than 6	30	70	25
Gate motion synchronizing systems	50	50	25
Sensors, limit switches, accessories	30	70	15
Power wiring, fuses, fittings etc.	80	20	25
PLC's, frequency converters	40	60	15
Emergency control systems	80	20	15
Heating elements, bubble screens etc.	70	30	20
Cameras	60	40	15
Screens (CRT, LCD)	60	40	5
Water level sensors	60	40	15
Low voltage wiring and accessories	80	20	15
Signalization systems for navigation	40	60	20