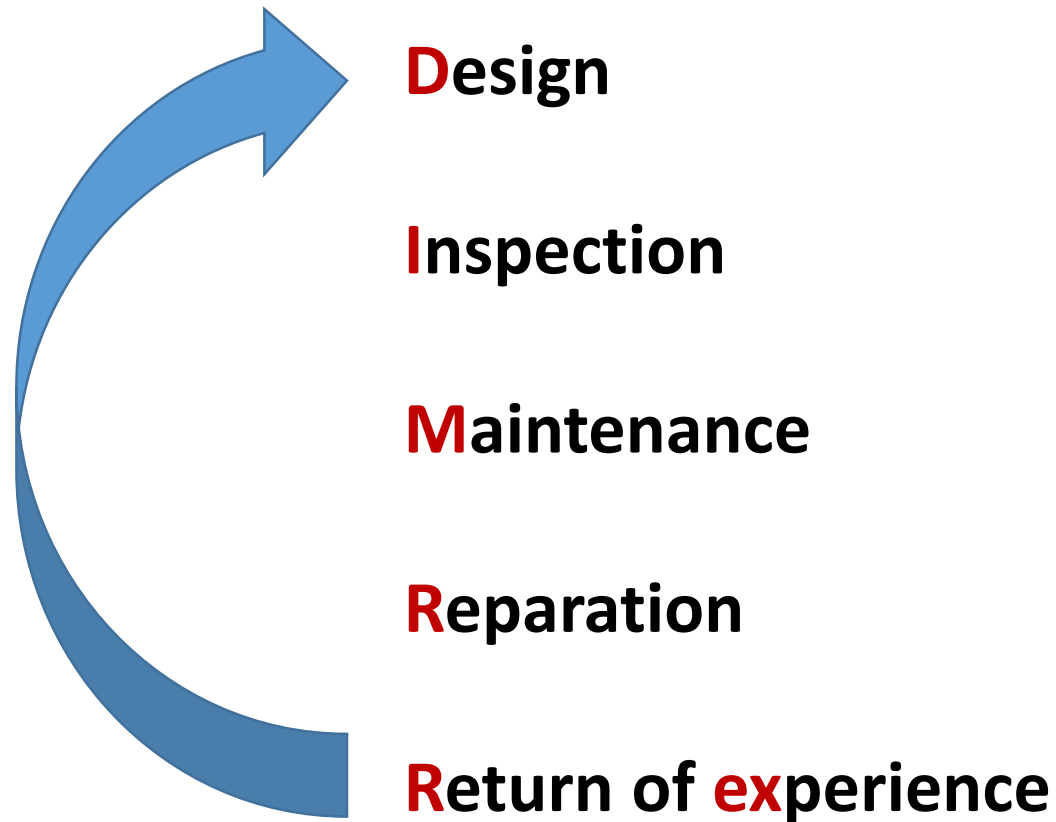


Lessons learned from pre-emptive replacement of mooring lines in West Africa

Alain Ledoux
Total S.A.



Mooring system life cycle - Focus on chain corrosion



The experience: Pre-emptive replacements due to chain corrosion

3 operations from 2013 to 2016:

- 2 turret moored floating units
- 1 spread moored floating unit

All in tropical waters of West Africa

All in limited water depth (up to 140m)



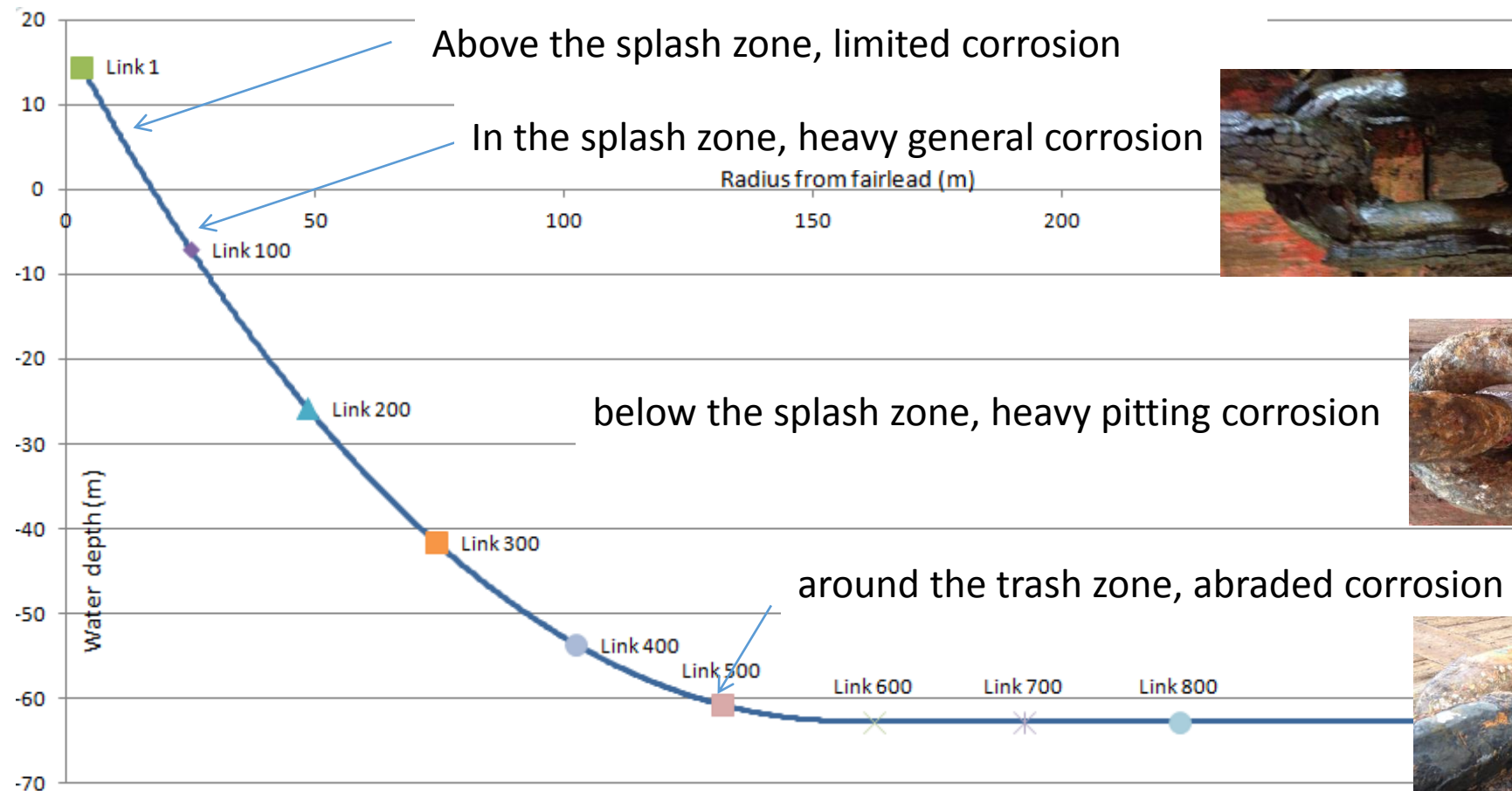
Corrosion allowance for permanent mooring design

0.4mm per year as per API 2SK (1995)

Protection against chain corrosion and wear is normally provided by increase of chain diameter. Current industry practice is to increase the chain diameter by 0.2 mm to 0.4 mm per service year in the splash zone and in the dip or thrash zone on hard bottom. The diameter increase is reduced to 0.1 mm to 0.2 mm per service year in the remaining length.

Now 1mm per year is commonly accepted in Tropical water

Corrosion pattern along the chain



INSPECTION

Inspection along the chain

Above water

with Rope Access Technician (RAT)

- Cleaning
- Diameter Measurements

Risk of increased corrosion



Underwater

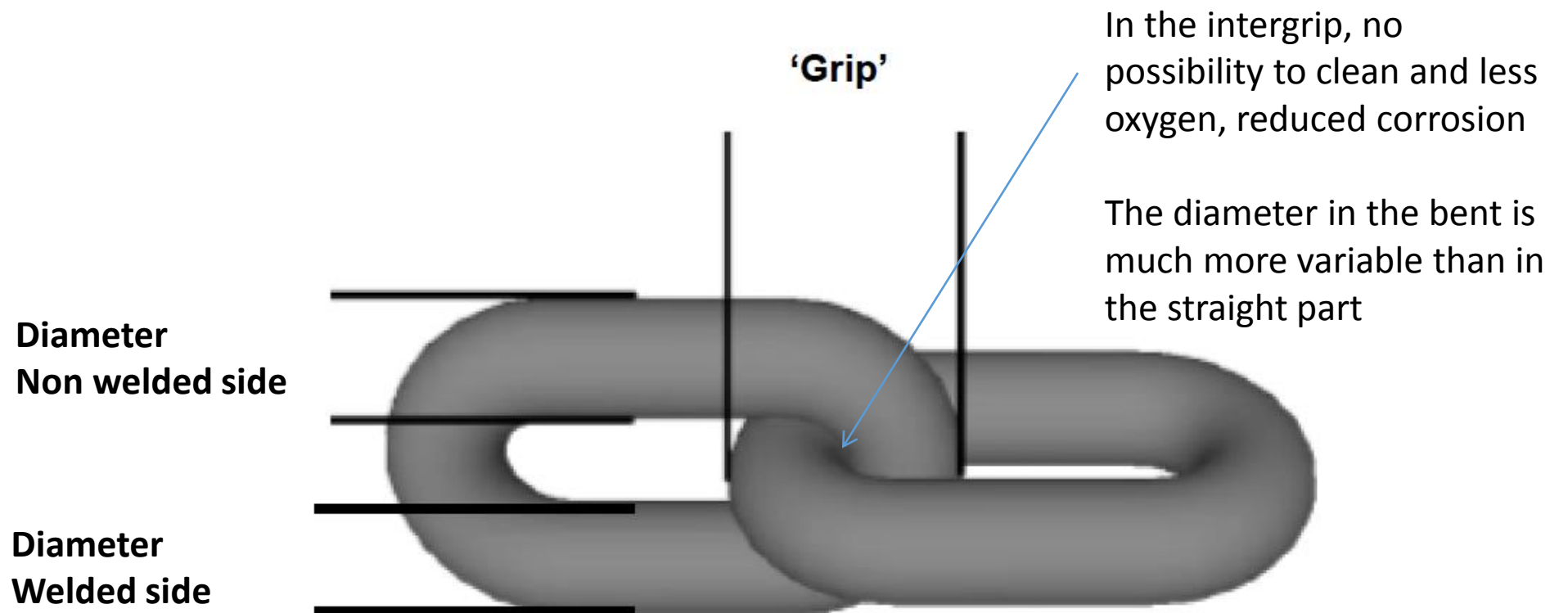
Not so easy

Replacement as an opportunity
for detailed inspection



Diameter measurement

API 2I recommends to measure the grip
in mild environment and with respect to uniform corrosion
More pertinent to measure **diameter on the non welded side**



General corrosion



INSPECTION

General corrosion model versus in-situ measurement

SCORCH JIP Model to predict general corrosion based on 2 parameters:

- Temperature
- Dissolved Inorganic Nitrogen (DIN)

On field:

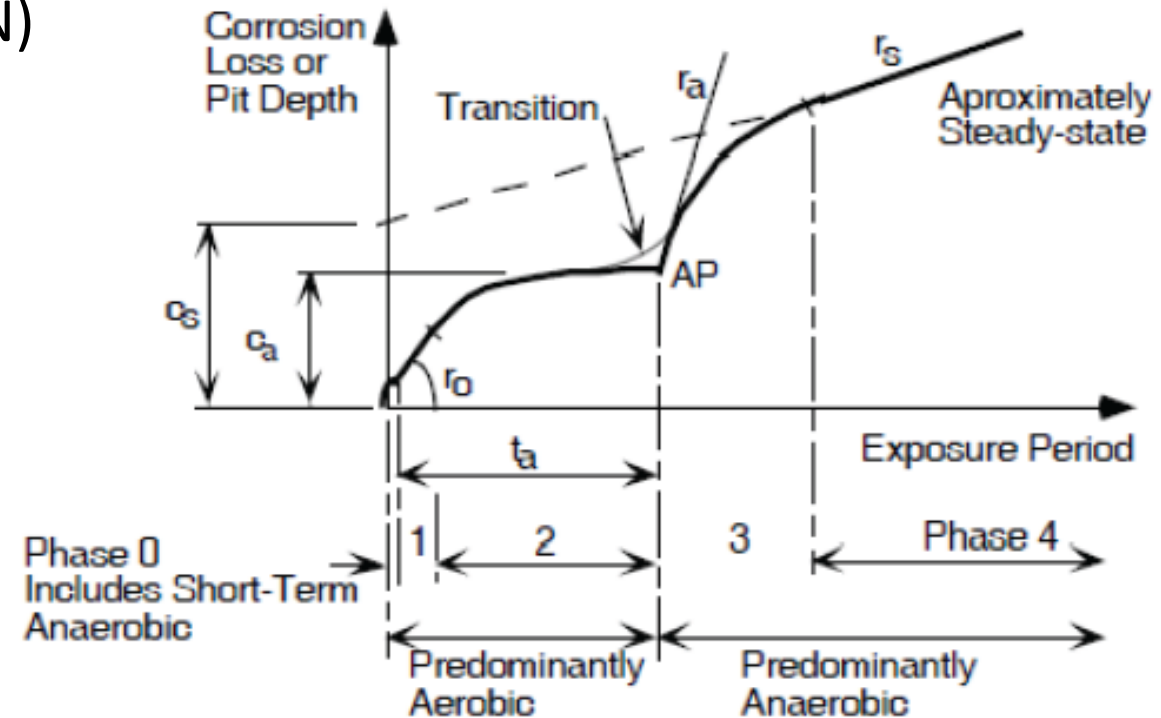
25°C to 30°C

Limited DIN <0.5mg/L

Splash zone

Model 6.6mm

Measured 16mm



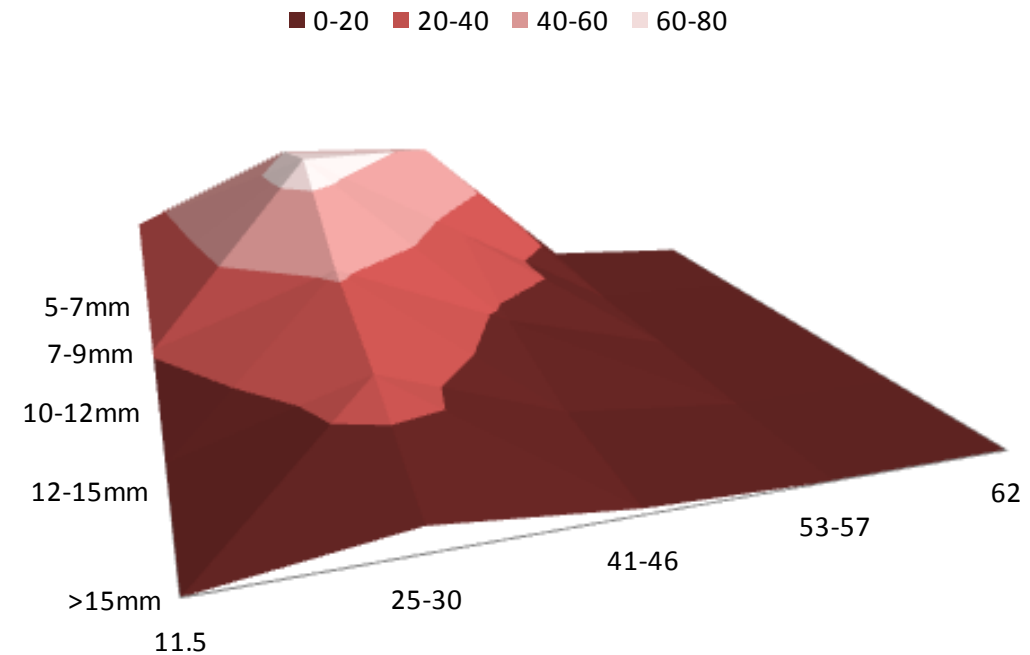
Under splash zone, model 4mm, measured between 1 and 5mm

Pitting corrosion



Observed nearly 8000 links

Pitting distribution wrt size (depth mm) and water depth



Water depth (m)	5-7mm	7-9mm	10-12mm	12-15mm	>15mm
11.5	34	28	21	8	0
25-30	60	68	42	27	8
41-46	57	34	17	6	2
53-57	4	1	1	0	0
62	0	0	0	0	0

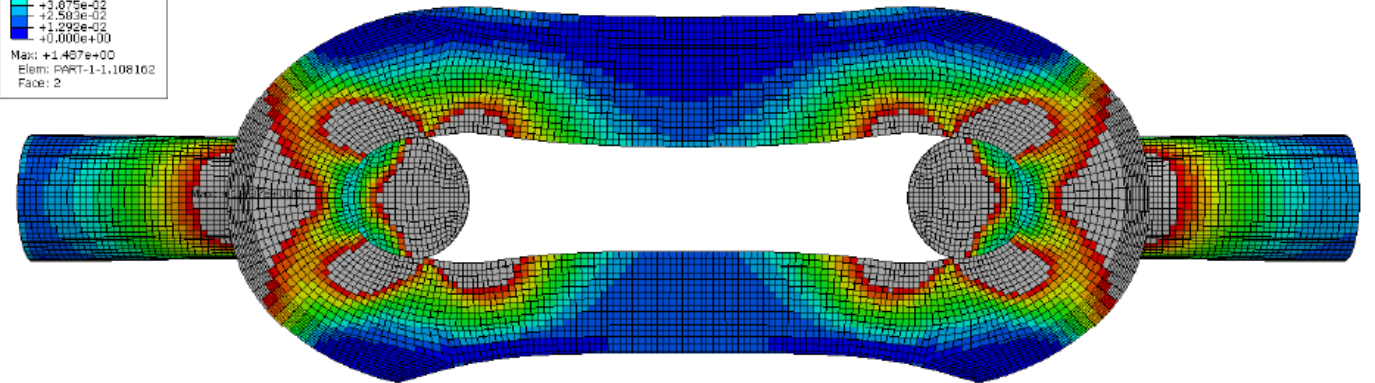
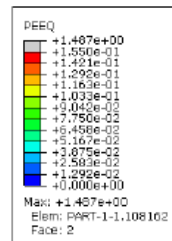
Weld preferential corrosion

2 to 35 indications per line
randomly distributed
depth < 3mm.



INSPECTION

Abraded corrosion around thrash zone



Strength
Not so critical

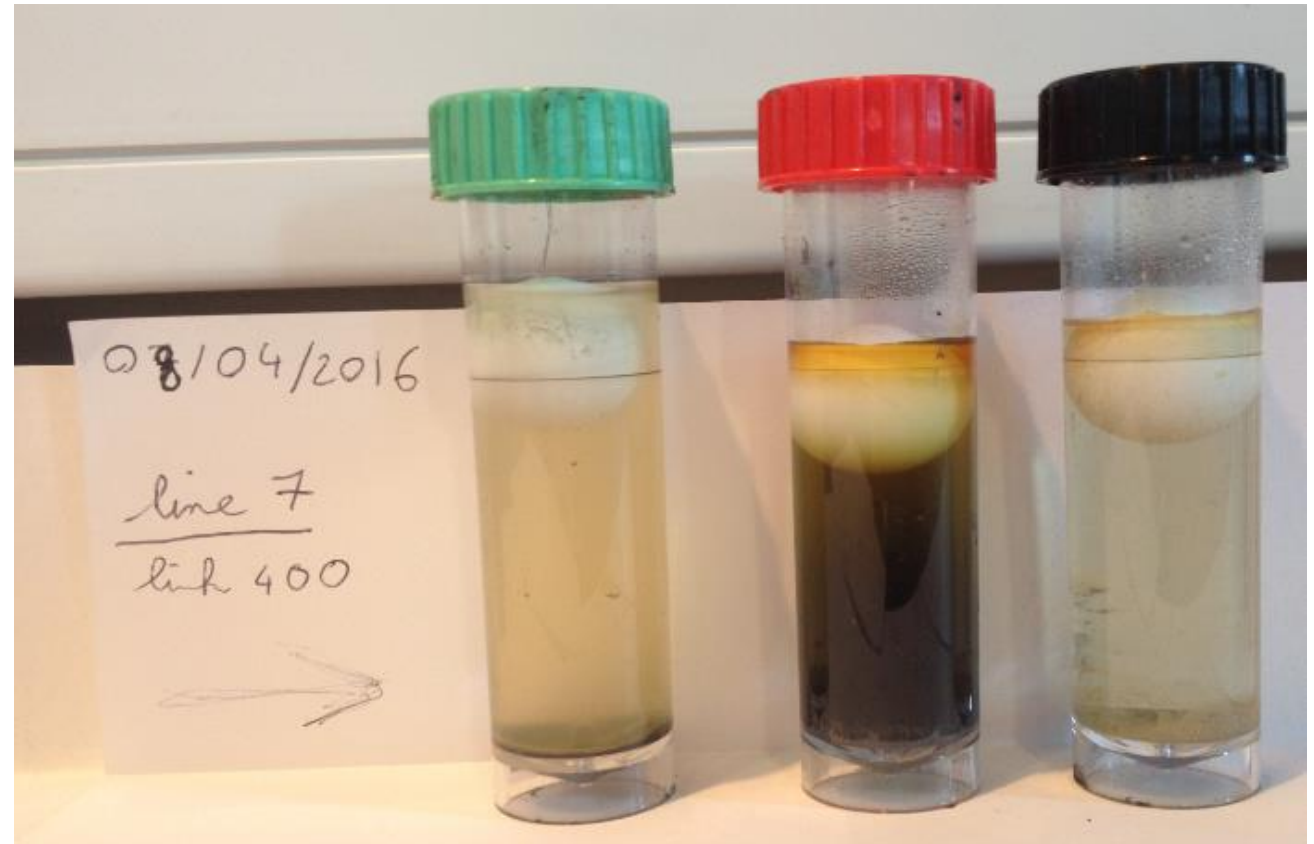
Microbiologically Induced Corrosion

BART Tests

IRB positive

Slime negative

SRB negative ??



Samples for more advanced test on-going

MAINTENANCE

Maintenance of a permanent mooring system

i.e. Maintenance of the deck mooring equipment

Repair readiness

Critical and expensive machine not used during years

Full replacement of the equipment often needed



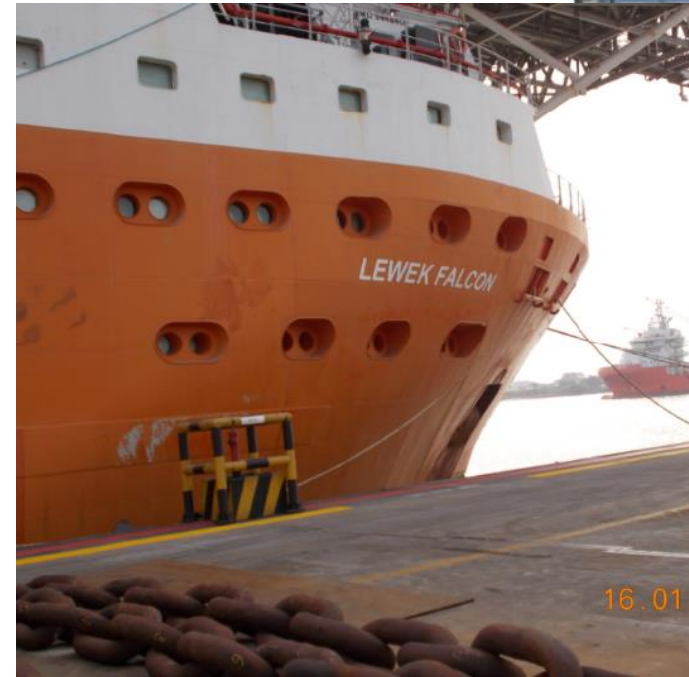
REPARATION

Reparation

Reverse of installation ?

Length of chain to be changed ?

In production or not ?



FUTURE MOORING SYSTEMS

Return of experience

Critical corrosion area on the top 70-100m

No top chain

No corrosion



Future mooring system



Fit for purpose permanent mooring

Not an adaptation of Mobile Offshore mooring system

