WHAT YOU NEED TO KNOW ABOUT WIRE ROPES

- Safety
- Inspection and typical damages
- Discard criteria

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GLOBAL R&D CENTRE

USHA MARTIN ITALIA

ITALY

- Technical department of Usha Martin Group, Global Design Centre for all Usha divisions
- Responsible for technical assistance: evaluation of customer concept design of new equipment, training for customers about rope properties and managing of special tests
- Active part of the most important International committees (CEN, IMCA, OIPEEC, OITAF, IABSE), taking care of technical and regulations workgroups

GLOBAL R&D CENTRE

USHA MARTIN ITALIA LABORATORY

ITALY

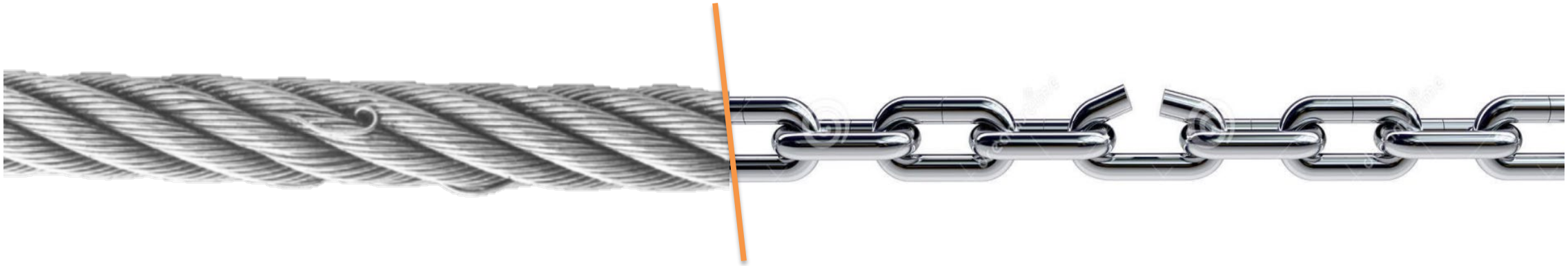
- Fatigue tests up to 100 mm rope diameter
- SEM and digital microscope analysis
- Wire break, elongation and torsions tests
- Stiffness, torque and rotation tests
- Post retirement inspection and rope dismantling
- Grease assessment and compatibility tests

Are ropes safe?

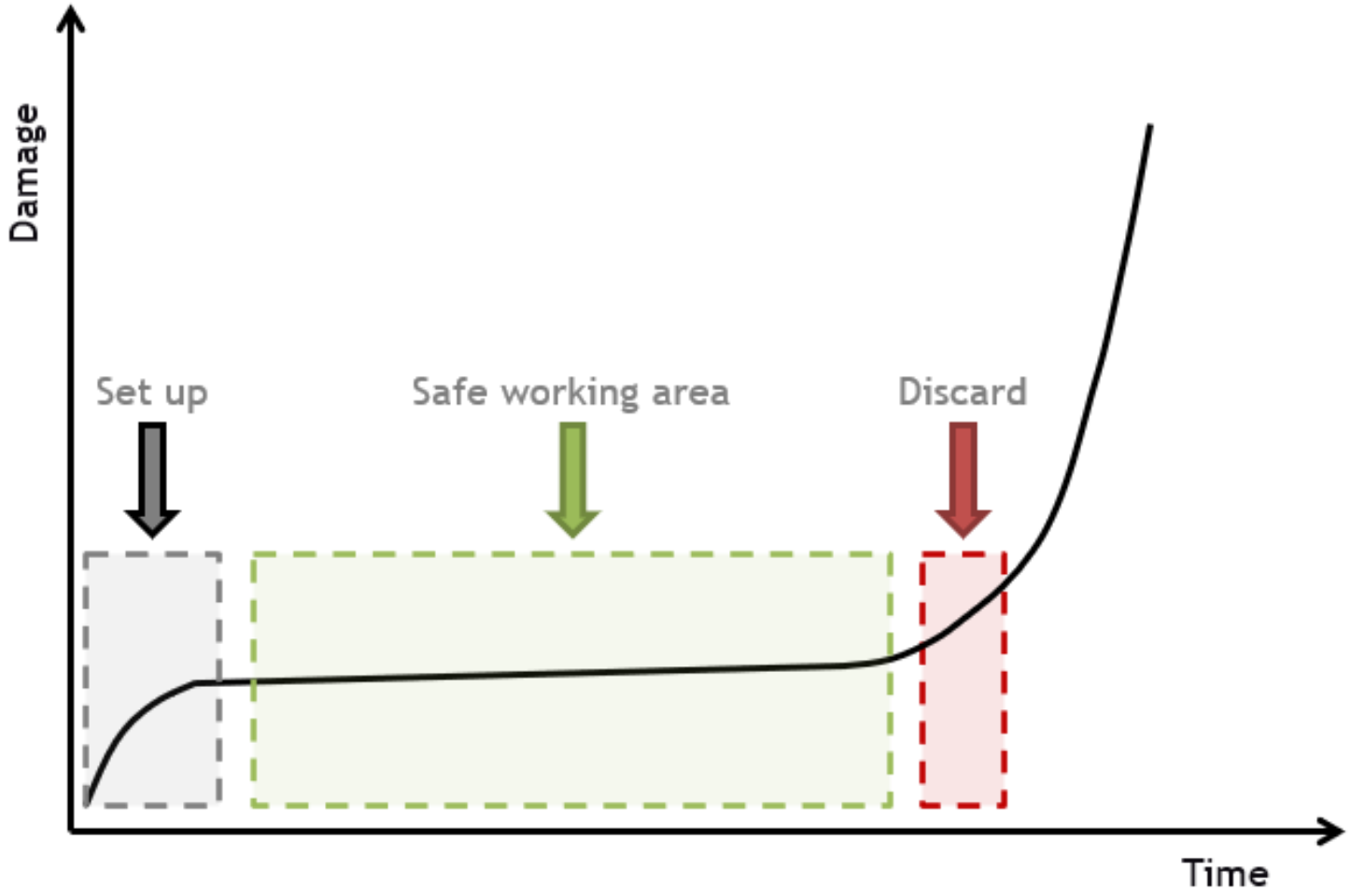
WIRE ROPES SAFETY

Wire ropes are safety components

1. Ropes are redundant — One single break does not affect rope integrity
2. Issues are detectable — Inspection gives indications about rope status
3. Damage is progressive — A rope will <u>not</u> break without any notice



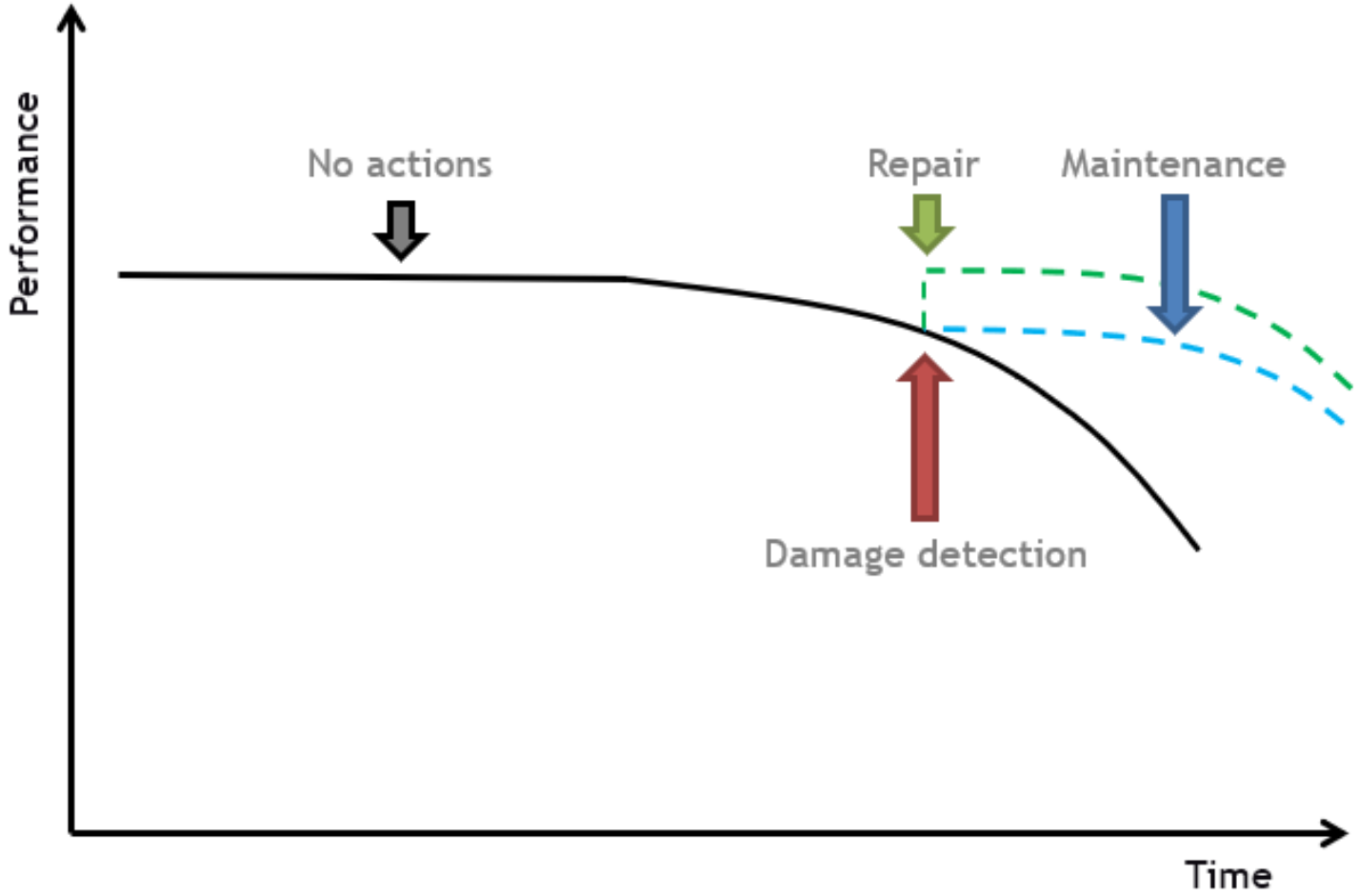
Evolution of rope damage



Evolution of rope damage

WIRE ROPES SAFETY

The importance of maintenance



Wire rope inspection and typical damages

Clearly it's the rope's fault…

WIRE ROPE INSPECTION

Type of inspections

- Visual Inspection (VI): non-destructive test of the state of a component by visual means only, possibly taking into account particular circumstances
- Magnetic Rope Testing (MRT): method of testing based on the detection of the magnetic flux leakage of a magnetized rope
- Optical Inspection device (OI): instrumentation designed to acquire and record images of the surface of a rope

WIRE ROPE INSPECTION

Where, what, when

- Where
  - Drum
  - Main reeving elements (block, sheaves, rollers etc.)
  - End connections
  - Areas subjected to specific stress, wear or other criticalities

- What
  - Diameter and lay length
  - Lubrication and corrosion level
  - Presence of external damages / abrasions, broken wires, loosen strands, etc.
  - Presence of permanent deformations and anomalies

- When
  - Periodically
  - On a special/extraordinary basis

ROPE DAMAGES

Corrosion

ROPE DAMAGES

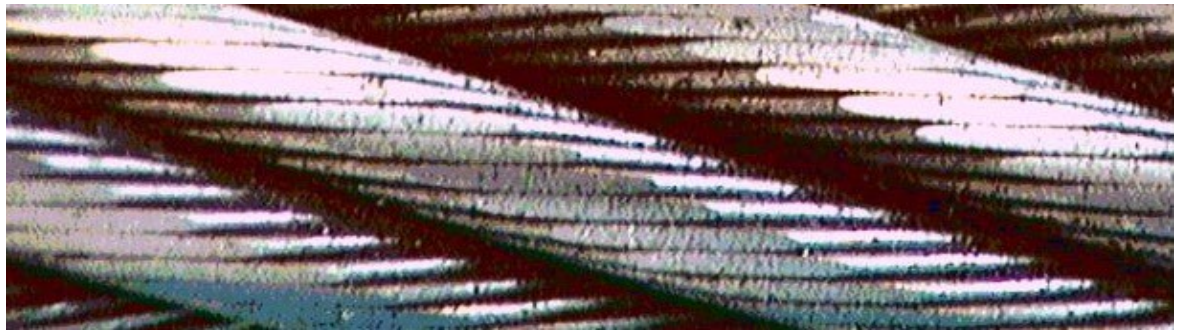
Corrosion

ROPE DAMAGES

Internal corrosion

ROPE DAMAGES

External wear

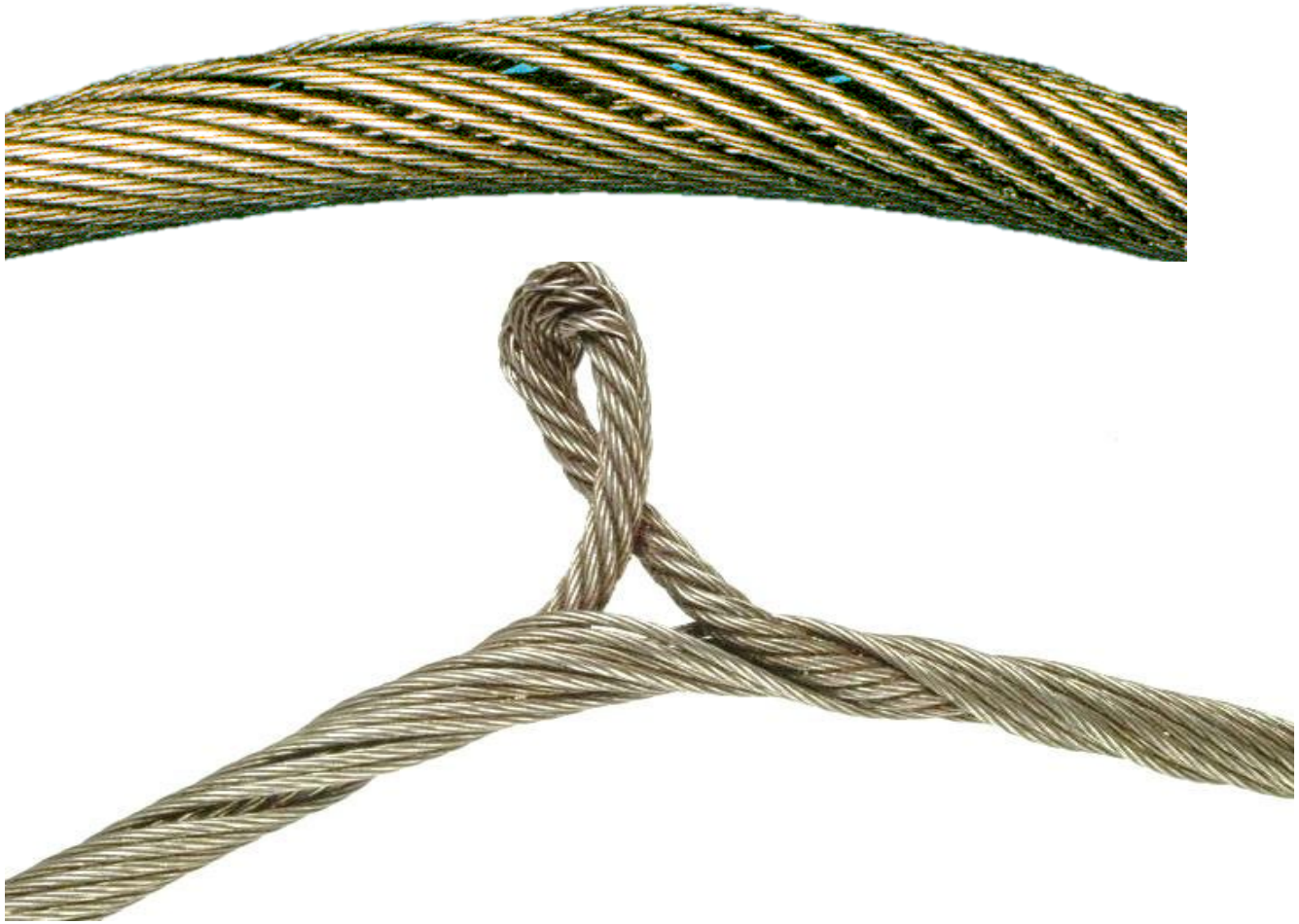


ROPE DAMAGES

Core damage

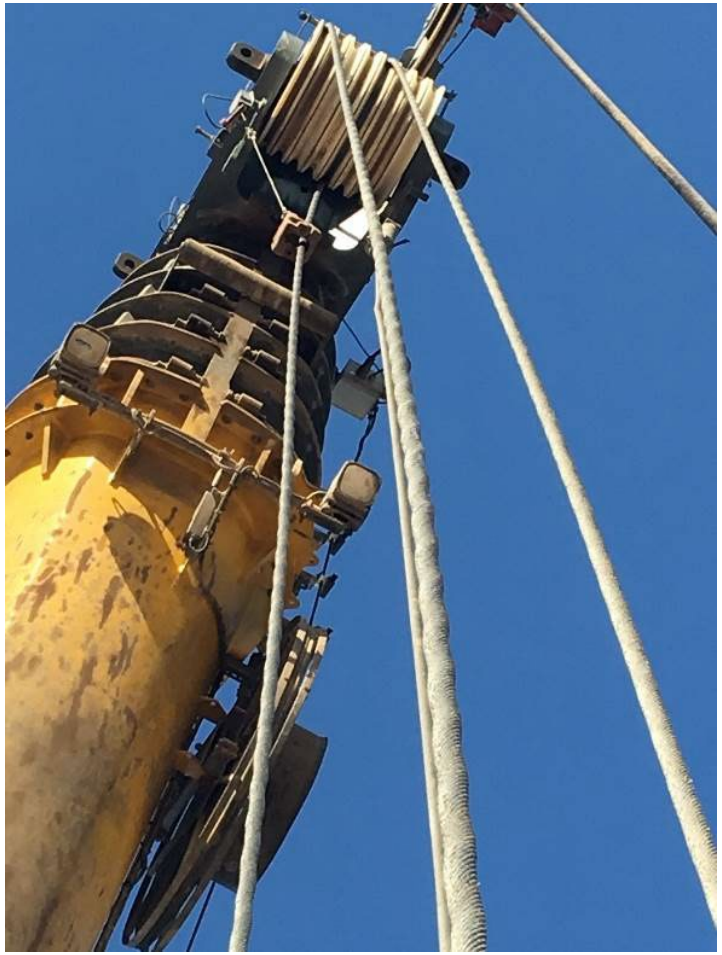
ROPE DAMAGES

Induced rotation – birdcage



ROPE DAMAGES

Waviness



ROPE DAMAGES

Spooling issues and cut in

ROPE DAMAGES

Spooling issues and squeezing

ROPE DAMAGES

Fatigue

ROPE DAMAGES

Very localized fatigue?

Wire rope discard criteria

ROPE DISCARD

Root cause analysis

- Defect
- Misuse, accidents
- Fatigue

Modes of deterioration

Mode of deterioration	Assessment method
Number of visible broken wires (including those which are randomly distributed, localized groupings, valley wire breaks and those that are at, or in the vicinity of, the termination)	By counting
Loss of metallic area caused by broken wires	Visual, MRT
Decrease in rope diameter (resulting from external wear/abrasion, internal wear and core deterioration)	By measurement
Loss of metallic area caused by mechanism other than broken wires e.g. corrosion, wear, etc.	Visual, MRT
Fracture of strand(s)	Visual
Corrosion (external, internal and fretting)	Visual, MRT
Deformation	Visual and by measurement (wave only)
Mechanical damage	Visual
Heat damage (including electric arcing)	Visual

Discard criteria – visible broken wires

	Nature of visible broken wire	Discard criteria
1	Wire breaks occurring randomly in sections of rope which run through one or more steel sheaves and spool on and off the drum when single-layer spooling or occurring at sections of rope which are coincident with cross-over zones when multi-layer spooling[a]	See Table 3 for single-layer and parallel-closed ropes and Table 4 for rotation-resistant ropes.
2	Localized grouping of wire breaks in sections of rope which do not spool on and off the drum	If grouping is concentrated in one or two neighbouring strands it might be necessary to discard the rope, even if the number is lower than the values over a length of $6d$, which are given in Tables 3 and 4.
3	Valley wire breaks[b]	Two or more wire breaks in a rope lay length (approximately equivalent to a length of $6d$)
4	Wire breaks at a termination	Two or more wire breaks

As a consequence of shipping, storage, installation and manufacturing, an individual wire can be broken. As such, isolated wire breaks are not attributed to deterioration resulting from in-service operation, such as bending fatigue on which the values in Tables 3 and 4 are largely based; they would not normally be counted when inspecting the rope for broken wires. Their existence, however, if discovered, should be recorded, as this can assist future inspections. The competent person shall take this factor into account when carrying out a periodic examination. See Figure 8.

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RCN – Rope Category Number

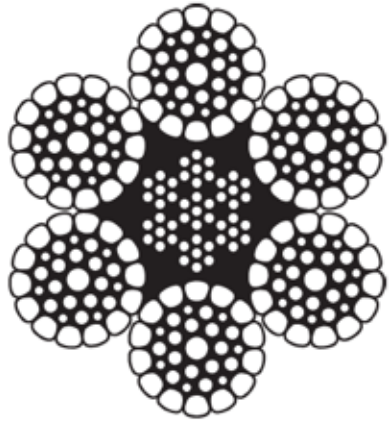
Rope category number (RCN) (see Annex H)	Total number of load-bearing wires in the outer layer of strands in the rope[a] n	Number of visible broken outer wires[b]					
		Sections of rope working in steel sheaves and/or spooling on a single-layer drum (wire breaks randomly distributed)				Sections of rope spooling on a multi-layer drum[c]	
		Classes M1 to M4 (ISO 4301-1:1986) or class unknown[d]				All classes	
		Ordinary lay		Lang lay		Ordinary and Lang lay	
		Over a length of $6d$ [e]	Over a length of $30d$ [e]	Over a length of $6d$ [e]	Over a length of $30d$ [e]	Over a length of $6d$ [e]	Over a length of $30d$ [e]
01	$n \leq 50$	2	4	1	2	4	8
02	$51 \leq n \leq 75$	3	6	2	3	6	12
03	$76 \leq n \leq 100$	4	8	2	4	8	16
04	$101 \leq n \leq 120$	5	10	2	5	10	20
05	$121 \leq n \leq 140$	6	11	3	6	12	22
06	$141 \leq n \leq 160$	6	13	3	6	12	26
07	$161 \leq n \leq 180$	7	14	4	7	14	28
08	$181 \leq n \leq 200$	8	16	4	8	16	32
09	$201 \leq n \leq 220$	9	18	4	9	18	36
10	$221 \leq n \leq 240$	10	19	5	10	20	38
11	$241 \leq n \leq 260$	10	21	5	10	20	42
12	$261 \leq n \leq 280$	11	22	6	11	22	44
13	$281 \leq n \leq 300$	12	24	6	12	24	48
	$n > 300$	$0{,}04 \times n$	$0{,}08 \times n$	$0{,}02 \times n$	$0{,}04 \times n$	$0{,}08 \times n$	$0{,}16 \times n$

NOTE Ropes having outer strands of Seale construction where the number of wires in each strand is 19 or less (e.g. 6 × 19 Seale) are placed in this table two rows above that row in which the construction would normally be placed based on the number of load bearing wires in the outer layer of strands.

[a] For the purposes of this document, filler wires are not regarded as load-bearing wires and are not included in the values of n.

Construction: 6 × K36WS-IWRC

Single-layer rope with compacted strands



RCN.09

6 x 26 = 156 -> RCN 06

6 x 31 = 186 -> RCN 08

6 x 36 = 216 -> RCN 09

Discard criteria – decrease in diameter

Table 5 — Uniform decrease in diameter signalling discard of rope — Rope spooling on a single-layer drum and/or running through a steel sheave

Rope type	Uniform decrease in diameter (expressed as percentage of nominal diameter)	Severity rating	
		Description	Percentage, %
Single-layer rope with fibre core	Less than 6 %	—	0
	6 % and over but less than 7 %	Slight	20
	7 % and over but less than 8 %	Medium	40
	8 % and over but less than 9 %	High	60
	9 % and over but less than 10 %	Very high	80
	10 % and over	**Discard**	**100**
Single-layer rope with steel core or parallel-closed rope	Less than 3,5 %	—	0
	3,5 % and over but less than 4,5 %	Slight	20
	4,5 % and over but less than 5,5 %	Medium	40
	5,5 % and over but less than 6,5 %	High	60
	6,5 % and over but less than 7,5 %	Very high	80
	7,5 % and over	**Discard**	**100**
Rotation-resistant rope	Less than 1 %	—	0
	1 % and over but less than 2 %	Slight	20
	2 % and over but less than 3 %	Medium	40
	3 % and over but less than 4 %	High	60
	4 % and over but less than 5 %	Very high	80
	5 % and over	**Discard**	**100**

If there is an obvious local decrease in diameter, such as that caused by failure of a core or rope centre, the rope shall be discarded (for an example of a decrease associated with a sunken strand, see Figure B.5).

Discard criteria – corrosion

Type of corrosion	Condition	Severity rating
External corrosion[a]	Signs of surface oxidation but can be wiped clean Wire surface rough to touch **Wire surface heavily pitted and slack wires**[b]	Superficial — 0 % High — 60 %[c] **Discard — 100 %**
Internal corrosion[d]	**Obvious visible signs of internal corrosion — i.e. corrosion debris exuding from the valleys between the outer strands**[e]	**Discard — 100 %** or if deemed practicable by the competent person, internal examination in accordance with the procedure described in 6.3 or Annex C
Fretting corrosion	The process of fretting involves the removal of fine particles of steel from the wires due to dry wires and strands constantly rubbing together and then oxidizing and creating internal corrosion debris, which manifests itself as a dry powder, similar to a red rouge.	Evidence of such a characteristic should be further investigated and if there is any doubt about its severity, the rope should be discarded (100 %).

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Severity matrix

Example	Severity rating of individual modes of deterioration %					Combined severity rating %	Comment
	Wire breaks		Decrease in diameter[a]	Corrosion			
	Visual	MRT LF		External	MRT LMA		
1	0	—	20	20	—	40	Safe to continue
2	20	—	20	0	—	40	Safe to continue
3	20	—	20	20	—	60	Safe to continue
4	40	—	20	20	—	80	Inspect more frequently
5	40	—	40	0	—	80	Inspect more frequently
6	0	—	80	0	—	80	Consider discard if reduction in diameter is mainly attributed to external wear
7	60	—	0	0	—	60	Inspect (particularly for broken wires) more frequently
8	60	—	20	0	—	80	Inspect more frequently (particularly for broken wires) and prepare for replacement
9	20*	20	20	20*	20	60	Safe to continue
10	10	30*	20	20*	20	70	Inspect more frequently
11	20*	20	20	10	30*	70	Inspect more frequently
12	10	30*	20	10	30*	80	Inspect more frequently
13	0	30	20	0	30*	80	Inspect more frequently

Figures with asterisk, e.g. 30*, indicate which of the two criteria are to be considered.

[a] Only taken into account when rope travels through steel sheave and/or spools on to single-layer drum.

Different mix, different outcomes

What you know NOW about wire ropes

- Safety
- Inspection and typical damages
- Discard criteria

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