Transocean Lifting Course
Wire Rope Examination

- Inspection and examination - differences
- Standards and Legislation
- What is a wire rope? - types/description
- Rope deterioration
- Examination procedures
- Individual discard criteria
- Cumulative effect and records
- Short written test

The difference between rope inspection and examination - Inspection

- Inspection – visual check to ensure that all ropes are correctly positioned on their sheaves and drums and have not been displaced

- When carried out – routine pre-use check - daily before start-up

- By whom – driver/operator may be authorised to carry out periodic checks and inspections to the extent that he is considered to be competent

The difference between rope inspection and examination - Inspection

- **Inspection – visual inspection of all ropes for broken wires, flattening, basket distortion or other signs of damage, excessive wear and surface corrosion**

- **When carried out – weekly, two weekly or monthly as determined by the competent person**

- **By whom – the appointed person –** *[the driver/operator may be authorised to carry out periodic checks and inspections to the extent that he is considered to be competent]*

The difference between rope inspection and examination – Thorough examination

- **Thorough examination – in-depth visual inspection plus** *(when practical)* **assessment of internal condition of rope, supplemented by other means such as diameter measurement and NDT** *(e.g. electro-magnetic)*

- **When – pre-determined routine intervals** *(e.g. as determined by legislation)***; after installation on new site; after major alteration or repair; or after occurrence of exceptional circumstances which may jeopardise the safety of the crane**

Thorough examination – Competent person

- **Should be trained and assessed** *(with documentary evidence)* **for the type of ropes and terminations that are to be examined**
- **Should be independent and impartial to allow objective decisions to be made** *(recommendations made without fear or favour)*
- **Should be fully conversant with the manufacturer's instructions**
- **Should be fully conversant with the relevant Standards/Codes applicable to the ropes and equipment being examined** *(e.g. ISO 4309; API 2D)*

Primary Functions of Rope Examiner (Competent person)

- To establish the condition of a rope
- To assess whether or not it is fit *(i.e. safe)* to remain in service

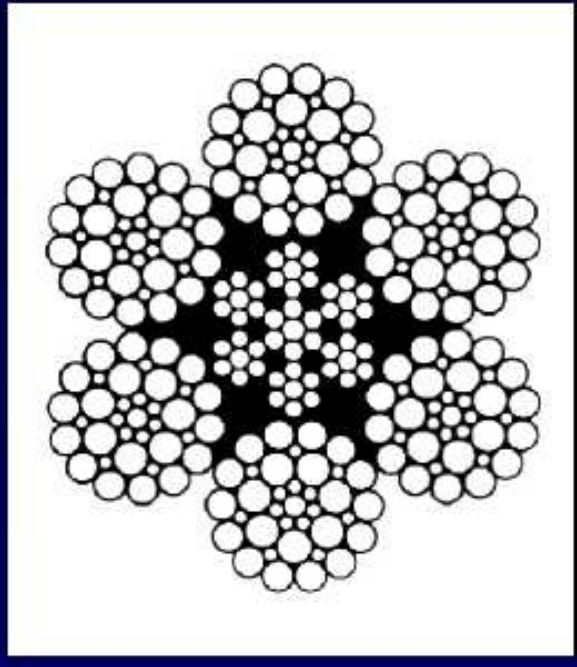
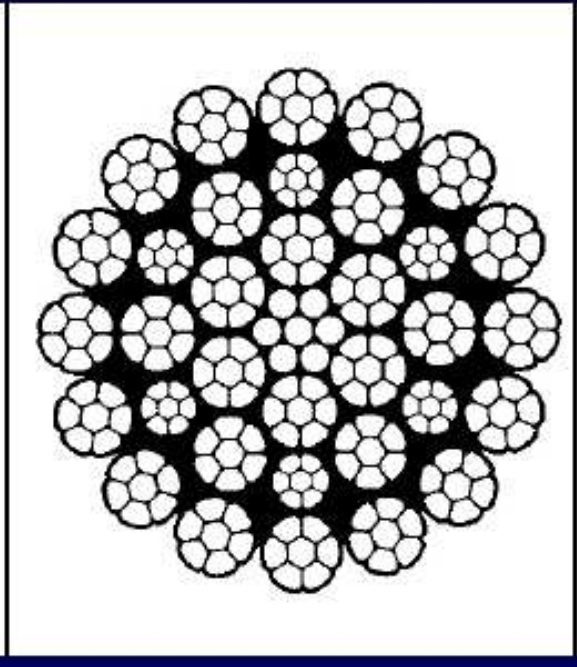
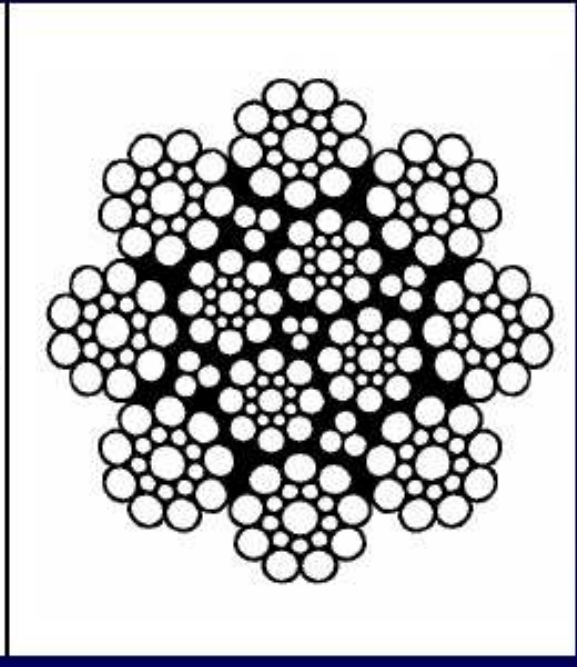
Competent Person
should take into account

- Current regulations (Local / National (e.g. LOLER)/European)
- Machinery handbook (safe use/discard criteria)
- Related standards/Codes of practices (e.g. ISO 4309; API 2D)
- Rope duty/Reeving system
- Frequency of use
- Previous rope history (performance/rope type)

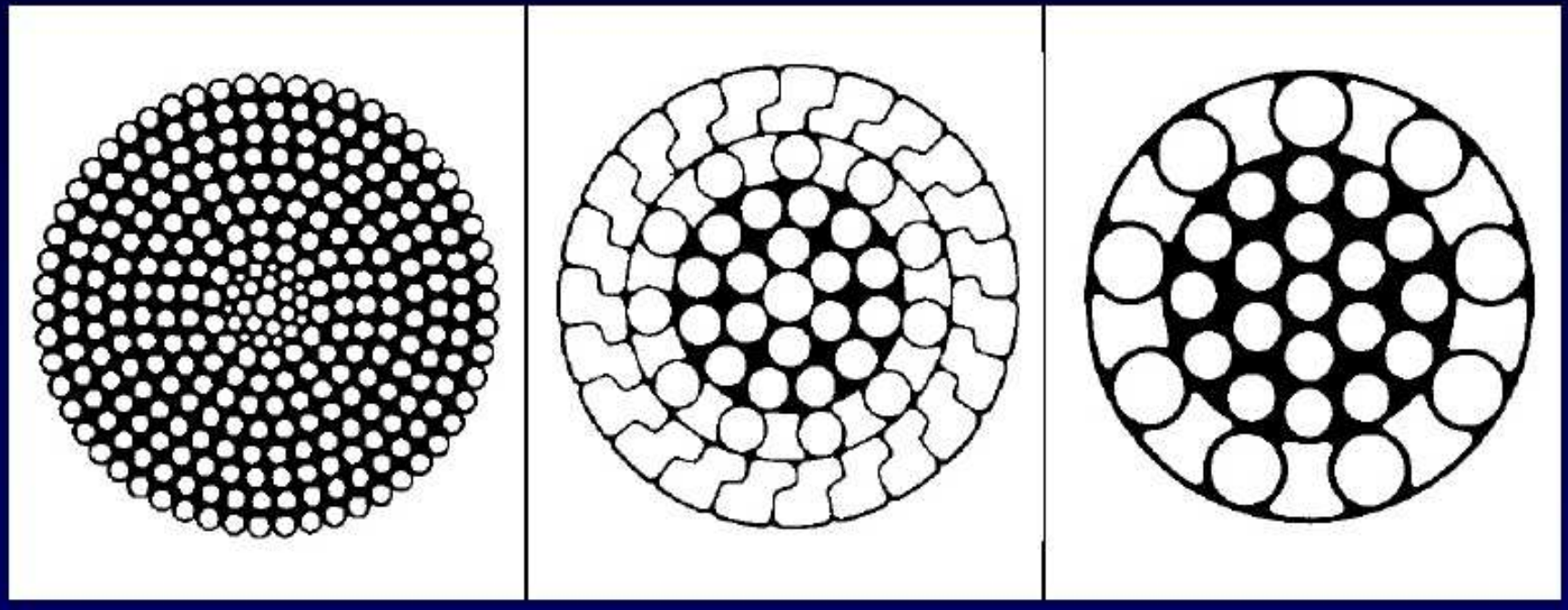
Two basic types of rope

- Stranded rope
- Spiral rope

Stranded Rope - 3 basic types

Blue Strand	Dyform 34LR	DSC 8
		
Single layer	Rotation-resistant	Parallel-closed

Spiral Rope - 3 basic types



Spiral strand

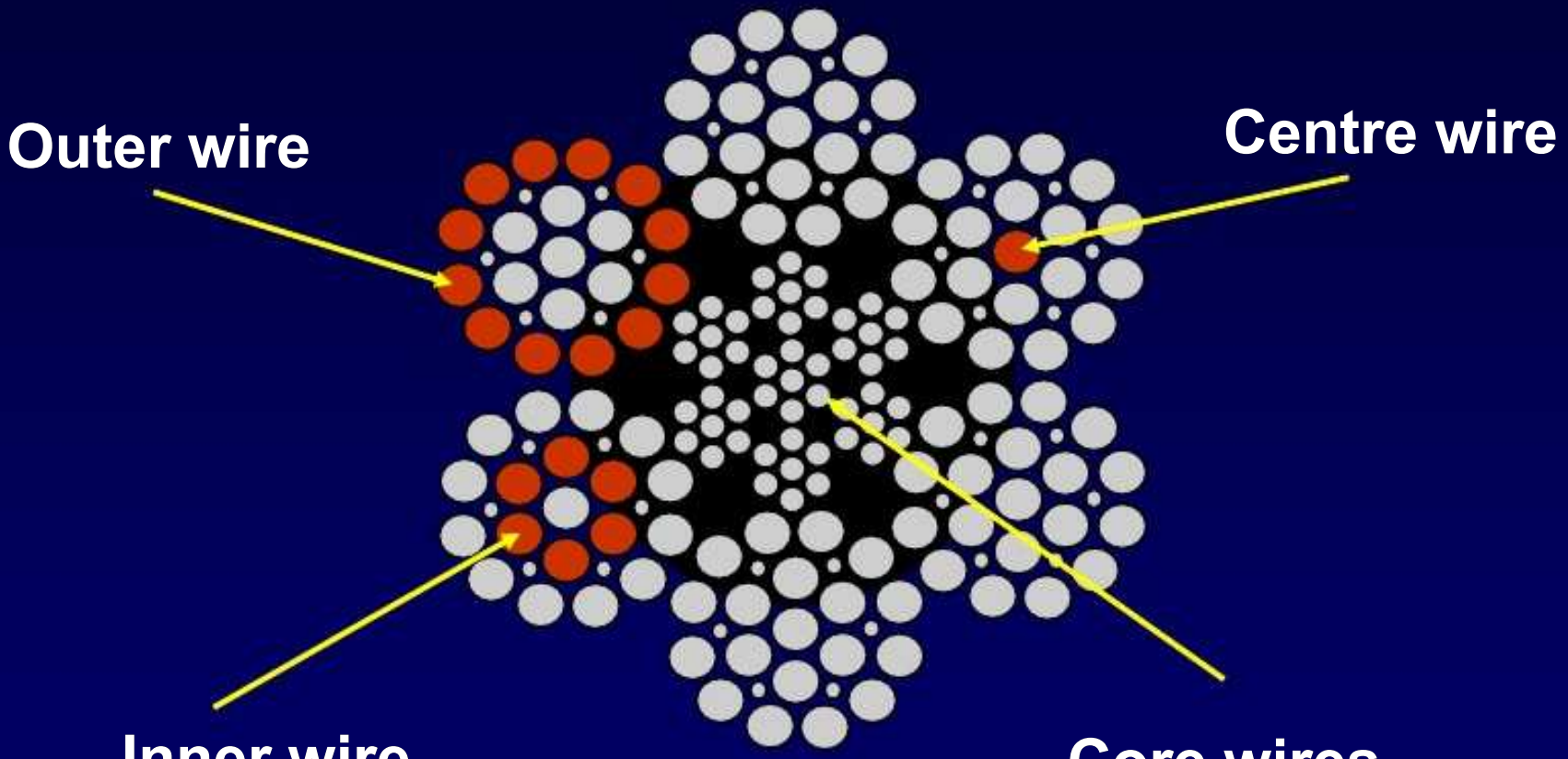
Full-locked coil

Half-locked coil

Stranded Rope
Single Layer

- One layer of outer strands (usually 6 or 8) laid helically over a centre core of fibre or steel
- Illustration - rope with independent wire rope core (IWRC)

Wires in a Stranded Rope

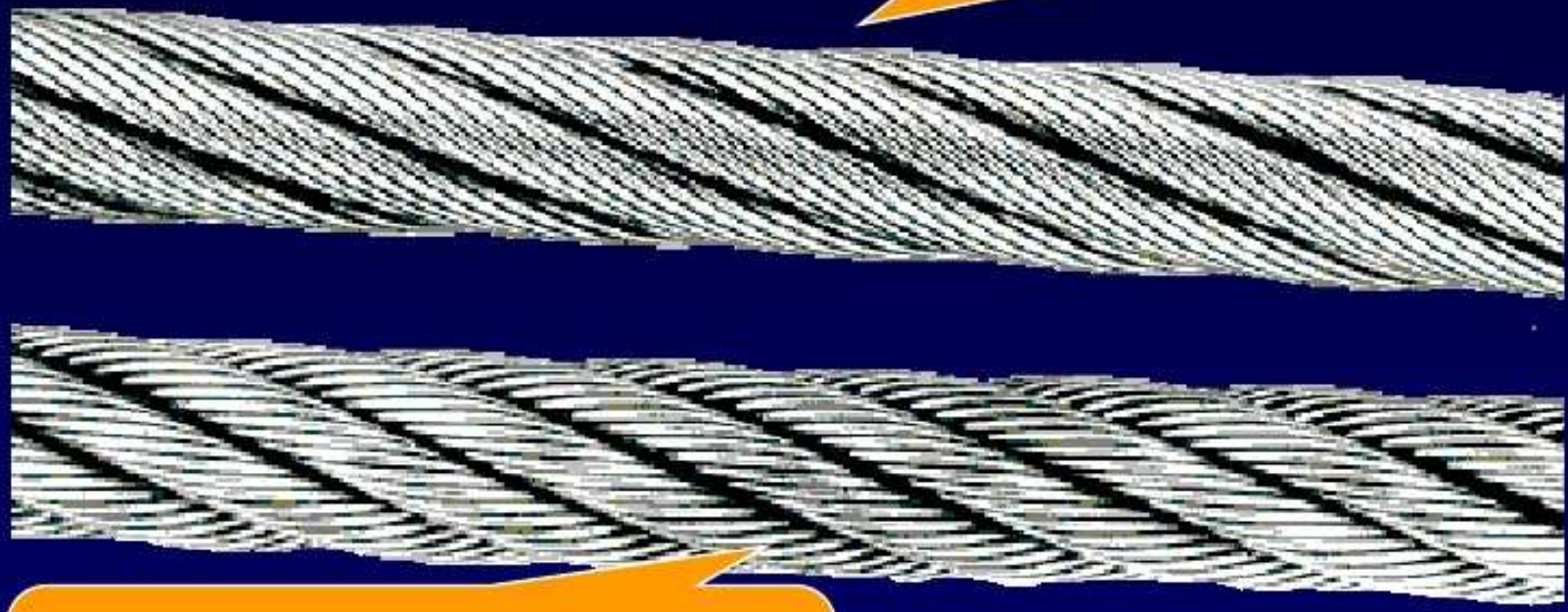


Cores for stranded steel wire rope

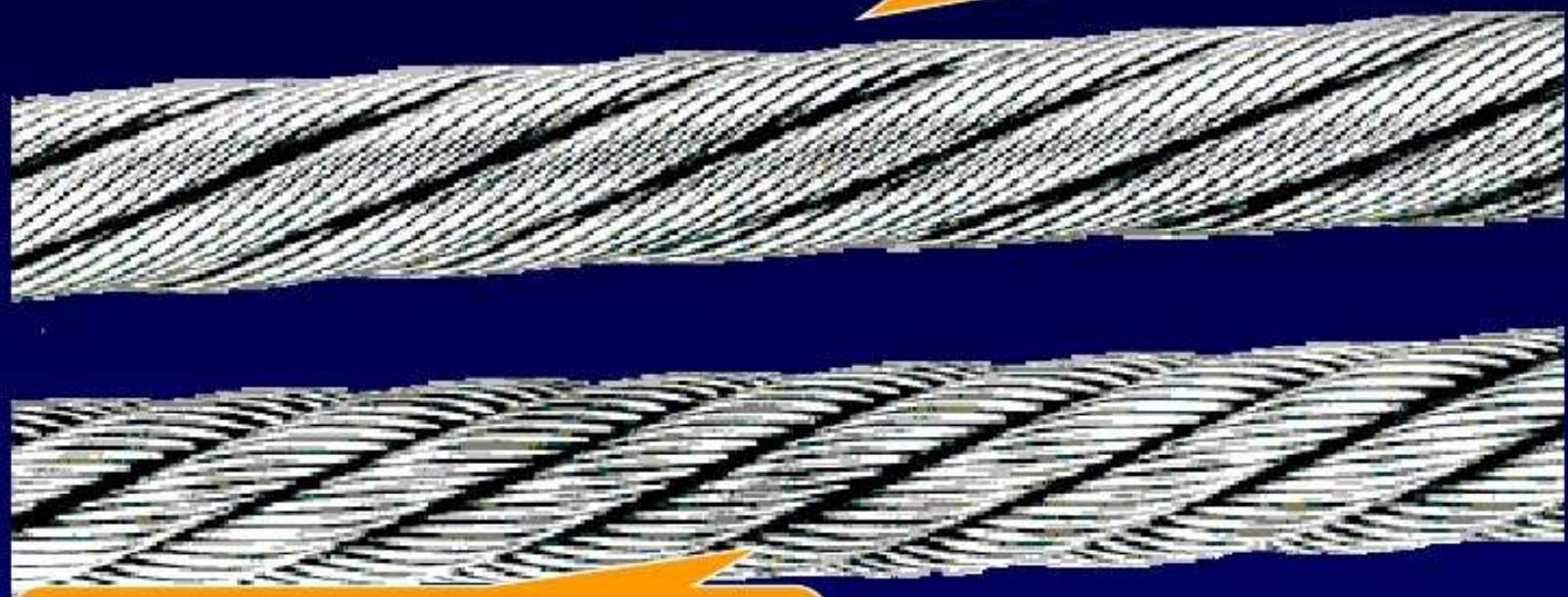
- **The core maintains the circular section of the rope by supporting the strands around it**

- **2 main types of core:**
  - Fibre cores
    - **natural (e.g. Manila, Jute or Sisal) = FC**
    - **man made (e.g. polypropylene) = FFC**
  - Steel cores
    - **Independent Wire Rope Core = IWRC or Wire Strand Core = WSC**
    - **Core covered with polymer = PIWRC**

Right Hand Lay Ropes



Left Hand Lay Ropes



Left Hand Langs (LHL)

Left Hand Ordinary (LHO)

Rope Grade (R_r)

Identifies the level of minimum breaking force (kN) or minimum breaking load (t)

- **Examples**
  - **1770 Grade**
  - **1960 Grade**
  - **2160 Grade**
  - **1370/1770 Grade**
    - **(dual tensile)**
- **American Grades**
  - **IPS**
  - **EIPS**
  - **EEIPS**

Tensile Strength and Finish of Wire

- **Wire tensile strength grade**
  - **Examples**
    - **1180; 1370; 1570; 1770; 1960; 2160 N/mm^2**
- **Wire finish**
  - **Examples**
    - **bright (ungalvanised)**
    - **zinc coated (galvanised) [or zinc alloy coated]**

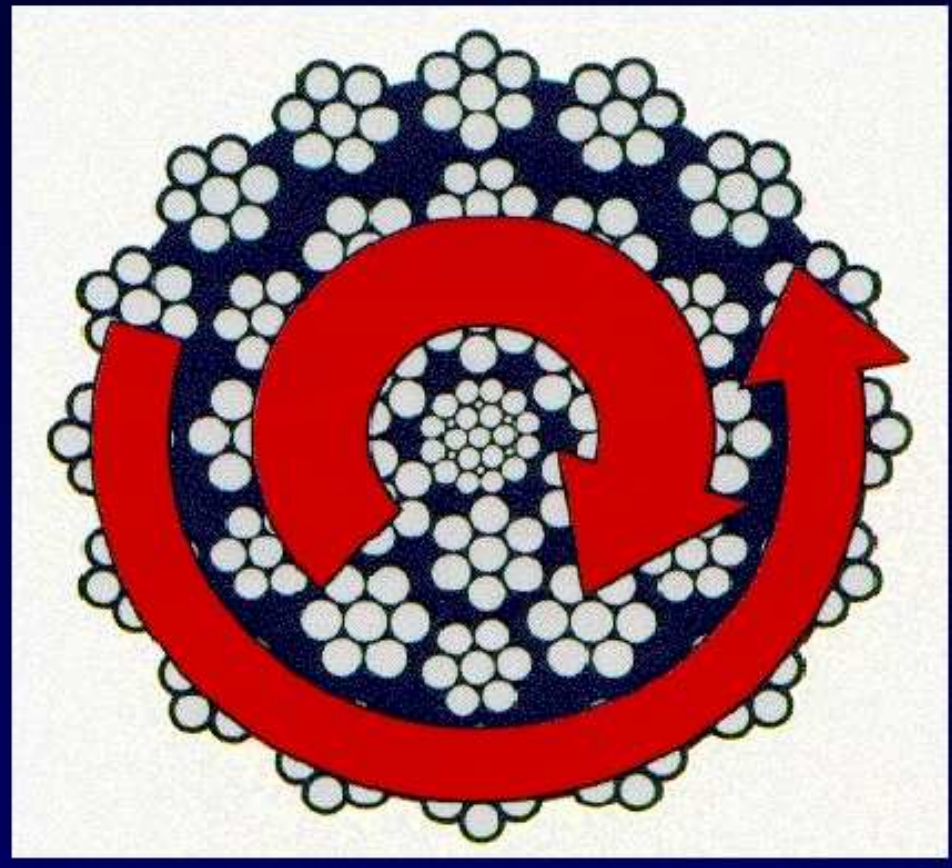
Example of Rope Description/Designation

- **22mm dia. 6x36 IWRC 1960 Ung/BT RHO**
- **22mm 6x36WS-IWRC 1960 U sZ** *(New European and International standards designation)*

– **22mm dia**	=	**Size** *(nominal diameter)*
– **6x36**	=	**Rope construction**
– **IWRC**	=	**Core type**
– **1960**	=	**Rope grade**
– **Ung**	=	**Finish of wires**
– **RHO**	=	**Direction and type of lay**

Rotation-resistant rope

(Illustration is BRIDON product 35LS - Low rotation rope)



Summary of Rope Lays
(Stranded ropes)

- **Ordinary Lay** (RHO or LHO) **sZ or zS**
- **Langs Lay** (RHL or LHL) **zZ or sS**
- **Alternate Lay** **aZ or aS**

Summary

- More wires in the outer strand (e.g. 6x36) will give improved fatigue characteristic
- Less wires in the outer strand (e.g. 6x19S) will give improved wear/abrasion characteristic
- Steel core (IWRC) better resists drum crushing than fibre core (FC) rope
- Langs lay resists interference better than ordinary lay BUT both ends must be fixed if single layer (6 or 8 strand rope) or parallel-closed type (DSC)

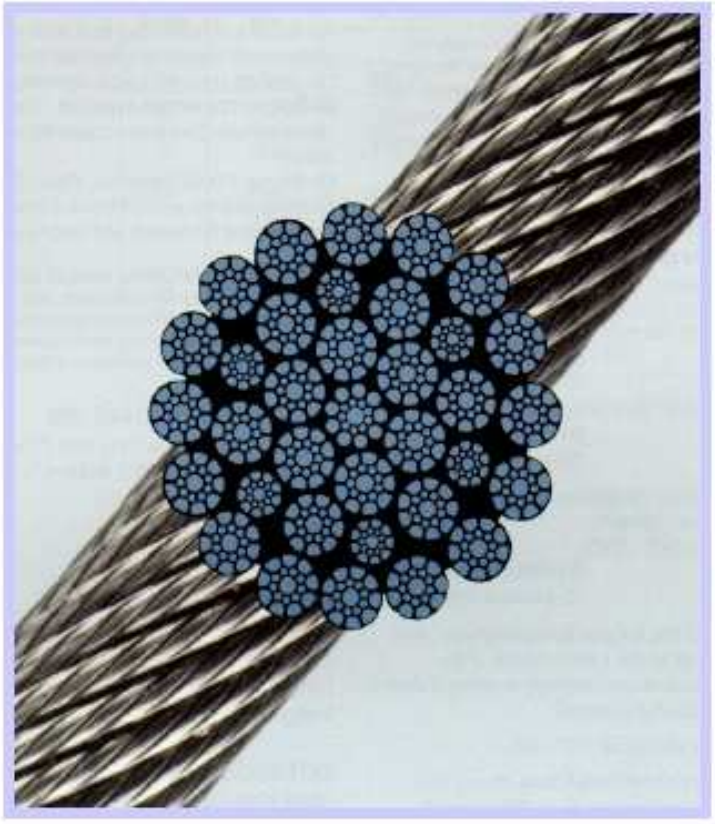
Summary

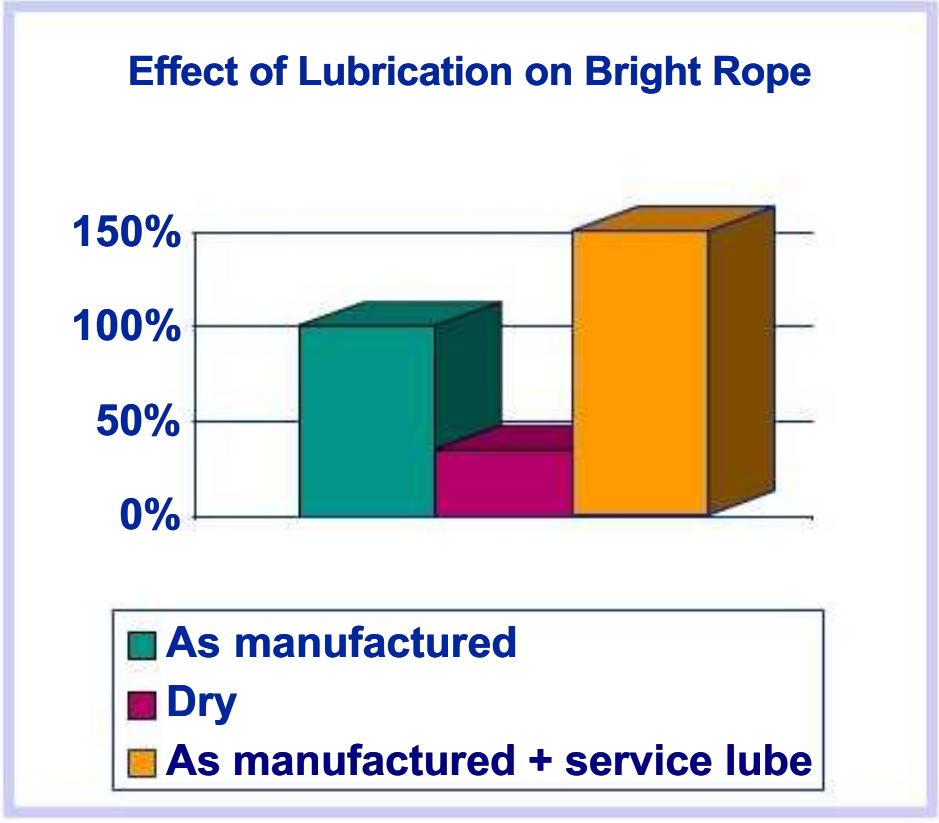
- *Rope performance characteristics*

  Additional factor which can affect rope performance

  - **Lubrication**
  - **During manufacture**
  - **In service**

Effect of lubrication
Bend fatigue tests - DYFORM 34LR



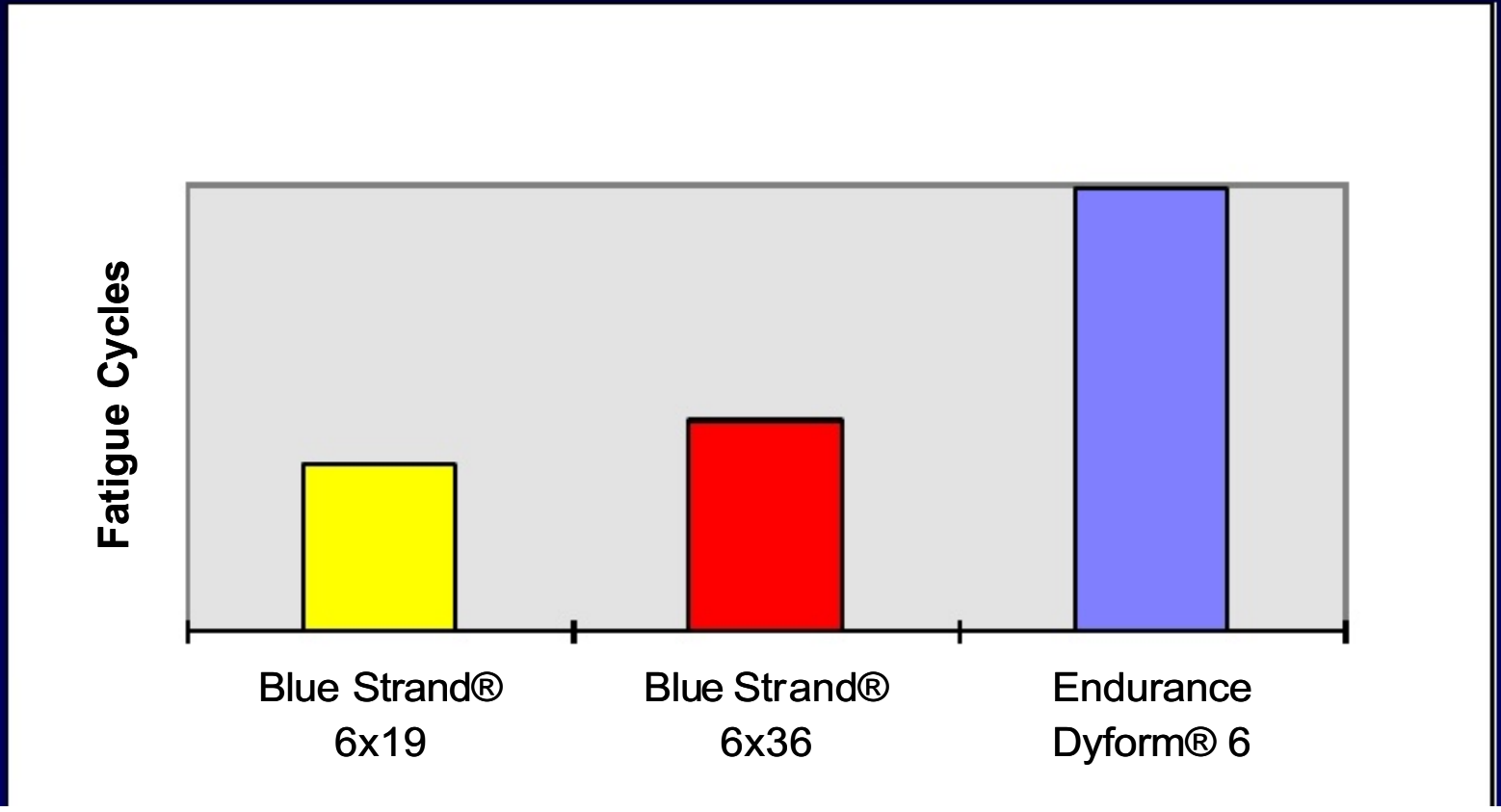


Fatigue

- **Bending fatigue**
- **Pulsatary** *(tension-tension)* **fatigue**
- **Torsional fatigue**

Bending fatigue resistance
Bridon Dyform® 6 v Blue strand ®

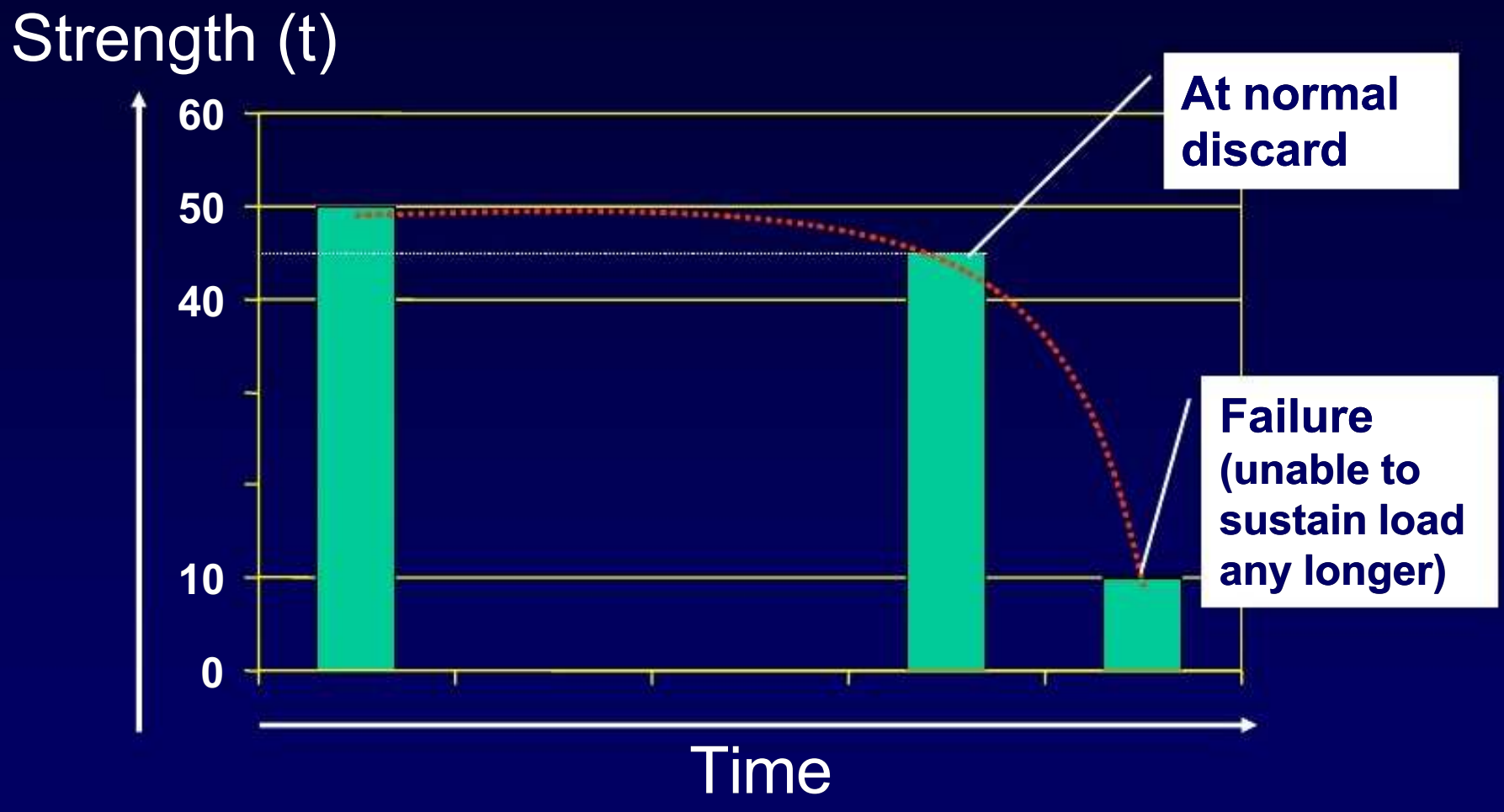
Continuous cycling - Constant tension – Zero fleet angle



TERMINOLOGY

- Minimum breaking force of rope - MBF
- Minimum breaking load of rope - MBL
- Working load limit - WLL
- Safe working load - SWL
- Ultimate strength of fitting
- Design factor/safety factor/factor of safety/coefficient of utilisation
- Terminal efficiency
- Bending ratio (D:d) - sheave dia:rope dia

Rope Deterioration → Loss in strength → Ultimate failure



Factors Causing Rope Deterioration

Normal wear and tear

Abrasion

Fatigue

Corrosion *(internal/external/fretting)*

Mechanical damage

Deformations

Rotation

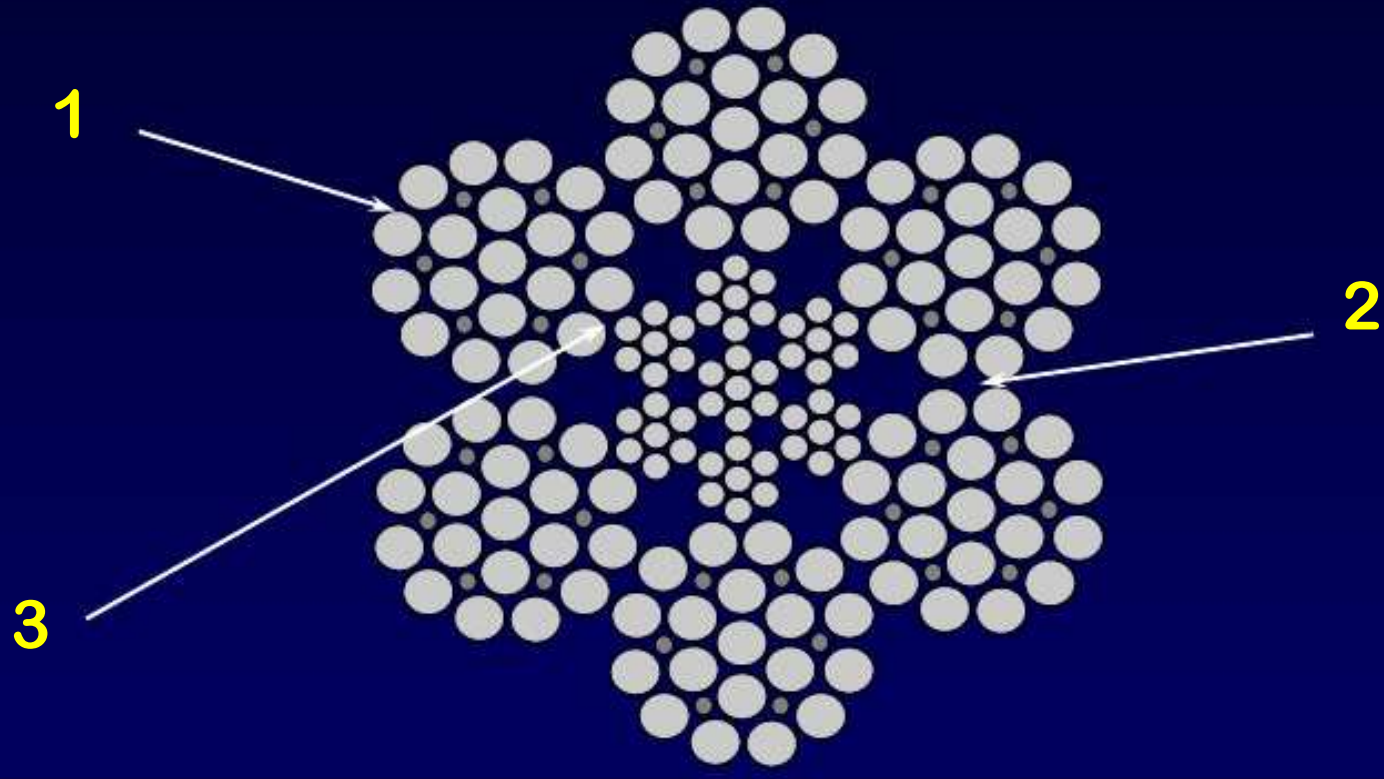
Thermal damage *(overheating)*

Termination failures

EXTERNAL WEAR

- Can also be affected by environmental conditions, e.g. abrasive dust

Areas of wear in a rope



1 = Crown wear

2 = Inter-strand wear/pressure marking (internal)

3 = Strand core wear/pressure marking (internal)

EXTERNAL WEAR

- Influenced by the following:
  - Rope tension
  - Size of drum /size of sheave
  - Number of sheaves in system
  - Condition of drum / sheave(s)
  - Rate of acceleration
  - Momentum of sheave(s)/roller(s)
  - Fleet angle & spooling arrangement at drum
  - Incorrect methods of operation

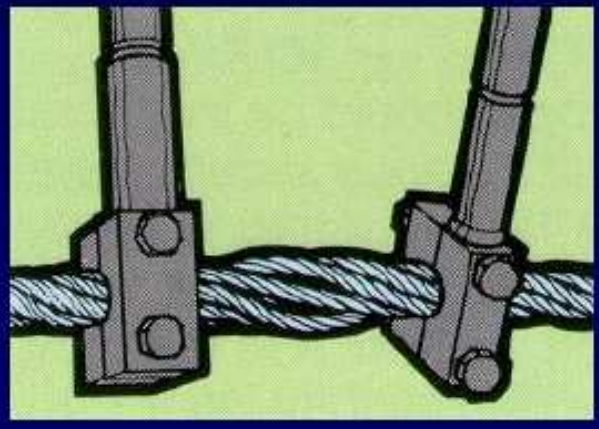
Examples of external wear

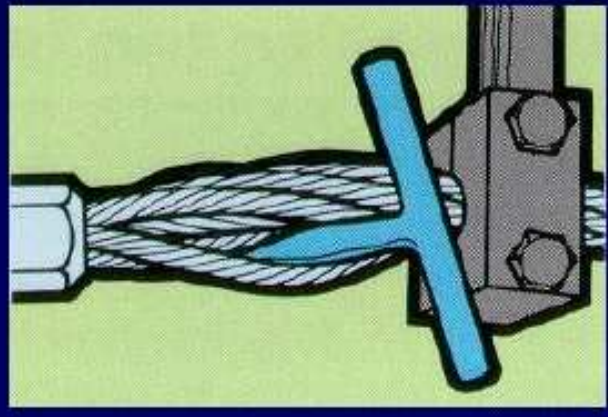
INTERNAL WEAR

- Results from pressure, stress and internal friction
- Influenced by
  - Level of rope tension and amplitude
  - Bending ratio and frequency of bending
  - Amount of lubricant/dressing in service

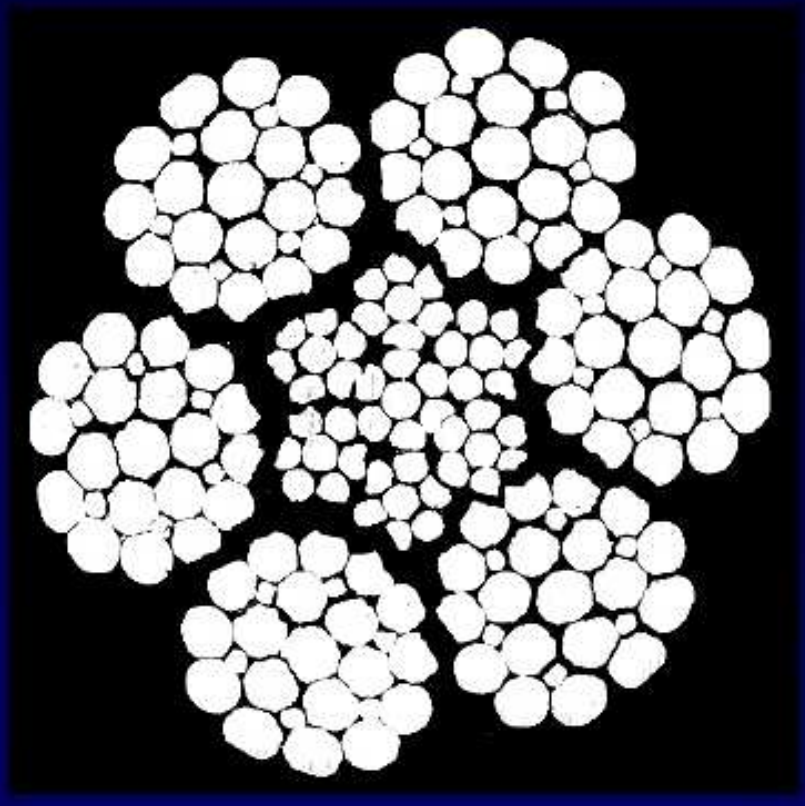
INTERNAL WEAR

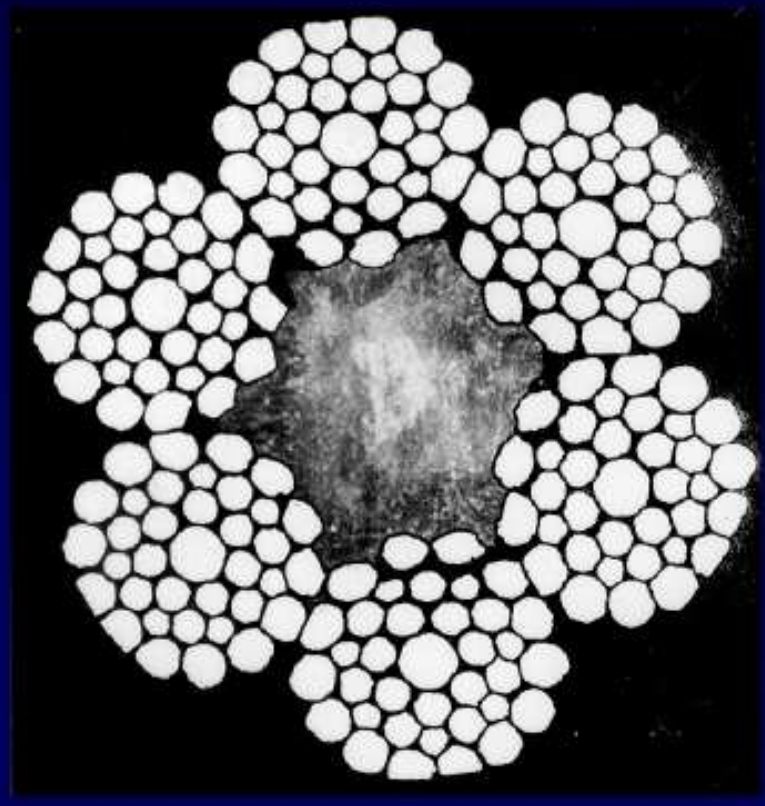
Unable to assess without opening rope up





Examples of Internal Wear and Corrosion





Severe wear - abrasion

- **Expected - associated with normal duty**
  - **e.g. drag rope on dragline; trawl warp**
- **Unexpected**
  - **e. g. contact with adjacent structure; seized sheave/pulley/roller/fairlead; undersized sheaves/pulleys; misaligned sheaves/pulleys**

Abnormal abrasion = Heat generated + cooling at rapid rate = Possibility of martensite *(exceptionally hard skin with transverse cracks)* **being formed**

Example of abrasive wear

Examples of External and Internal Corrosion

MECHANICAL DAMAGE

- During storage/handling
- During installation - forming kinks & bends
- In service - rope jumping out of sheave
- Incorrectly profiled sheave grooves
- Poor/uncontrolled spooling at drum

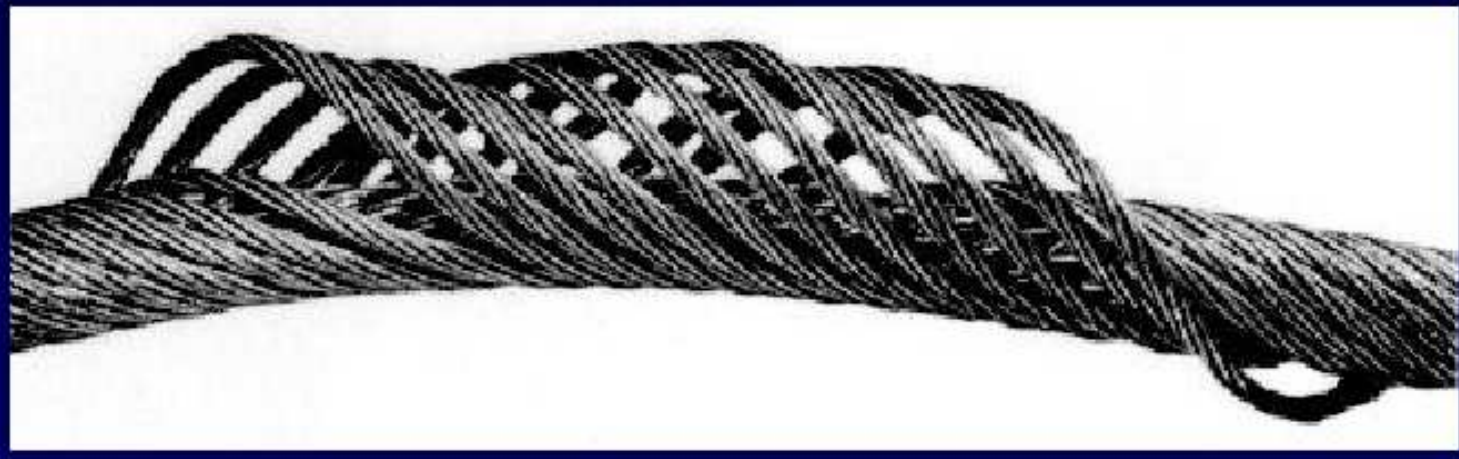
THERMAL DAMAGE

- Too high operating temperature - loss in strength
- Improperly grounded welding leads - localised damage

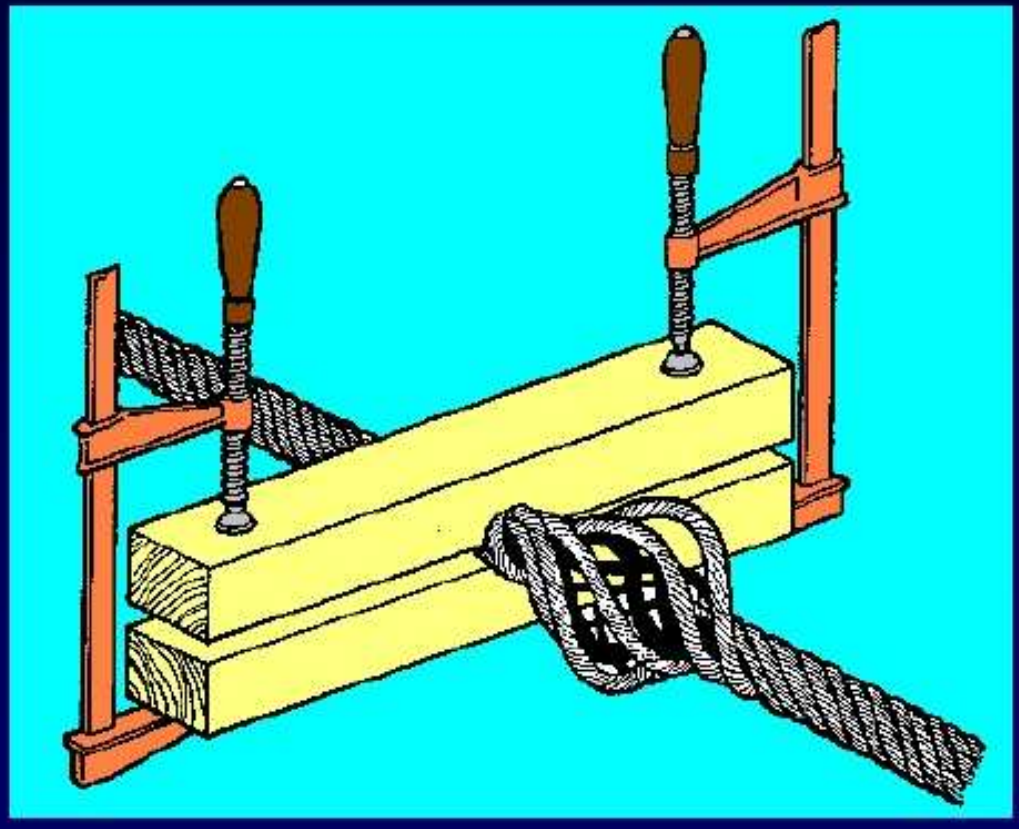
Deformations

- Can result from:
  - incorrect installation procedure
  - shock loading
  - unacceptable fleet angle - causing rolling of rope
  - tight groove profiles

Example of ‘birdcage’ due to incorrect method of installation

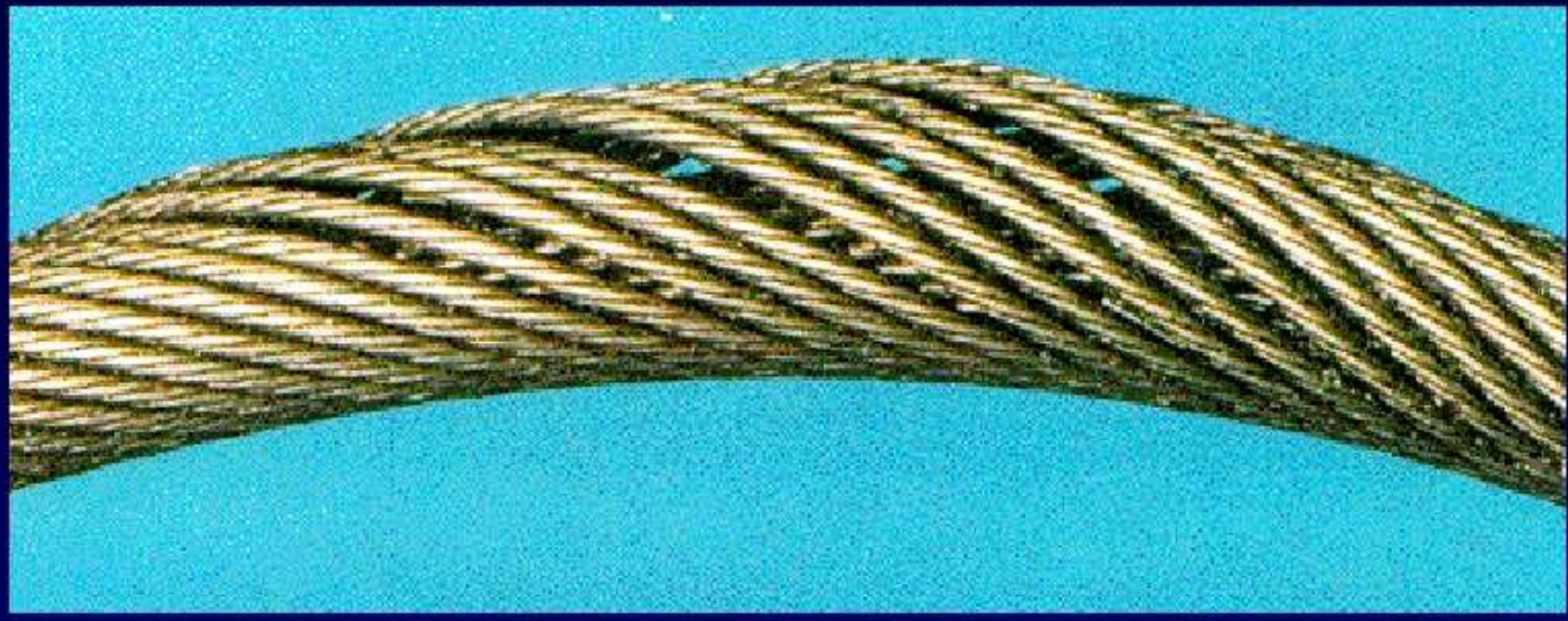


Incorrect handling during installation



This method will cause rope damage!

‘Bird Cage’

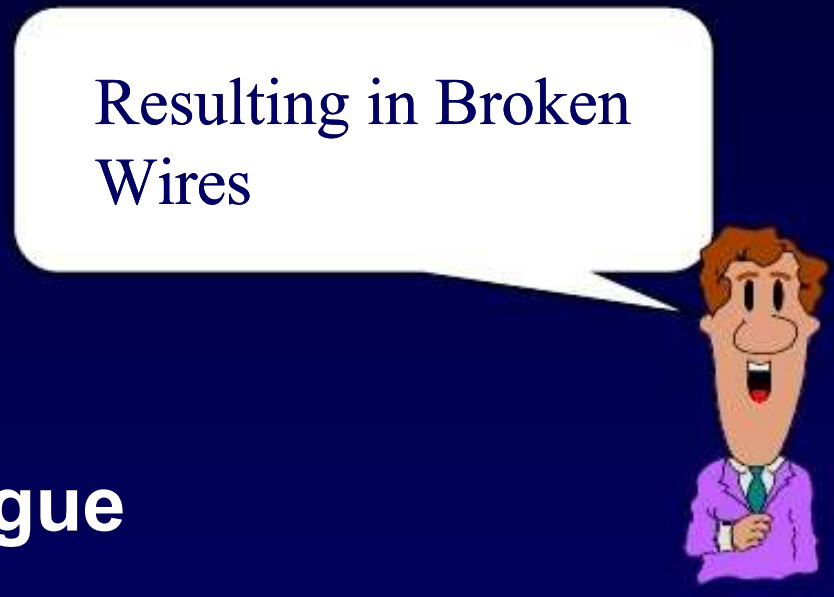


ROTATION / TURN

- Incorrect handling/installation techniques
- Incorrect use of swivel
- Wrong rope for job

FATIGUE

- **Bending fatigue**



- **Tension - tension fatigue**

- **Torsional fatigue**

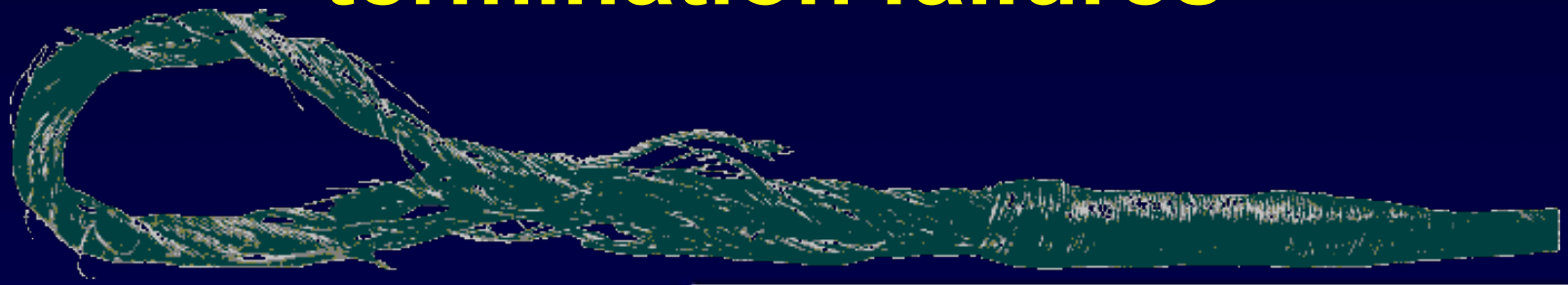
Examples of Broken Wires Due to Fatigue

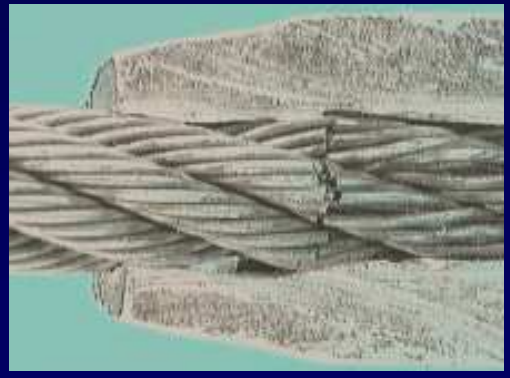
upper rope: 6 strand
lower rope: rotation-resistant

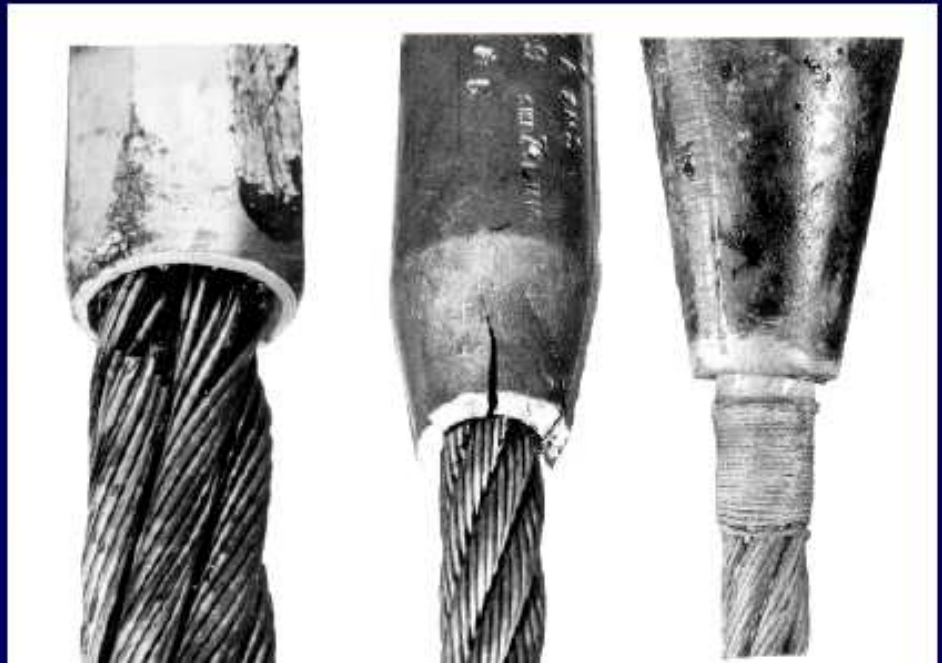
TERMINATION FAILURES

- Incorrect fitting of termination
- Failure to maintain (e.g. re-terminate wedge socket) in service
- Incorrect selection of termination
- Inadequate inspection / examination

Examples of termination failures







CERTIFICATE OF TEST OF WIRE ROPE

Test Certificate Number Z12345A / F1851923/51

DESCRIPTION OF WIRE ROPE

Trulift 8F
13 mm dia 8x19S FC 1370/1770 BT RHO ZL010005 MBL 6,45t

Rope Number	Z12345A	
Quantity and Rope Length	1 x 2800	(m)
Date of Manufacture	05/08/96	

DETAILS OF TEST

Method of Test	IS0 3108	
Date of Test	05/08/96	
Breaking Load	> 6,45	(t)
Safe Working Load at a Coefficient of Utilisation of 5 *	1,29	(t)

OTHER INFORMATION

Testing Machine Calibrated to BS EN 10002-2
BRIDON Product Code : 13.00819AF11RA
Actual breaking load - 7,02t

* If the rope is to be used at a coefficient of utilisation different from the example above, it should be re-rated by a competent person

Rope Strength

		Unit
– Minimum Breaking Force	MBF	kN
or		
– Minimum Breaking Load	MBL	tf

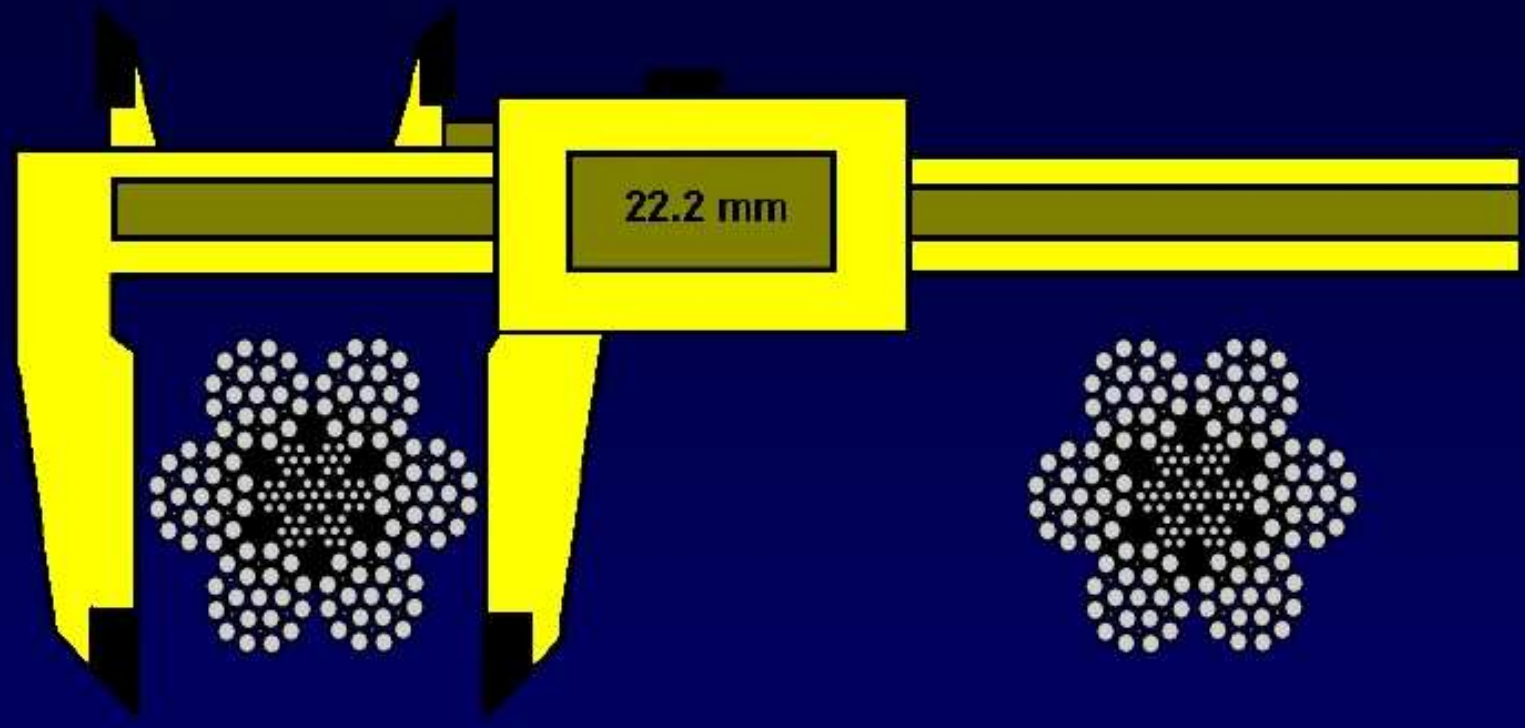
(MBF/9.81=MBL)

Tool kit

- **Rope caliper/vernier**
- **Sheave groove gauge**
- **Tape measure**
- **Chalk/electricians tape**

- **Cleaning materials**
- **Notebook & pencil** (or tape recorder)
- **Pliers**
- **Clamps** (wood or steel)
- **Straight edges**
- **“T” needle** (flat spike with rounded edges; modified screwdriver)
- ppe

Rope dimensions – caliper/vernier



Actual (measured) **diameter**
22.2 mm

Nominal diameter (*d*)
22 mm

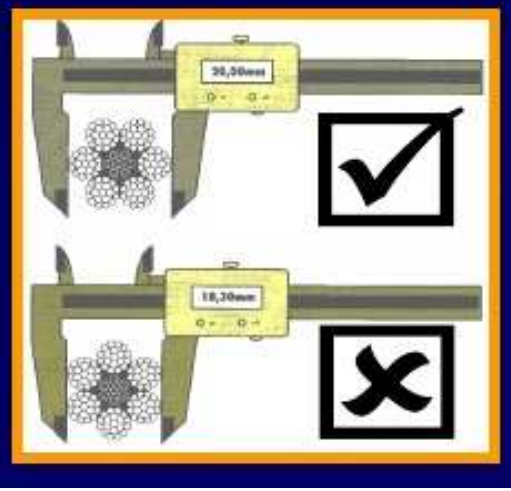
Measurement of rope diameter

New rope

- Take 2 measurements at right angles at two positions spaced approximately one metre apart

  (Measurements taken over strand crowns – see figure)

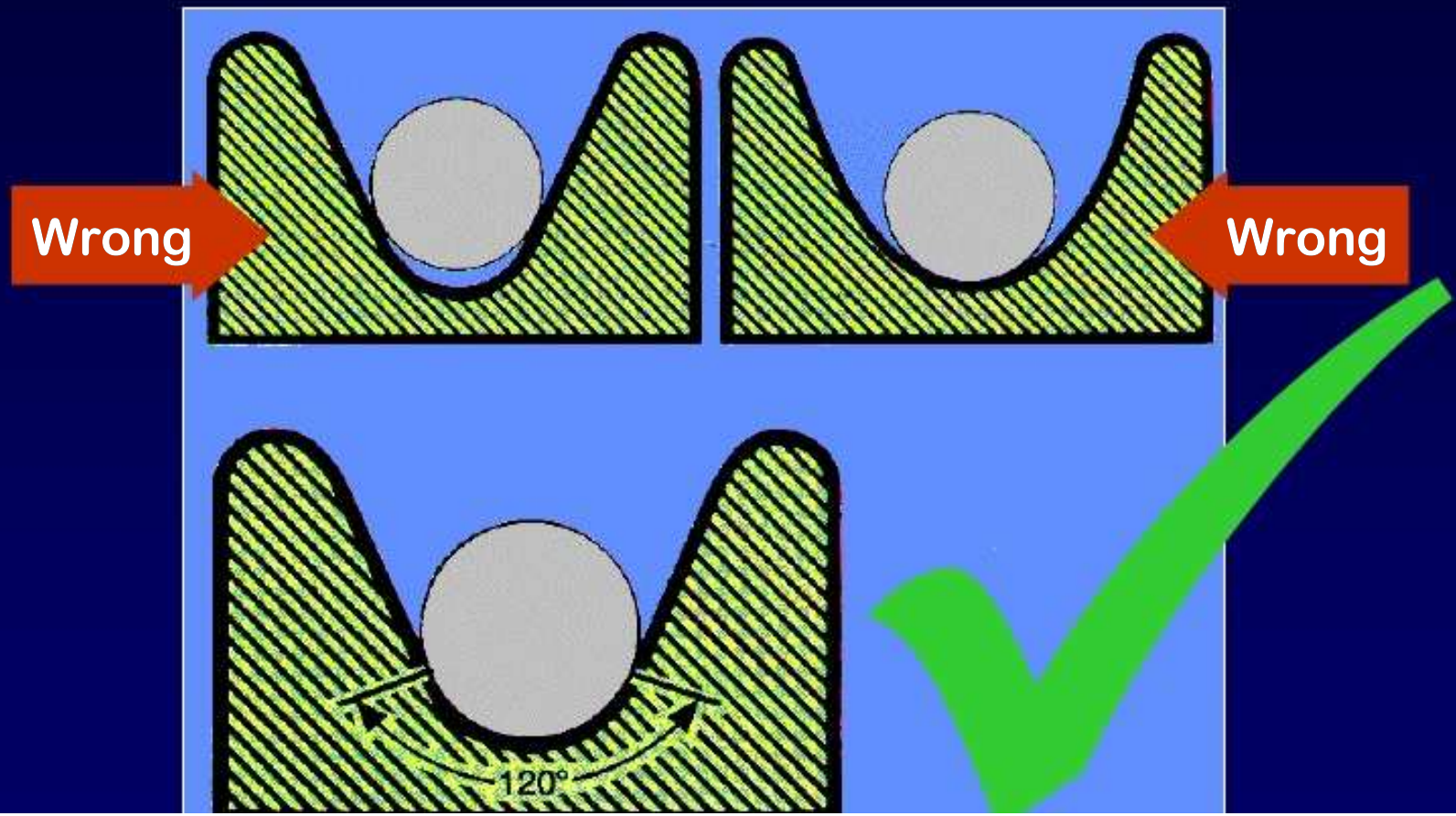
- Average of the four measurements is the rope diameter



Checking of sheave groove profile

- Groove gauge to check for wear
- Also visually check for corrugations – the rope imprint in the groove surface
- Also visually check for broken or chipped flanges

Checking Sheave Groove Profile



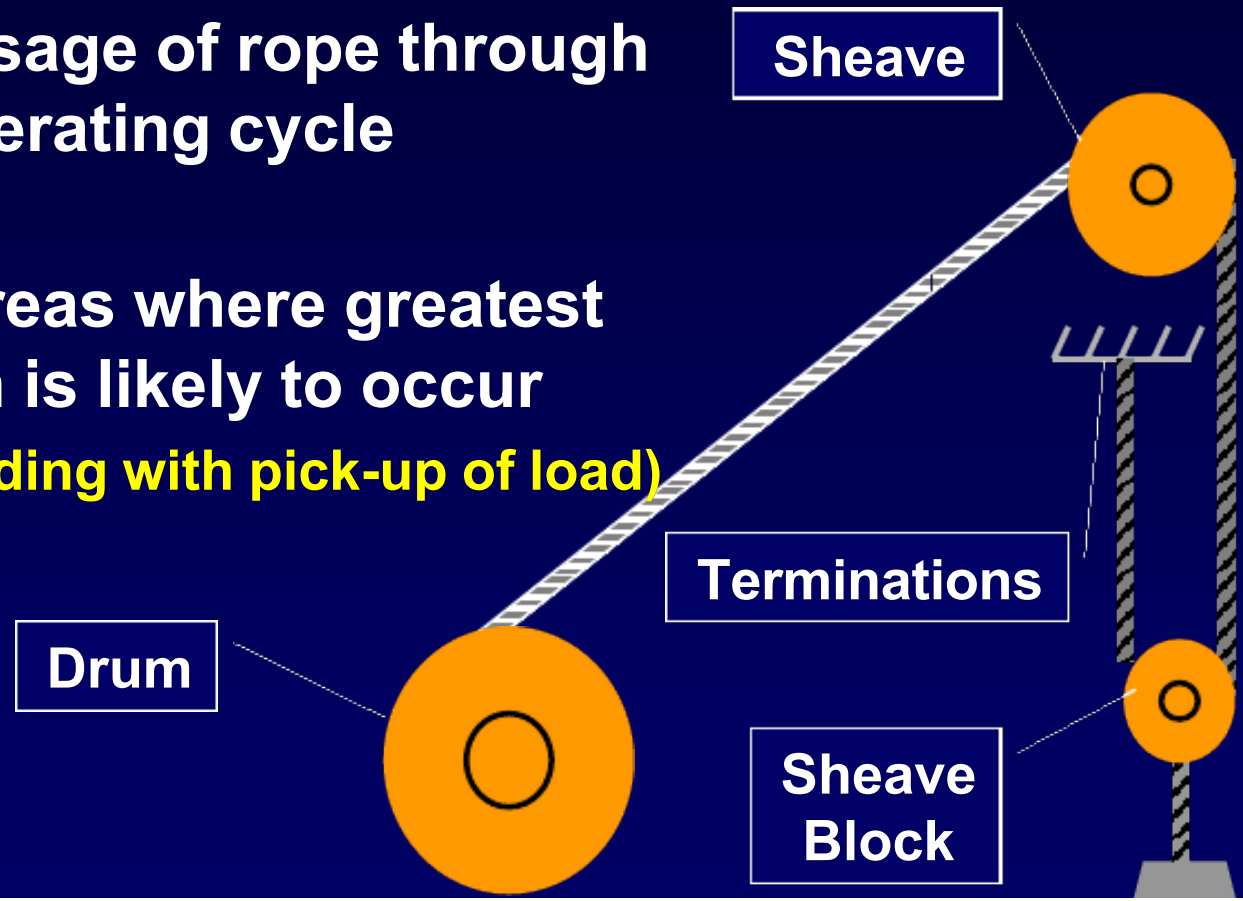
Where To Examine - Critical Areas
(typical but not exhaustive list)

- Points of attachment - outboard and inboard ends of the rope
- Rope at compensating sheave
- Dead laps and cross-over points at drum
- Rope running through sheave(s)
- Rope spooling on/off drum
- Areas exposed to abnormal environmental conditions
- Areas subject to damage or likely to be damaged

Areas of Deterioration

Simple two fall reeving system

- Witness passage of rope through complete operating cycle
- Determine areas where greatest deterioration is likely to occur
  - (e. g. coinciding with pick-up of load)



WHAT TO LOOK FOR
- At drum -
(Principal modes of deterioration)

- At drum anchorage
  - corrosion/evidence of rope movement (e.g. slip)
- In dead wraps
  - corrosion/localised damage from overlying layers
- At cross-over points
  - localised damage
- Portion entering and exiting drum at pick up point
  - corrosion/wear/broken wires/deformations

WHAT TO LOOK FOR

- At Rope Termination -

Wire breaks at or near rope entry

Corrosion

Abrupt reduction in rope diameter *(suggesting core failure)*

Abnormal rope movement *(out of the termination)*

Evidence of rope end

Evidence of any incorrect fitting

Evidence of any unusual component wear

Internal Examination of Ropes

Rope running through sheave(s)

Use of clamps – rope under no tension

- Attach clamps approximately 100mm-200mm apart
- Contra-rotate clamps to unlay outer strands
- Ensure strands are not excessively moved - avoiding any permanent deformation
- Manipulate strands with probe to facilitate examination
- Check -
  - presence of any broken wires
  - presence of any interwire pressure
  - degree of corrosion
  - state of internal lubrication
- Apply dressing
- Apply additional reverse torque to re-bed strands on core

Internal Examination of Ropes
(At rope termination)
Use of clamps – rope under no tension

- Only ONE clamp necessary
- Rotate clamp to unlay outer strands
- Manipulate strands with probe to facilitate examination

Internal Examinations of Ropes
(At rope termination)

- Check for presence and significance of:
  - any broken wires
  - any interwire pressure/friction marks
  - any corrosion
  - internal lubrication
- Apply service lubricant at examination location before closing up rope
- Apply additional reverse torque to re-bed strands on core

The 9 Key Points of Discard Criteria

1. Randomly distributed visible broken wires
2. Local groups of visible broken wires
3. Visible broken wires in the immediate vicinity of the rope termination
4. Core deterioration
5. Wear (expressed as reduction in diameter below nominal)
6. Internal corrosion
7. External corrosion
8. Deformations
9. Thermal damage

Ropes Operating in Synthetic Sheaves

- Wire breaks may occur in large numbers internally before there is any evidence of external wear or wire breaks
- Manufacturer of the appliance should specify the particular discard criteria
- The number of allowable visible broken wires should never be greater than ONE HALF of the numbers shown for ropes operating in metal sheaves
- Particular attention should be paid to any localised area exhibiting dryness or denaturing of the lubrication

Key Points of Rejection / Discard Criteria

❷

LOCALIZED GROUPING OF BROKEN WIRES

(Discard)

May be necessary to discard rope even if number is fewer than those given in Tables 1 and 2

Key Points of Rejection / Discard Criteria

3 DETERIORATION AT OR WITHIN VICINITY OF ROPE TERMINATION

Discard when

absolute maximum of 3 broken wires at rope termination - but consider replacement when only 1 is evident at rope entry - difficult to find

Key Points of Rejection / Discard Criteria

❹ CORE DETERIORATION

(Discard)

Characterised by abrupt reduction in diameter

Key Points of Rejection / Discard Criteria

❺ Reduction in dia – ISO 4309

Rope Type	Reject/Discard Criteria
6 & 8 strand engineering rope	10% (7% if abrasive wear only)
Rotation-resistant	3%
6 & 8 strand lift (elevator) rope	6%

Key Points of Rejection / Discard Criteria

❻ CORROSION - INTERNAL

(Discard)

Key Points of Rejection / Discard Criteria

7

CORROSION - EXTERNAL

(Assess degree of severity)

Discard rope when wires are slack and badly pitted, i.e. individual RF = 100

If surface rust can be removed without leaving any pitted wires - assume 10% to 20% towards discard, i.e. individual RF = 10 to 20

Key Points of Rejection / Discard Criteria

❽ DEFORMATIONS

(Assess degree of severity where appropriate)

Discard rope:

Wavy - max. height of wave = 4/3 x *d* in standing part; 1,1 x *d* over sheave or drum

Permanent bend (or dog leg); Flattened; Basket/birdcage; Core exits rope between outer strands; Wires exude from strands; Kink

Key Points of Rejection / Discard Criteria

⑨ THERMAL DAMAGE

(Discard)

Examiner's Record (example only) - based on BS ISO 4309 discard criteria (18/30*d*)

Rope: 22mm 6 x 36 IWRC
Appliance: Smiths 8T O.H.T.C.
Location: BOS Plant

Certificate No. 15/1234/1234/01
Date fitted 1.1.01

Date	Degree of degradation												Condition of lubrication	Examiners Notes and Signature
	Broken wires (in 30d)			Diameter measurement			Deformations			Corrosion		Total		
	No.	Position	R.F.	Dia	Position	R.F.	Type	Position	R.F.	Position	R.F.	R.F.		
1.6.01	0	-	0	22.3	At drum	0	-	-	-	-	0	0	Good	J. Smith
2.12.01	0	-	0	22.0	At drum	0	-	-	0	-	0	0	Good	Possible damage at one point on drum J. Smith
5.6.02	0	-	0	21.6	At drum	20	-	-	0	-	0	20	Dry	Dress rope. No rope damage at drum J. Smith
7.11.02	4	Pick up on drum	20	21.1	Pick up point on drum	40	-	-	0	-	0	60	Good	Reduce inspection to 3 months - J. Smith
2.3.03	7	Pick up point on drum	40	21.1	Pick up point on drum	40	-	-	0	-	0	80	Good	Recommend rope be removed within 3 months (Check availability of spare rope - J. Smith)
2.3.03	4	10 metres from hook	20	21.2.	10 metres from hook	40								
2.3.03	5	21 Metres from hook	30	21.2	21 metres from hook	40								
2.6.03	11	Pick up point on drum	60	21.0	Pick up point on drum	40	-	-	0	-	0	100	Dry	Reject rope J. Smith
2.6.03	7	10 metres from hook	40	21.1	10 metres from hook	40								
2.6.03	7	21 metres from hook	40	21.1	21 metres from hook	40								

Agreed to replace rope: P.M.Pollard