Measurement of Equipment Life and Life Extension, Experience from National Grid

WG A3-06 Tutorial course on Reliability of HV Equipment

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Overview

- Definition of Equipment Lives
- Examples of derivation
- Application
- Life Extension

Different Types of Equipment Lives

- Technical lives
  - technical state requiring replacement
- Commercial lives
  - legal agreement for charging purposes
  - typically 40 years but can be negotiated
- Financial lives
  - period over which assets are financially depreciated over their useful economic life
- Regulatory lives
  - used in the regulatory cash flow model

Technical Equipment Life

Safety Risk

Network Risk

Environmental Risk

Cost of Operation

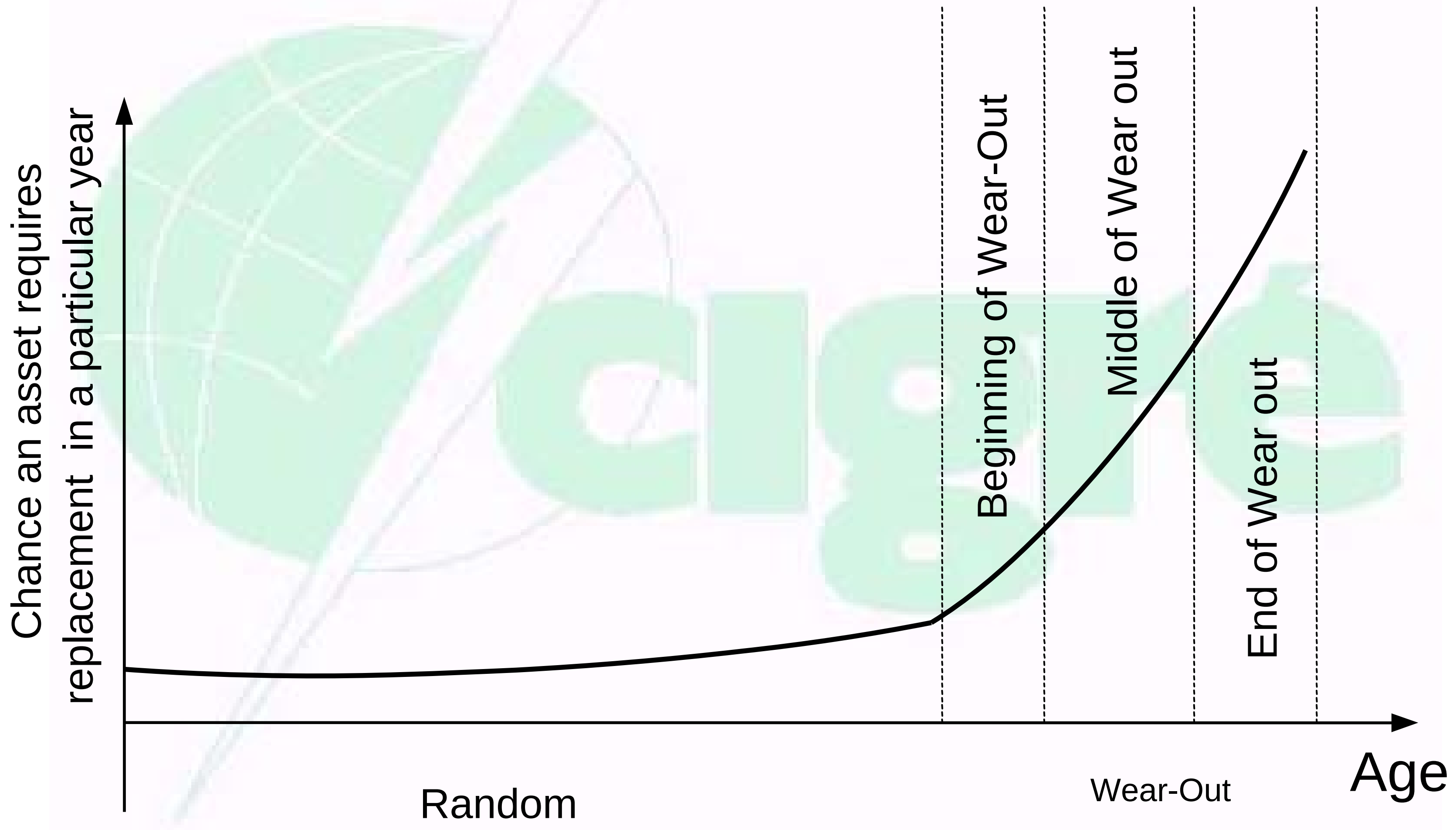
Cost of Maintenance

Cost of Replacement

Technical Equipment Lives

- Represent state requiring replacement - in most cases this is not failure (e.g. loss of strength in overhead line conductor)
- Derived using a pragmatic approach which is based on technical requirements using all available information (e.g. asset health, condition, R&D, failures, defects)
- Recognise technical differences in asset families
- Not just one number - actually a distribution
- Consistent definition for all assets

Hazard Rate


Chance an asset requires replacement in a particular year
Beginning of Wear-Out
Middle of Wear out
End of Wear out
Age
Random
Wear-Out

Technical Asset Life Definitions

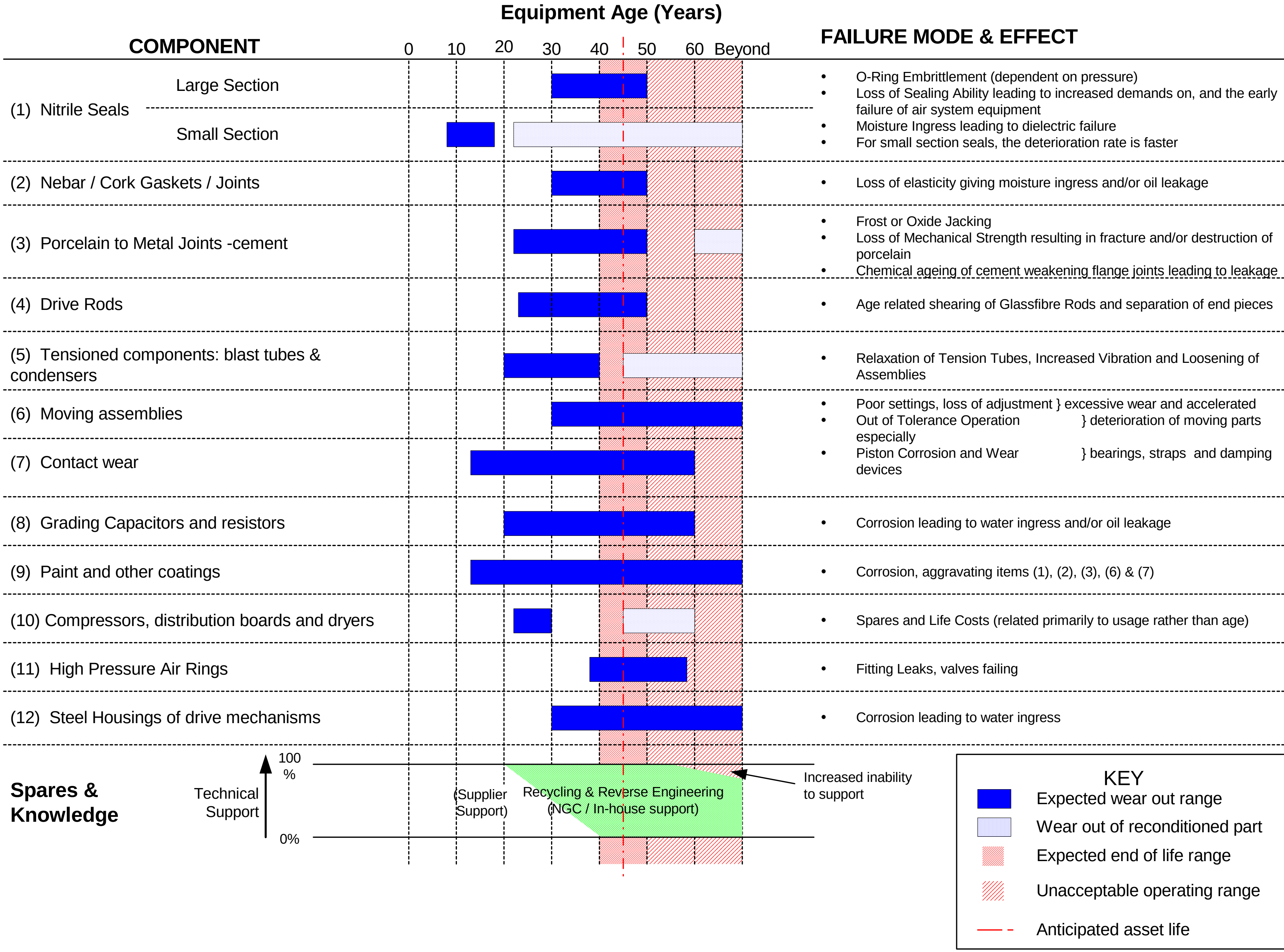
- Same definition for all assets
- Many technical criteria for end of life
  - Based on requiring replacement
- Age related replacement (wear-out):
  - Earliest onset (2.5%) require replacement
  - Anticipated life (50%) require replacement
  - Latest onset (97.5%) require replacement
  - Each points rounded to nearest 5 years (indicates best view on accuracy)

Technical Lives - circuit breaker grouping

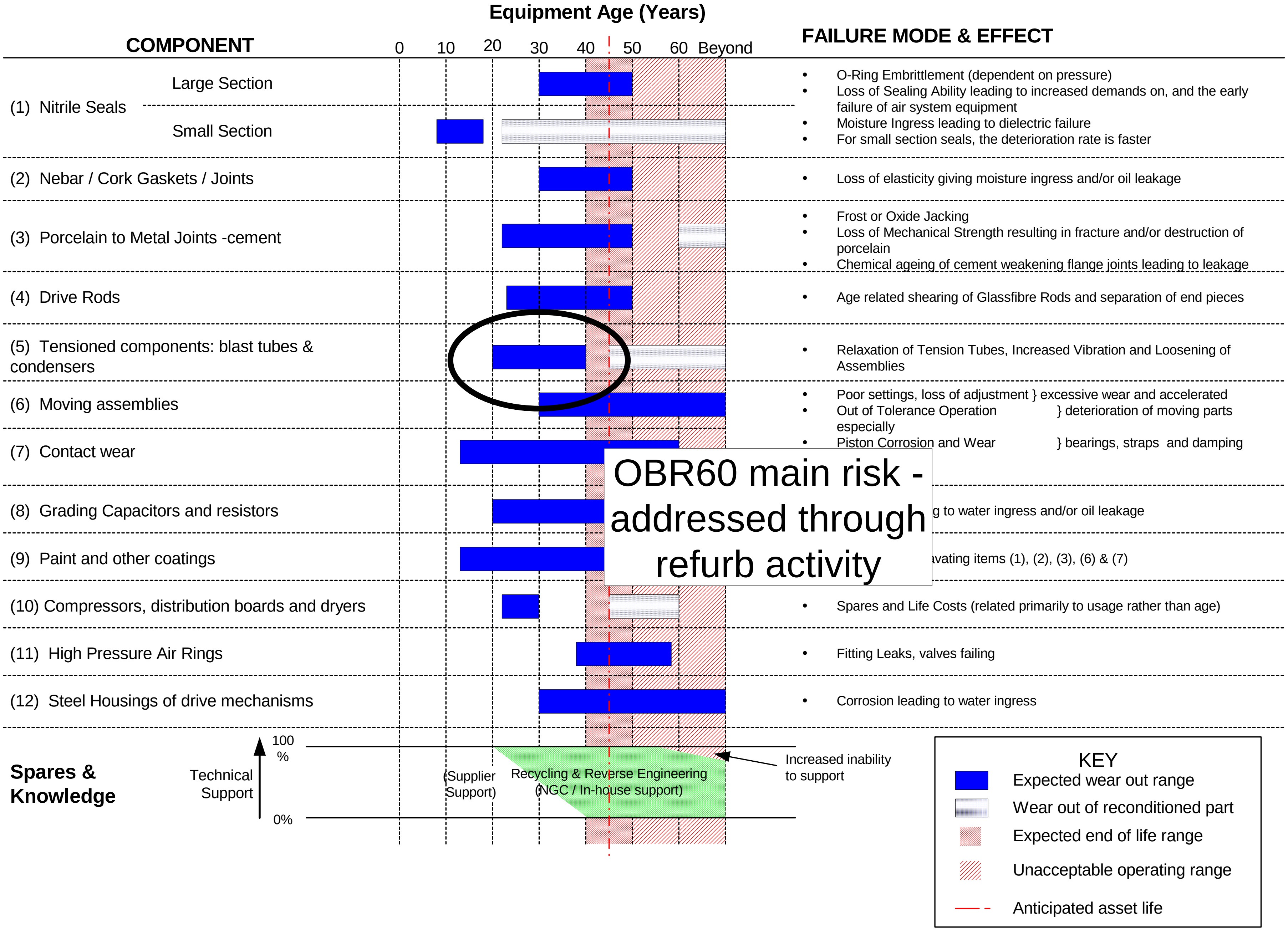
- **Family**
  - common design groups have common deterioration modes
  - Maintenance is defined by family (rather than environment or duty)
- **Maintenance history**
  - Generally common preventative maintenance approach
  - Where mid-life refurbishment has been applied recognised in lives
- **Installed environment**
  - Certain failure modes independent of environment
  - Differences recognised within range rather than sub-dividing categories
- **Duty**
  - common low level duty, except reactive switching devices

Life Limiting Factors - Non-Pressurised Head ABCBs

COMPONENT		FAILURE MODE & EFFECT
(1) Nitrile Seals	Large Section / Small Section	• O-Ring Embrittlement (dependent on pressure) • Loss of Sealing Ability leading to increased demands on, and the early failure of air system equipment • Moisture Ingress leading to dielectric failure • For small section seals, the deterioration rate is faster
(2) Nebar / Cork Gaskets / Joints		• Loss of elasticity giving moisture ingress and/or oil leakage
(3) Porcelain to Metal Joints -cement		• Frost or Oxide Jacking • Loss of Mechanical Strength resulting in fracture and/or destruction of porcelain • Chemical ageing of cement weakening flange joints leading to leakage
(4) Drive Rods		• Age related shearing of Glassfibre Rods and separation of end pieces
(5) Tensioned components: blast tubes & condensers		• Relaxation of Tension Tubes, Increased Vibration and Loosening of Assemblies
(6) Moving assemblies		• Poor settings, loss of adjustment } excessive wear and accelerated • Out of Tolerance Operation } deterioration of moving parts especially
(7) Contact wear		• Piston Corrosion and Wear } bearings, straps and damping devices
(8) Grading Capacitors and resistors		• Corrosion leading to water ingress and/or oil leakage
(9) Paint and other coatings		• Corrosion, aggravating items (1), (2), (3), (6) & (7)
(10) Compressors, distribution boards and dryers		• Spares and Life Costs (related primarily to usage rather than age)
(11) High Pressure Air Rings		• Fitting Leaks, valves failing
(12) Steel Housings of drive mechanisms		• Corrosion leading to water ingress



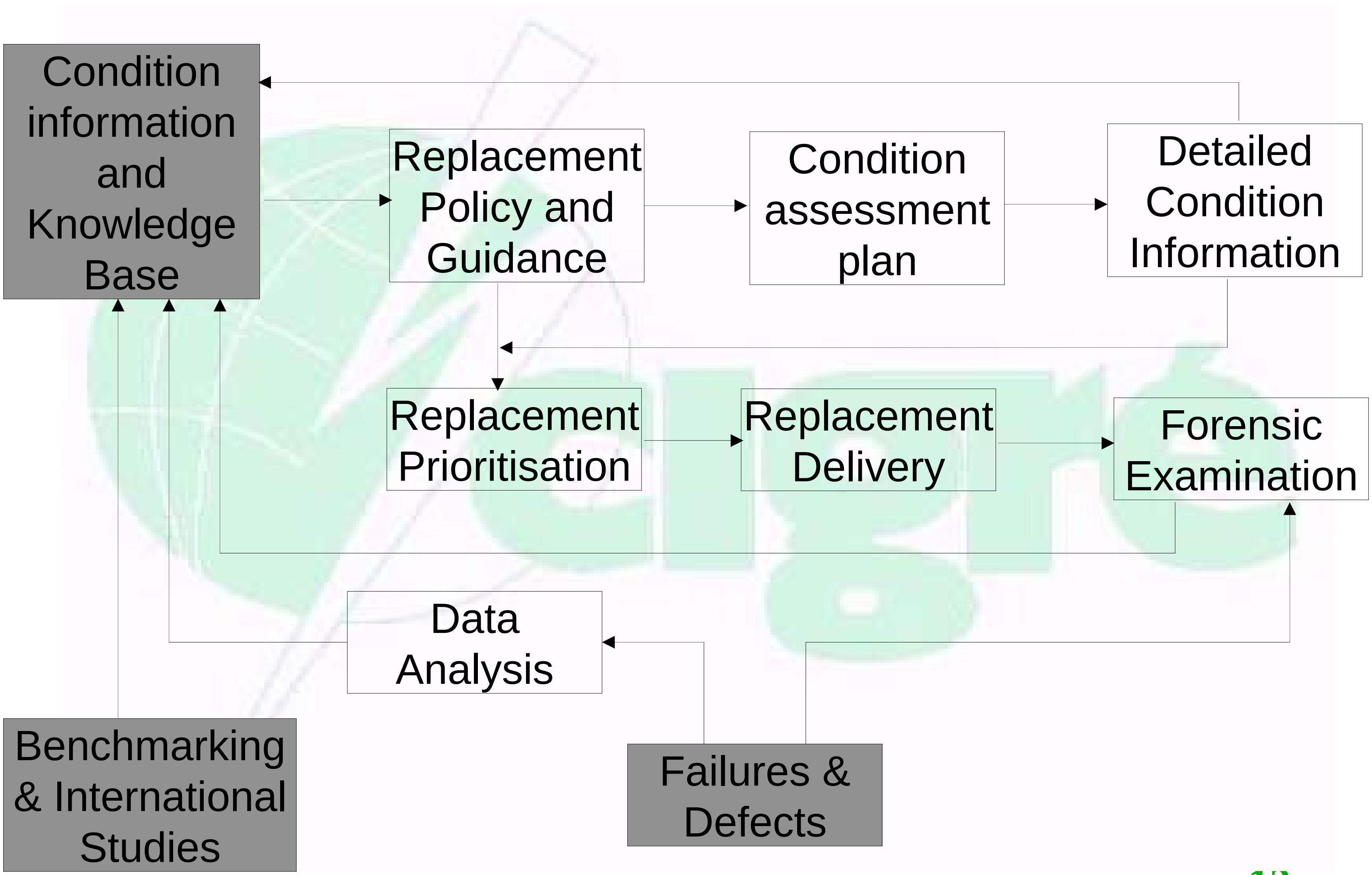
Life Limiting Factors - Non-Pressurised Head ABCBs



Technical Equipment Life Distributions

- **Provide generic guidance on when assets require replacement**
- **Many are not symmetric**
- **Used to forecast:**
  - **Long term capital requirements**
  - **Future asset replacement volumes**
- **Used to understand risks:**
  - **Uncertainty around long term capital requirements and asset replacement volumes**
  - **Identify future system risks**

Development of equipment technical lives and the use of lives for asset replacement

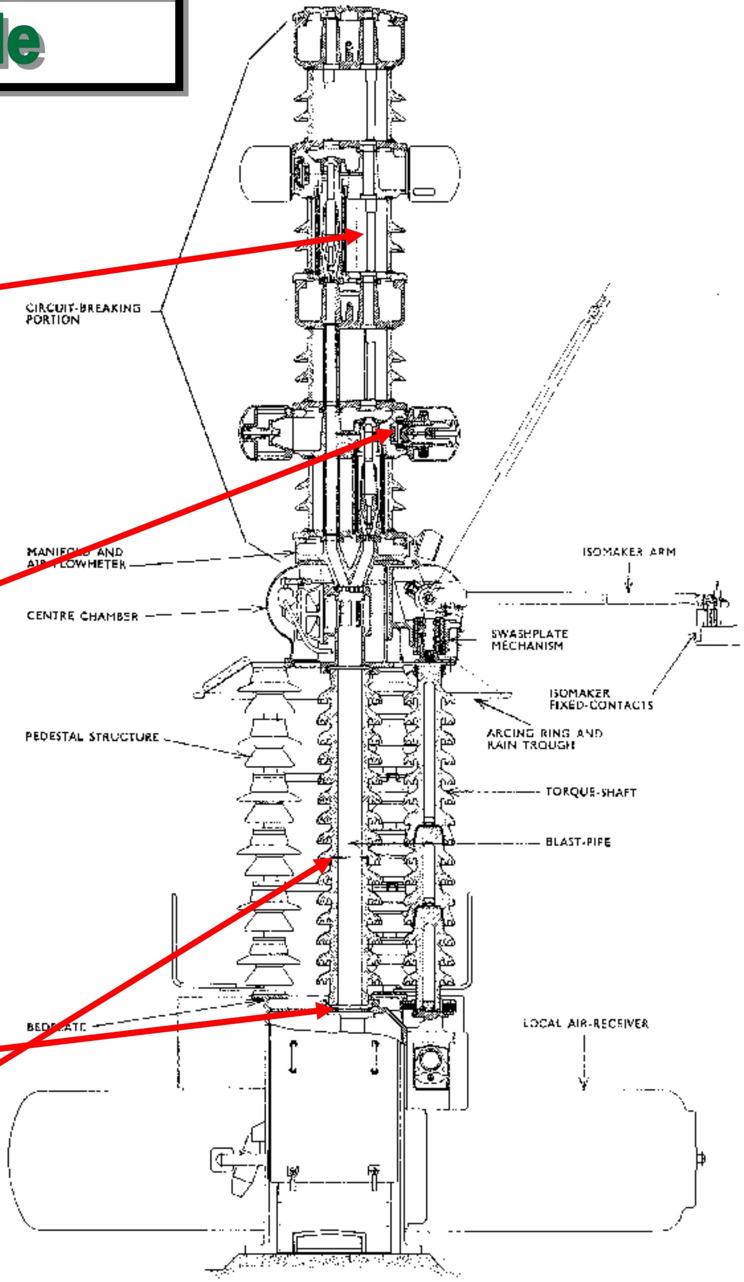


Condition Assessment Example

Some of the interrupter paxalin tie bars have cracks running lengthways approximately 15 cm along the bar. Cross sections cut from such tie bars show that the cracking extends up to 6 mm into the bar. The end of a tie bar have a build up of white deposits on the paxalin bar and corrosion on the metallic end collar..

The interrupter exhaust valve are heavily corroded showing the ingress of a significant amount of moisture

Blast tube and bed plate interface joint showing severe corrosion reducing the clearance at the top of the blast tube which will apply pressure on the blast tube leading to failure of the blast tube cemented mid joint.



Life Extension Example - OBR60 Refurbishment

- One of the oldest design 275kV Air Blast Circuit Breakers
- Two known disruptive failure modes - a number of disruptive failures in the last 15yrs
  - Condenser tube failure - mechanical failure (10m range)
  - Contact block failure - catastrophic failure (80m range)
- Risk Management procedures in place
- Specialists employed to advise/condition assess
  - OBR60 Condenser Tubes
  - OBR60 Material Analysis
- Scope of Refurbishment
  - Breaker Refurbishment addressing all seals, gaskets, corrosion
  - Whole Bay refurbishment in line with condition assessment

Summary

- Equipment life set by risk cost performance
- Equipment lives are set and reviewed using:
  - Condition information
  - Forensics
  - Failures
  - Performance
  - R&D
  - Benchmarking and international studies
- Used for the refurbishment and replacement program
- Life can be extended with refurbishment