Extending the life of LW Roof Supports through the use of a Life Cycle Testing Management Plan

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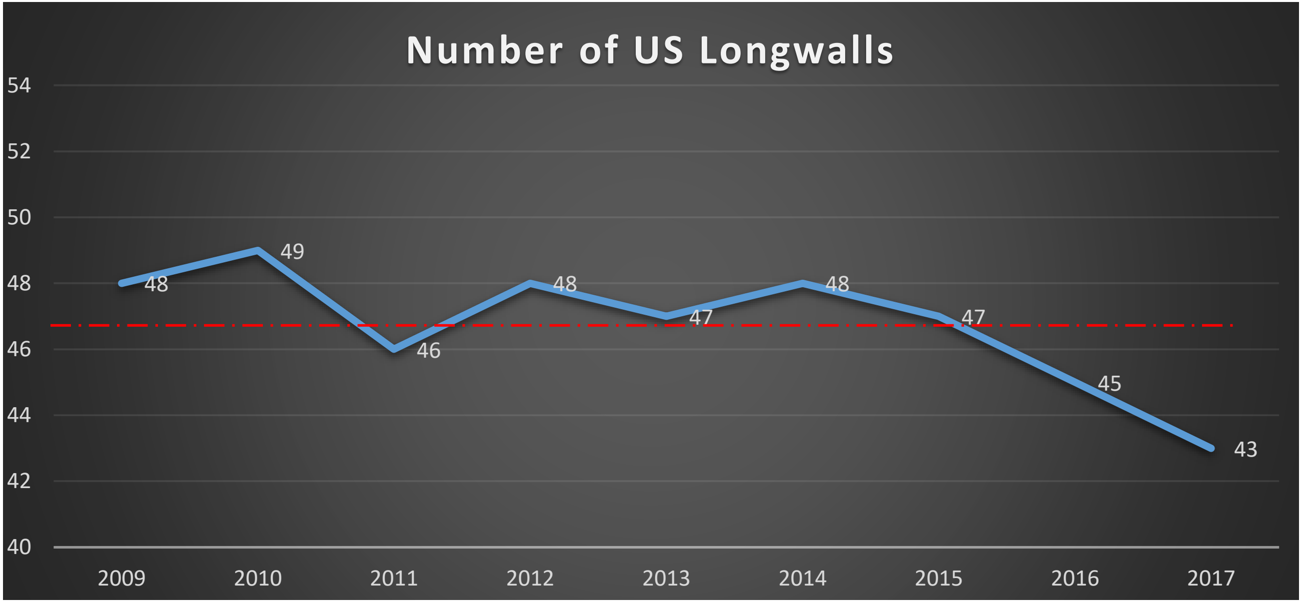
Introduction

US Longwalls are Reducing

Since 2014 the reduction in the number of LW has accelerated
Coal companies are faced with reduced capital expenditure
To survive companies need to improve productivity
Mines need to extend the life of core assets



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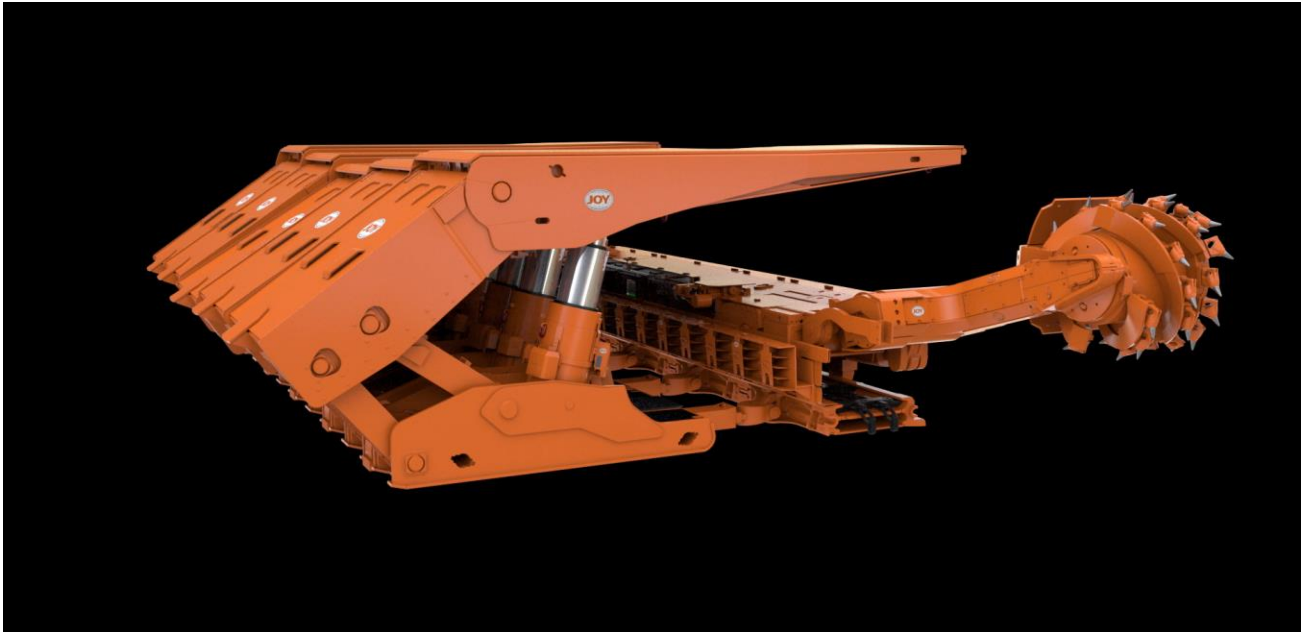
A successful Longwall

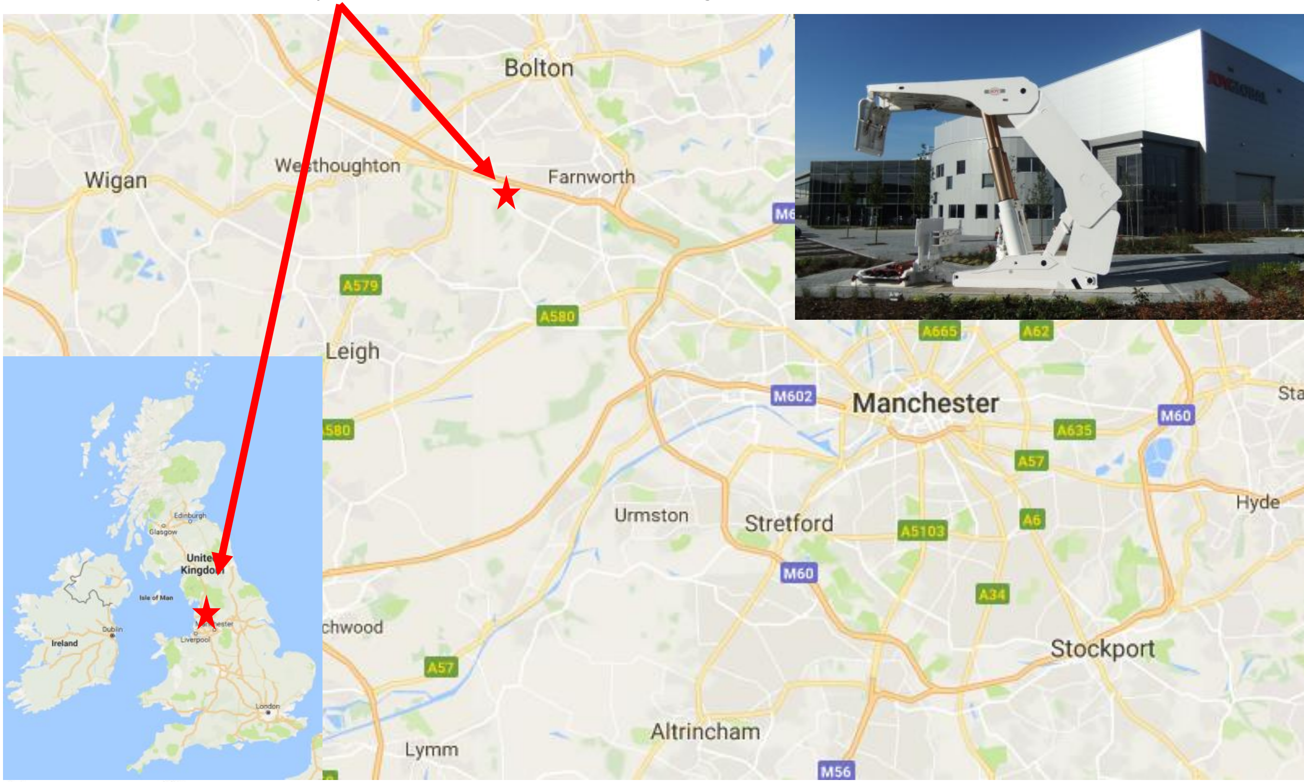
Managing a successful LW is as much about managing the asset

- The Shearer is about reliability
- The AFC is managing the wear
- The PRS is achieving longevity



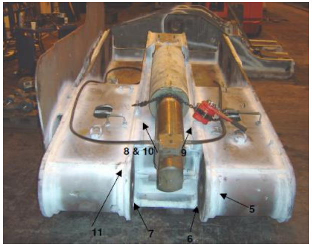
Original Equipment Manufacturer's Test Facilities

Our Manchester Facility, in the North-West of the England



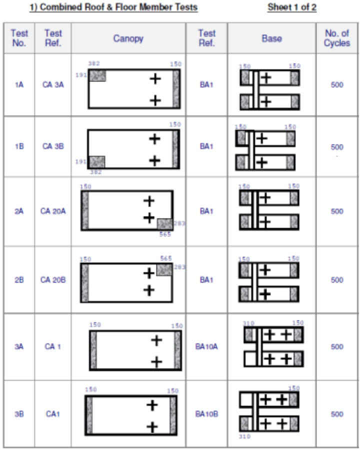
Extended Life Testing

Extended life testing is a process used to evaluate the longevity of powered roof support structures, it can also be used as a predictive tool to determine when individual components are likely to reach the end of their serviceable life.



Stages

- A representative support is taken out of service.
- This is striped and fully evaluated in the UK.
- The results set a base line on the condition of the support though its service to date.
- Load cases to a bespoke test schedule are designated to replicate the actual service seen.
- The support is then tested up to the customers required number of life cycles.
- From the results the customer gets:
  - Confidence in the longevity of the supports going forward.
  - A recommendation of any essential repairs needed.
  - Detailed reports and Life Cycle Management plans.
  - Actual test result when components will reach the end of their serviceable life.
  - The ability to plan future maintenance budgets with a high level of accuracy.
  - The option of upgrades with the latest improvements, features and solutions.



Test Ref.	Canopy Load Case	Base Load Case	No. of Cycles
1	Front Offset (CA3)	Bending (BA 1)	1,000
2	Rear Offset (CA 20)	Bending (BA 1)	1,000
3	Bending (CA 1)	Front Torsion & Bending (BA 10)	1,000
4	Bending (CA 1)	Rear Torsion & Bending (BA 11)	1,000
NUMBER OF CYCLES			4,000
The above sequence to be repeated 7 times – Number of Cycles			28,000
1	Front Offset (CA3)	Bending (BA 1)	1,000
2	Rear Offset (CA 20)	Bending (BA 1)	1,000
TOTAL CYCLES			**30,000**

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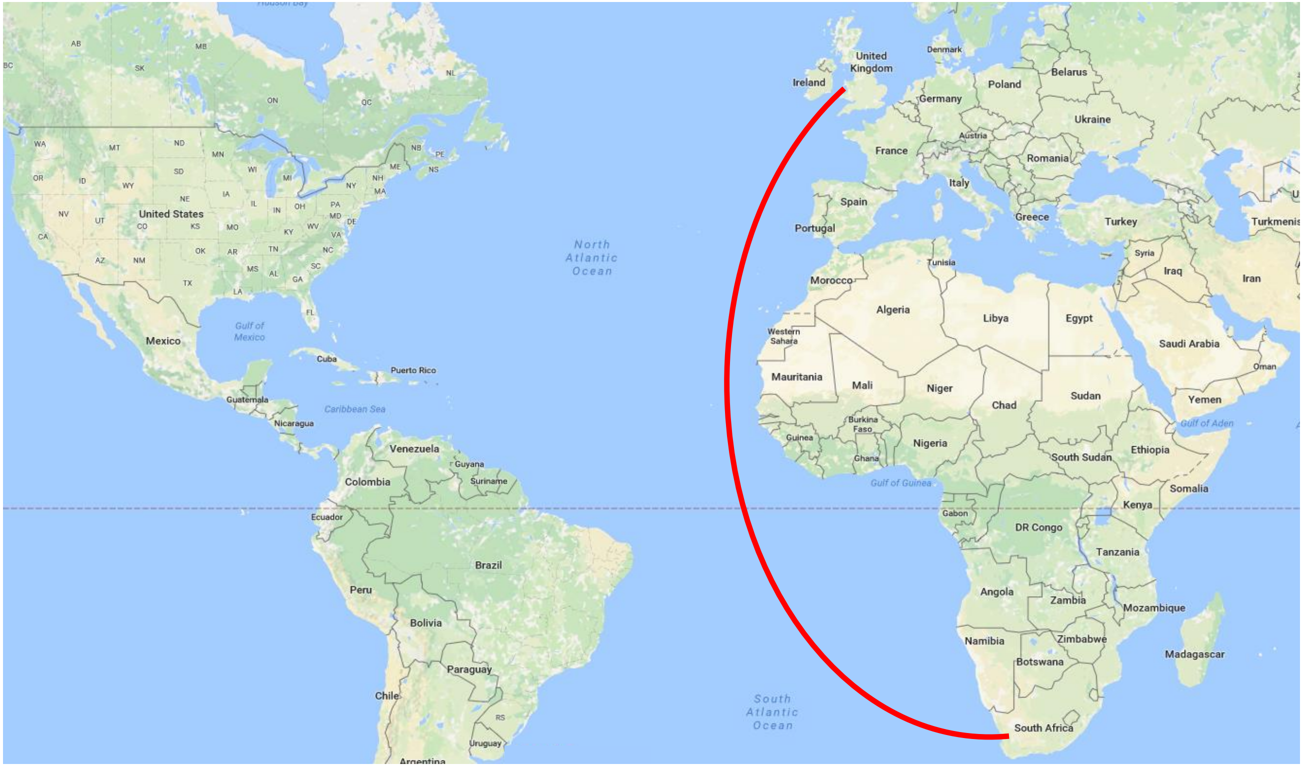
An Overview of the Equipment

Original Specification

- A 1250 Tonne (1378UST) support
- Supplied in 2009
- 1.75m wide
- 400mm legs, 200mm stab, 150mm D/A ram.
- Open / Closed heights 53” / 98”
- Tested to 30,000 cycles, 100% amplitude

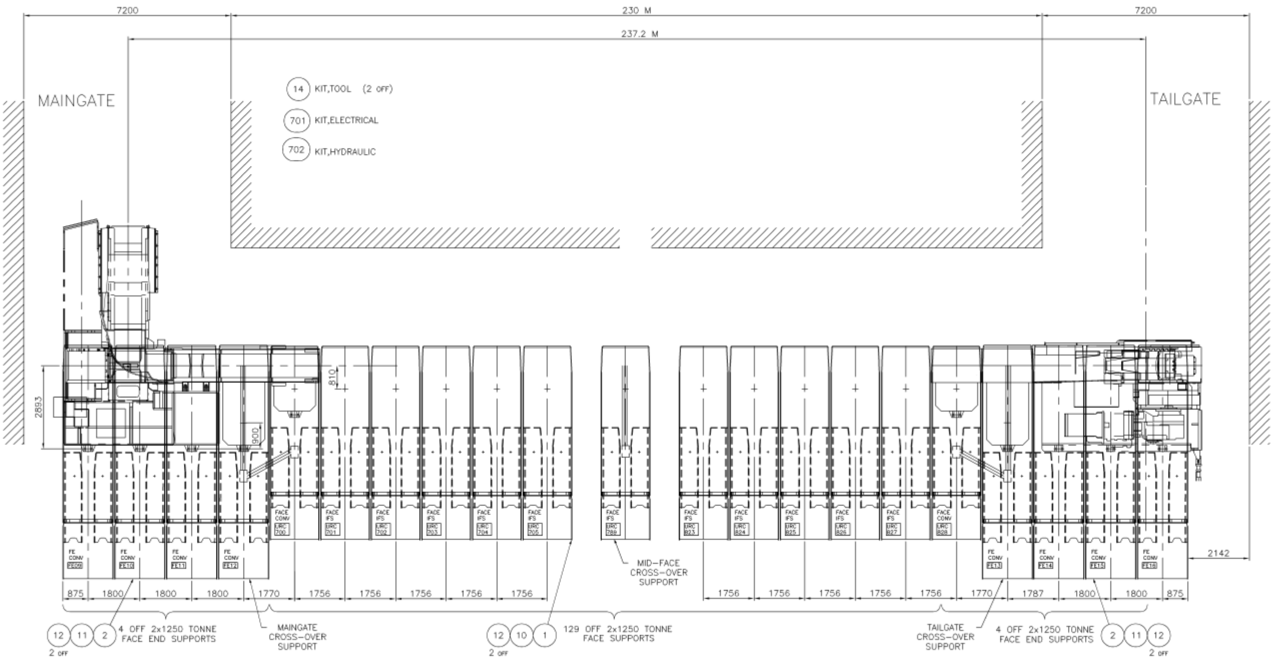
Transport to New Denmark Colliery

The supports were transported some 8,500 miles



Face Layout

- Total of 137 Powered Roof Supports
- Made up of 8 x Gate Ends, and 129 Run of Face Supports
- Mining a 230m (face side rib to face side rib) coal block.



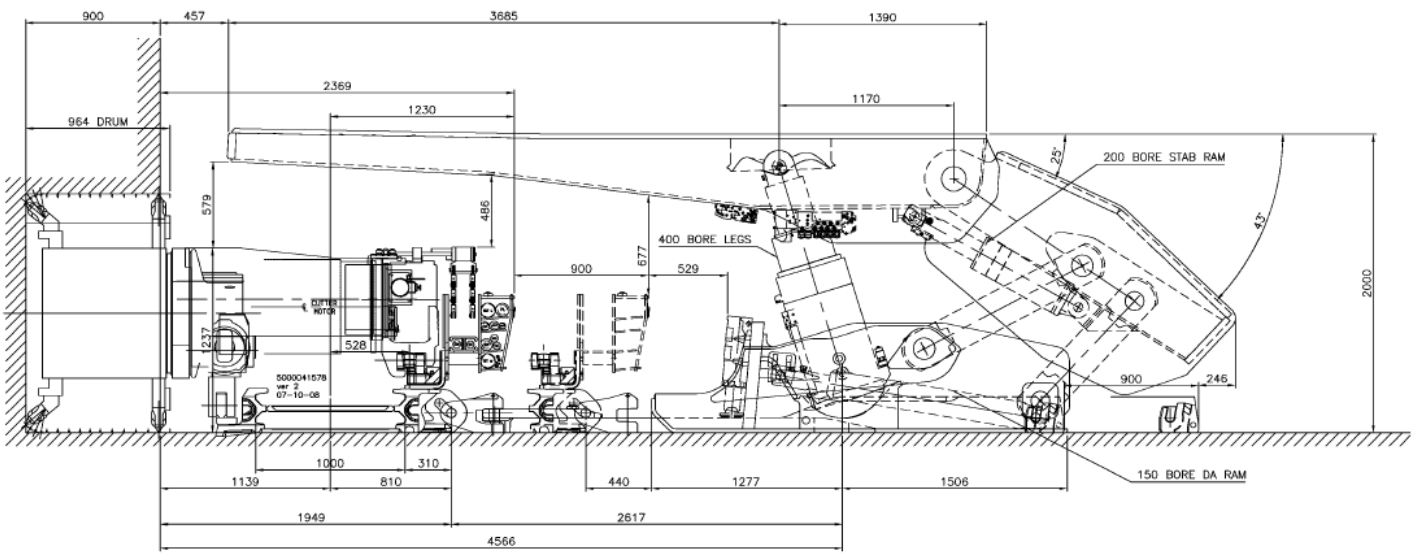
Face Cross Section

Shearer – 7LS2A

Cutter Motor Power	470 kW
Cutting Height	1,6 to 3,5 Metres
Tunnel Clearance	0.398 Square Metres
Haulage Power	80 kW VFD
Max Haulage Cutting Speed	16 metres per min
Cutter Drums	Dia 1600 mm, 968mm Width

AFC

Capacity	2500 Tonnes per Hour
Maingate Transmission	855 kW, TTT, 1000EP G/Box
Tailgate Transmission	855 kW, TTT, 1000BP G/Box
Chain	42 mm Broad Band
Chain Speed	1.6 Metres per sec
Panline Width	1000 mm
Chain Management	Dynamic Chain Control



Test Specification in Detail

- Not all test specifications are the same.

- There can be a minimum regional standard for example:

EN1804	European Union
GOST	Russia
MA	China

- There can also be mining company specific standards in place of, or in addition.
  For the New Denmark support the standard required for:
  15,000 cycles without test induced cracks, followed by
  15,000 cycles with allowable cracks within a strict tolerance

As an indication of how rigorous this test was
Comparing the lowest to the highest specification
And using a scale of 1 – 10 this would represent a 8

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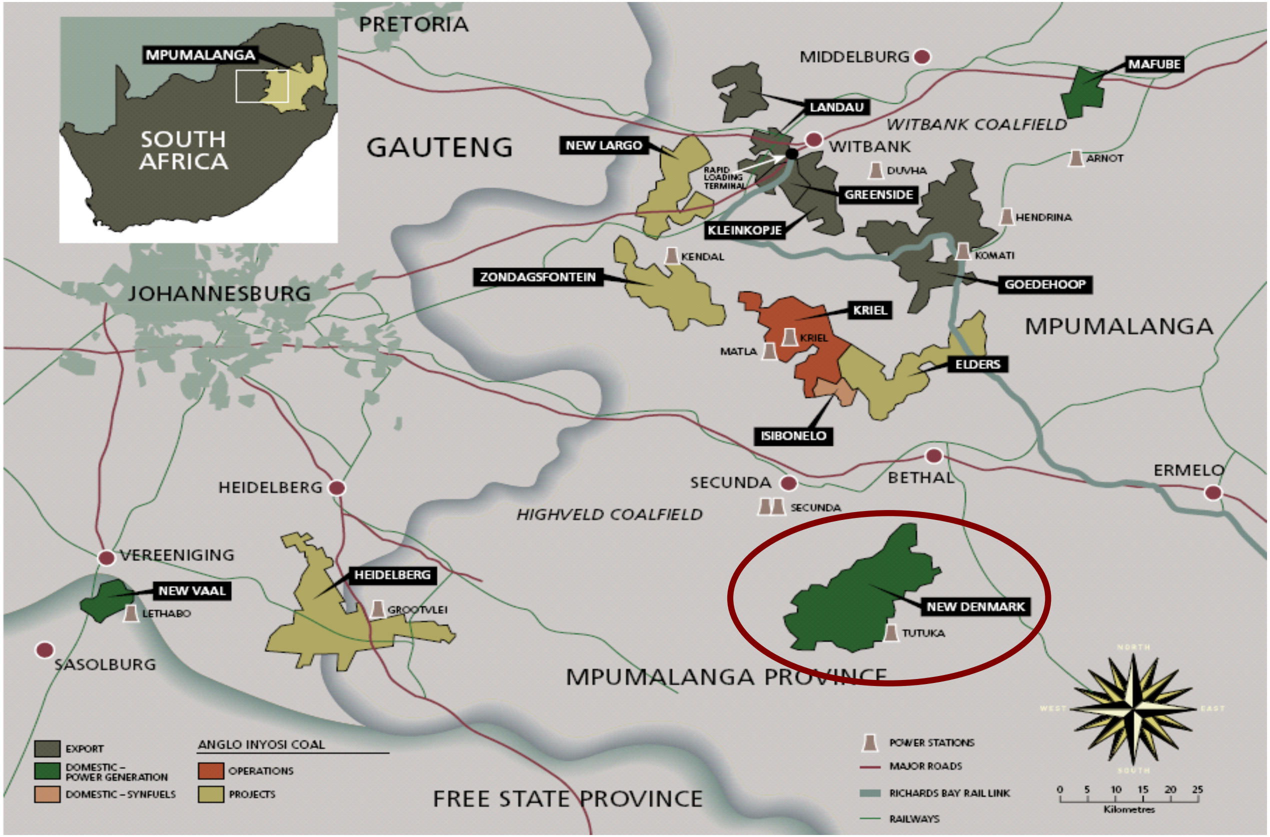
An Overview of New Denmark Colliery

New Denmark Colliery



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New Denmark Overview

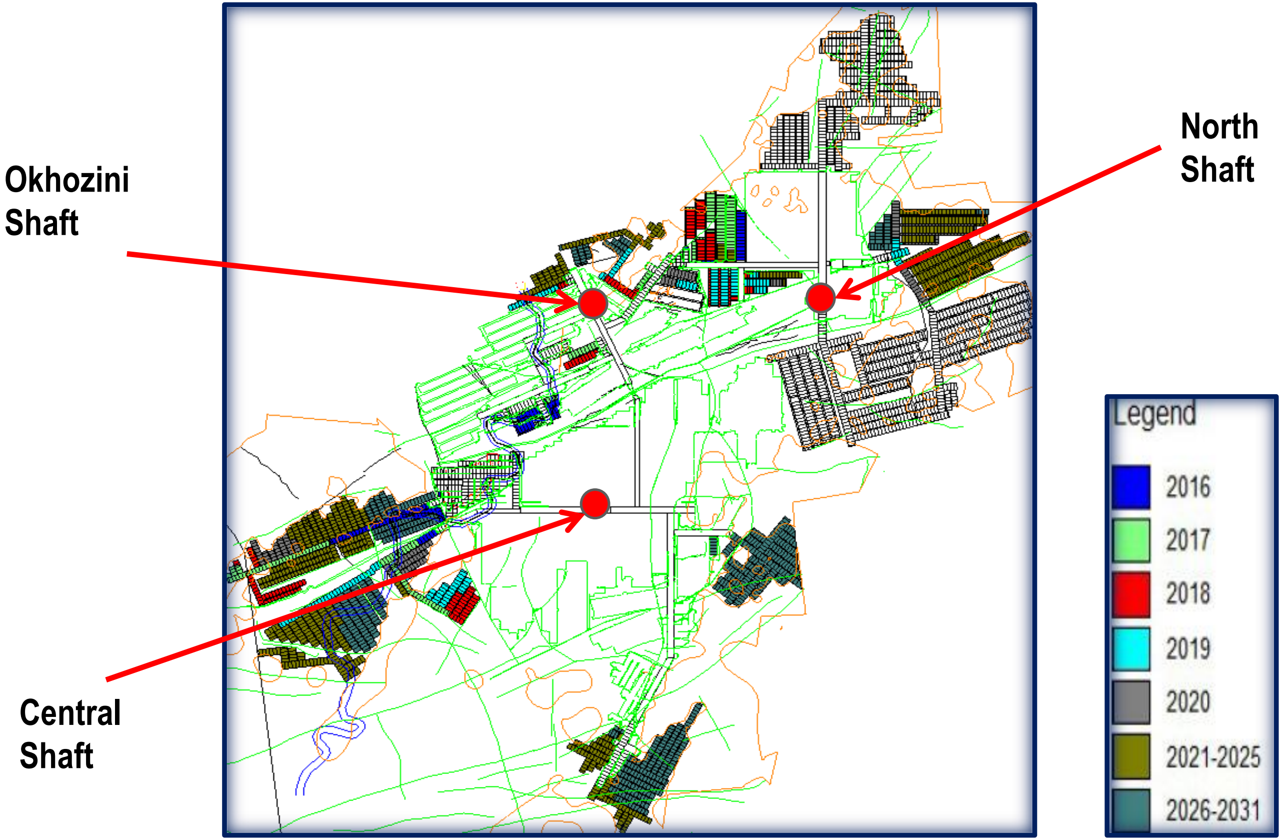
New Denmark Colliery is an Anglo American U/G Coal Mine Supplying Coal to Eskom's Tutuka Power Station and was Established in 1982
Mining the no 4 Seam at an Average Depth Below Surface of ± 200 m and an Average Seam Height = 1.85m

Eskom Original Contract:
- 10.05 Mt/a Commencing from 1989 Producing 433.5Mt Over the Life of Mine
- Production Output was Based on : 2 x Longwalls , 2 x Shortwalls and 14 Continuous Miner Sections

Eskom Subsequent Requirements:
- Reduced to 3.75Mt/a in 2001 by Eskom (North Shaft Mothballed)
- Increase Tonnage from 4.0 - 4.5 Mt/a in 2006
- 2010 Eskom Extends Power Station Life - 60y (2049)

Current:
- 2016 Budget is 3.2Mt. Production Build up From 4.27Mt to 5.0Mt in 2017 and 2018 Respectively.
- The Longwall Stops in 2020 and CM Production will Continue until 2030 at ± 3Mt/a
- NDC - 3 Shafts:
  - Central Shaft – 4 CM's (2 X Double Header Sections and 1X Dev Section)
  - Okhozini Shaft – 1 CM Section
  - North Shaft - 2 CM's & Longwall

New Denmark Mine Orientation



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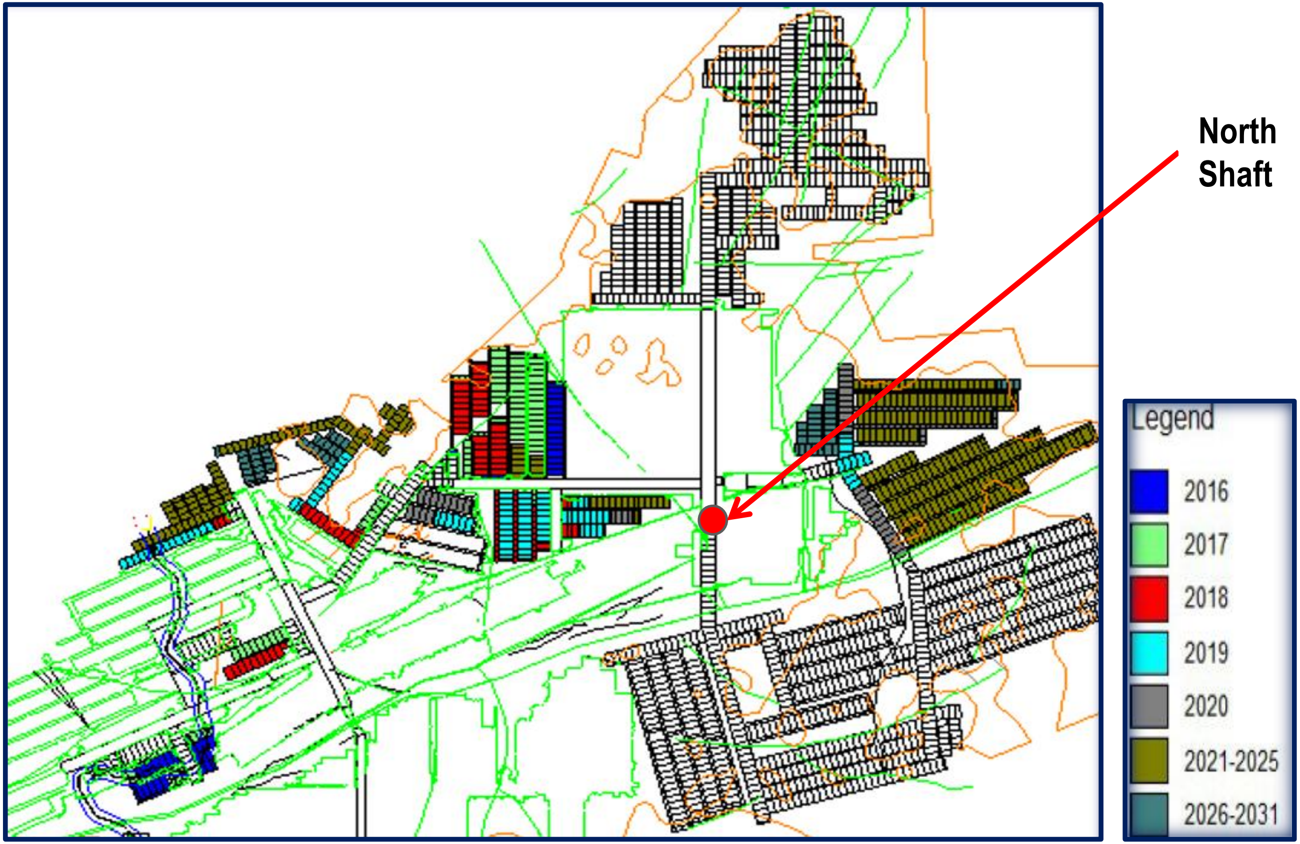
New Denmark North Shaft Orientation



Mine Overview

- **Mine / Product Characteristics**
  - Average Seam Height 1.85m
  - Average CV 22.8 MJ/kg
  - Average Ash 27.6%
  - Average AI 649 mgFe

- **Mining Method**
  - **Bord & Pillar – Continuous Miner Sections**
    - 2 x Double Header Sections

      New Concept to South Africa:
      Shosholosa Implemented Aug 2016
      Simunye Implemented March 2017

    - 3 x Single Header Sections
      2 x Chain Road, 1 x Multi Road

  - **Total Extraction - Longwall**

The Case Study

New Denmark – Case Study

The supports were supplied in 2009 and tested up to 30,000 cycles

A requirement was to extend the support's life to 45,000 cycles

The support had seen 13,000 underground cycles

And seen some pretty tough conditions

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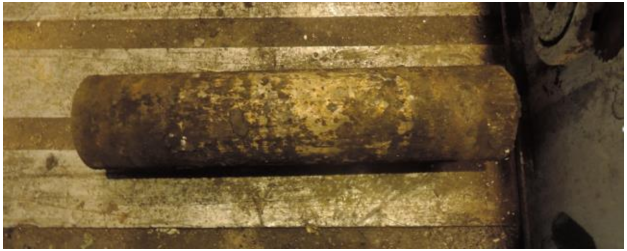
New Denmark - Case Study

Preliminary inspection prior to being dismantled

New Denmark - Case Study

It was dismantled and visually inspected

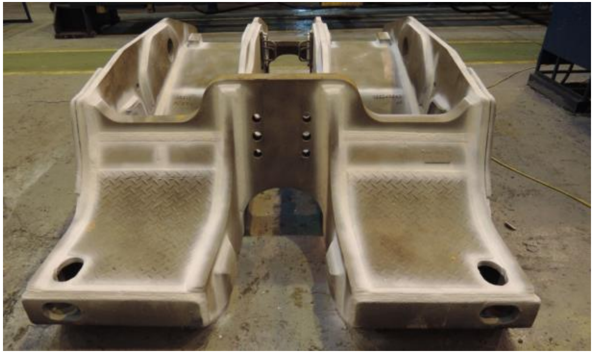


New Denmark - Case Study

All cracks & damage identified and assigned unique crack ID marks

New Denmark - Case Study

The components are then shot blasted and visually inspected with the addition of magnetic particle NDT testing to establish the location of any additional weld cracks



New Denmark - Case Study

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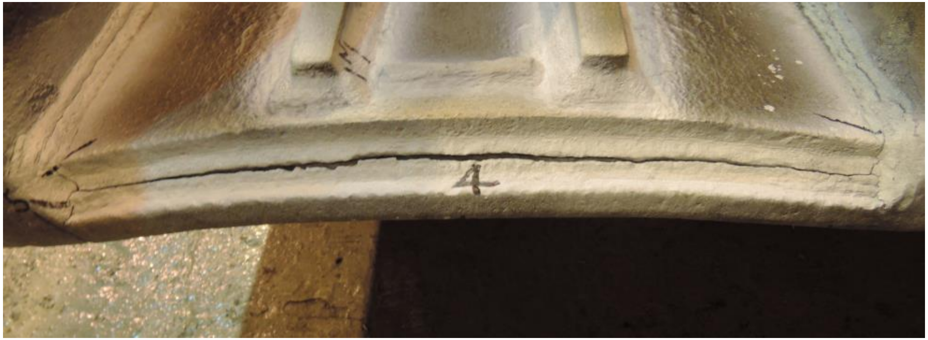
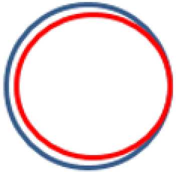


New Denmark - Case Study

Hinge pins and bores were also examined, measured and recorded.

As Manufactured

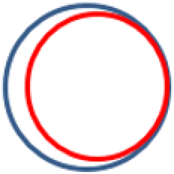


Bore Diameter
nominal 141

Pin Diameter
nominal 140

Reference for datum

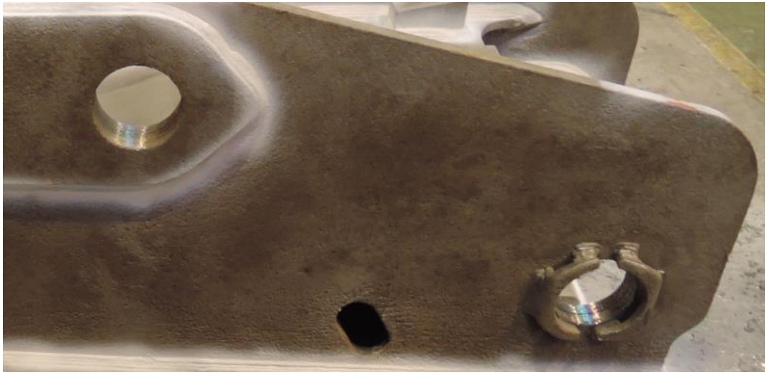
As Measured



Bore Diameter
nominal 142

Pin Diameter
nominal 138

Wear of 3mm



New Denmark - Case Study

Based on the results of these inspections, a unique test program was agreed upon that best replicated the load cases the support had seen in actual service.

The test schedule for the roof support was agreed and carried out in 5 phases.

Phase 1: 2000 cycles this gives the supplied roof support a cyclic count of 15,000 cycles

Phase 2 to 5: 7500 cycles per phase (total roof support cyclic count of 45,000)

Note: the support was stripped down after phase 3 and 5 and underwent a full MPI inspection.

<u>Phase 1</u>		
Waste to face lateral test	1,000 cycles	
Canopy high offset yield test	500 cycles	
Canopy low offset yield test	500 cycles	(2,000)
<u>Phase 2</u>		
Combined roof / floor member tests	4,000 cycles	
Waste to face lateral test	2,500 cycles	
Canopy high offset yield test	500 cycles	
Canopy low offset yield test	500 cycles	(9,500)
<u>Phase 3</u>		
Combined roof / floor member tests	4,000 cycles	
Waste to face lateral test	2,500 cycles	
Canopy high offset yield test	500 cycles	
Canopy low offset yield test	500 cycles	(17,000)
<u>Phase 4</u>		
Combined roof / floor member tests	4,000 cycles	
Waste to face lateral test	2,500 cycles	
Canopy high offset yield test	500 cycles	
Canopy low offset yield test	500 cycles	(24,500)
<u>Phase 5</u>		
Combined roof / floor member tests	4,000 cycles	
Waste to face lateral test	2,500 cycles	
Canopy high offset yield test	500 cycles	
Canopy low offset yield test	500 cycles	(32,000)
<u>Total for project</u>	<u>32,000 cycles</u>	

The definition of test failure was agreed as damage that would leave the fabrication in a condition such that it would be unfit for service or economical repair.

This could be either:-

a) Sudden acceleration of crack propagation rate.

b) Parent metal failure such that a salvage repair would be inappropriate.

c) Loss of prime function. I.e. unable to sustain yield loads.

New Denmark – Case Study

Testing commenced and was progressing very well:

- Phase 1, 2, and 3 where completed successfully
- The strip and NDT testing was conducted with no significant issues to the welds detected
- The testing of the support (phase 4) then recommenced

New Denmark – Case Study

During phase 4, at 19,000 cycles (a total of 32,000 cycles including these seen underground) there was a catastrophic failure of the lower links, and the test had to be suspended.

The lower links were replaced, and the test resumed successfully completing phase 4, and 5. Deterioration was monitored throughout the extended testing but didn't impact the structural performance and the support achieved the target 45,000 cycles.

New Denmark – Case Study

From the results of the test ,a comprehensive plan was devised. advising on when to carry out proactive replacement of the lower links, as well as any other work required to take the supports to the required 45,000 cycles.

Structure	Component area	Inspection plan (PRS cycles)**	Action
Rear Shield	No structural deterioration expected		
Canopy	Leg casting welds (fig 5.1)	0-20,000 20,000 30,000 40,000	No action required Inspect welds Inspect welds Inspect welds
	Canopy bottom plate local apertures (fig 5.2)	0-30,000 30,000	No action required Inspect lifting hole plate area – consult Joy engineering with results
	Canopy Local top plate dishing to hinge area (fig 5.3)	On-going consistent with panel change	Conduct audit – weld repair as appropriate
Base	Base skid to outer side walls (fig 5.4)	On-going –consistent with panel change	Conduct audit – weld repair as appropriate
	Base skid plate to side wall at lower link bore (fig 5.5)	On-going –consistent with panel change	Conduct audit – weld repair as appropriate
	Vertical rear bridge (fig 5.6)	30,000	Inspect and consult with Joy to discuss extent of repair requirements
	Upper link base doublers (fig 5.7)	30,000	Area to be monitored
Bores		30,000	To be repaired when Joint clearances exceed maximum OEM recommendation of 2mm
Lower Link (LH and RH)	N/A	25,000	Replace link

Summary

Extended life testing is a process to evaluate if a support can be taken past its original life cycles, with those results feeding into a detailed report or Life Cycle Management plan.

Due to its predictive nature, the life cycle management plan identifies when components are likely to reach the end of their serviceable life and allows maintenance budgets to be developed with greater accuracy, and also phased in over a number of years / face moves.

Importantly this provided operators with options when evaluating equipment going forward with the added confidence in the proven longevity of the supports.

Questions?