

5 Conclusion

Until new Eskom plants enter in service, the current and near term future power needs have to rely on the existing plants. It is logical that as the age of the units remaining in service increases, their performance deteriorates. Life extension programs are a way to reverse the effects of the aging process and permit cost effective operation of coal fired power plants beyond their traditional lifetime.

Normally life extension has some advantages over new construction: it is noticeably less expensive, has fewer environmental and siting complications, and offers less financial risk.

The very first step to take in a life extension program is to find out the present conditions of the candidate plant. The present condition of the plant determines the number and extent of equipment modifications needed for extended operation. A review of the plant's operating history combined with visual inspection of components and non-destructive tests is the only reliable path of determining this. The different companies involved in the life extension study made use of the historical documentation available and in absence of it, interviews with the plant personal were normally done.

The different companies involved in the study assessed the remaining life of the diverse components and defined the equipment replacement schedules, operating and maintenance procedures to assure the reliability of the corresponding system, as well as the associated costs (investment and maintenance).

Defining and implementing an optimum life extension program comprehends a considerable planning effort. To simplify the work for this study some units were used as sample basis, and it was assumed that the findings and necessary actions for the life extension could be applied for the rest of the units. This is a good approach, however, it has to be pointed out that although having fairly similar operating conditions, the diversity in designs, histories, operating and maintenance practices, make the effects of aging quite unique for each unit. Even near-twin units can have substantial differences in the remaining lives of the major components.

Across the compiled document the main findings and recommendations of the different companies involved in the life extension study were included. The statements of the companies sound in general reasonable, and additional comments were just done in points in which a different opinion and or suitable recommendation arose.

No amount of planning can define the exact duration or complete cost of a retrofit effort in advance. That is why the costs which were shown for the different scenarios can be considered as a sound and reliable approximation, since as exposed before, the study itself bases on simplified work and assumptions, therefore exact prices need to be confirmed.

In general the actions and recommendations made for the different scenarios are similar; most of the differences are related to the frequency and or extension in which the actions are to be done.

Comparing and compiling all results of the investigations, evaluations and assessments of the various scenarios

- a) Run the power station up to 2025, as per Eskom current plans
- b) Run the power station up to 2035, i.e. 10 years or more extension
- c) Capacity increase benefits by improving (Maintenance / repair / replacement) relevant particular systems,

Siemens recommends the following procedure:

1. Run the power station up to 2035 or even longer by investing and modernizing life exhausted components and systems as well as on outdated and maintenance "intensive" components and systems because the costs of this option significantly outweigh the costs of investing in a new plant e.g. approx. one third. The infrastructure of the station is in place and is sound to implement the modernization concept.
However, it is also recommended to do a review of the current status of the different systems before applying the corresponding investments.
2. It is not recommended to increase the capacity of the boilers. The reasons for this recommendation are discussed in detail in the related chapters

However it has to be expected that an improvement of efficiency of the plant as a whole will occur along with further improved maintenance, repair and replacements as described in scenario "run to 2025 and 2035".

Therefore it is also highly recommended to take care of "capacity improving solutions" when maintenance / repair / replacement work is due. This way is the most economic and risk minimized way to operate the power station properly in the future.

6 Appendix

6.1 Boiler Plant Area

6.1.1 Boiler U1 – U5

Sub reports			
No.	Document	Doc. No.	Rev.
1	Babcock Life-ex Study Final Report Rev 4	80913-03-16-RE000431	4
2	Babcock Desktop Study	AK96/99/E0001	3
3	Preliminary Report Boiler and Auxiliaries (SE)	064079-T-STD-001-00	0
Test and Inspection Reports			
4	Boiler Tube Life Prediction Unit 1-5 Report		
5	Unit 3 Main Steam Pipework Stress Analysis	80913-3/90/E/0027	0
6	Process And Modelling Boiler Report		
7	Unit 3 Feed Water Pipework Stress & Fatigue Analysis	80913-3/90/E/0082	0
8	Fatigue Screening Of Thick-walled Components	80913-3/16/E/0020	1
9	Rough Creep Life Estimates Of Thick-walled Components	80913-3/16/E/0011	1
10	Feedwater - Visual Inspection		
11	Feedwater - Wall Thickness Reading		
12	Boiler Data Sheet	CDS - 80913	
13	Historical Coal Analysis	80913/70/E0002	3
14	Design Basis	AK96/16/E0002	2

6.1.2 Boiler U6 – U10

Sub reports			
No.	Document	Doc. No.	Rev.
1	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Final Report	TRPT002166	1
2	Hendrina Power Station Unit 6-10 Desktop Study for Economizer (Flow Scheme No. 12-17)	TRPT001581	2
3	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Study for the Evaporator (Flow Scheme No. 27 - 43)	TRPT001601	4
4	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Study for Attemperator I & II (Flow Scheme No. 60-62 & 71-72)	TRPT001586	4
5	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Studies for Distribution Header before SH3 and Connecting Pipes (Flow Scheme No. 63-64)	TRPT001588	2
6	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Studies for Distribution Header before SH3 and Connecting Pipes (Flow Scheme No. 63-64)	TRPT001589	4
7	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Study for Superheater II Outlet Header (Flow Scheme No. 58)	TRPT001583	4

8	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Study for Superheater 3 (Flow Scheme No. 65 to 71)	TRPT001758	4
9	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Study for the Final Stage Superheater Convection Coil (Flow Scheme No. 77, 78, 79, 80 & 81)	TRPT001780	3
10	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Study - Final Superheater Inlet Header (Flow Scheme No. 76)	TRPT001751	4
11	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Study for the Final Superheater Outlet Header (Flow Scheme No. 82)	TRPT001752	4
12	Hendrina Power Station Unit 6-10 Life-ex Desktop Study for Boiler Drum and Down comers	TRPT001540	2
13	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Studies for Ash Removal System	TRPT001593	2
14	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Study for the Fuel Supply System	TRPT001594	2
15	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Study for the Milling Plant	TRPT001595	2
16	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Studies for Sealing Air System	TRPT001596	2
17	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Study for Combustion Equipment	TRPT001582	2
18	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Report for PF Pipe Work	TRPT001884	2
19	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Studies for Secondary Air System	TRPT001584	2
20	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Study for Flue Gas System	TRPT001585	2
21	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Report for Feed water System	TRPT001602	3
22	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Study for Steam Generator Blow Down System	TRPT001597	2
23	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Report for Main Steam System	TRPT001604	3
24	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Report for Boiler Drain Pipe Work	TRPT002194	0
25	Hendrina Power Station Unit 6-10 Life-ex Study 2012 Desktop Study for the Boiler Steel Structures	TRPT001598	2
26	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Studies for Air Ejector	TRPT001599	1
27	Hendrina Power Station Life-ex Study 2012 Unit 6-10 Desktop Studies for Deaerator and Feed water Storage System (flow index no.208)	TRPT001600	1
Test and Inspection Reports			
28	Economizer Wall Thickness Calculation	TCLC001013	2
29	Fatigue Analysis for Economizer Inlet Header	TCLC000918	0
30	Fatigue Analysis for Economizer Intermediate Header	TCLC000913	0
31	Evaporator Wall Thickness Calculation	TCLC001012	0
32	Attemperator 1 Header Creep Calculation	TCLC000922	1
33	Attemperator 2 Header Creep Calculation	TCLC000923	2
34	Attemperator Header and Branches Wall Thickness Calculation	TCLC001002	1
35	Attemperator 1 Spraywater Branch Creep Calculation	TCLC001023	1
36	Attemperator 2 Spraywater Branch Creep Calculation	TCLC001024	1
37	Distribution Header (FSN 63) Before Superheater 3 Creep Calculations	TCLC000920	2
38	Distribution Headers upstream SH3 and Final SH	TCLC001006	1

39	Connecting Pipes Before Superheater 3 Inlet Header (FSN 64) Creep Calculation	TCLC001018	1
40	Connecting Pipes Before Final Superheater (FSN 75) Creep Calculations	TCLC000921	1
41	Distribution Header (FSN 74) Before Superheater 4 Outlet Header Creep Calculations	TCLC001020	2
42	Fatigue Analysis for Superheater 2 Outlet Header	TCLC000914	0
43	Superheater 2 Wall Thickness Calculation	TCLC001005	1
44	Superheater 2 Outlet Header (FSN 59) Creep Calculation	TCLC001029	2
45	Superheater 2 Outlet Header Inspection Branch Creep Calculation	TCLC001030	1
46	Superheater 2 Outlet Vent Branch Creep Calculation	TCLC001031	1
47	Fatigue Analysis for Superheater 3 Outlet Header	TCLC000915	0
48	Superheater 3 Wall Thickness Calculation	TCLC001004	1
49	Superheater 3 Inlet Header (FSN 65) Creep Calculation	TCLC001019	1
50	Superheater 3 Outlet Header Stubs (FSN 69) Creep Calculation	TCLC001021	1
51	Superheater 3 Outlet Header (FSN 70) Creep Calculations	TCLC001025	2
52	Connecting Pipe (FSN 71) Creep Calculations	TCLC001027	1
53	Superheater 3 tubes (FSN 68) Creep Calculations	TCLC001356	0
54	Final Superheater Wall Thickness Calculation	TCLC001003	1
55	Superheater 4 Tubes (FSN 78, 79 & 81) Creep Calculations	TCLC001026	2
56	Superheater 4 Tubes (FSN 77 & 80) Creep Calculations	TCLC001028	1
57	Final Superheater Inlet Header Creep Calculation (FSN 76)	TCLC001040	0
58	Fatigue Analysis for Final Superheater Outlet Header	TCLC000916	0
59	Superheater 4 Outlet Header (FSN 82) Creep Calculations	TCLC001022	2
60	Boiler 9 Steam Drum Fatigue Analysis Calculations Prelim Report	TRPT002214	1
61	Steam Drum Wall Thickness Calculation	TCLC001011	2
62	Calculation of Fatigue Life Boiler 9 Drum – Trip Type 1	TCLC001416	0
63	Calculation of Fatigue Life Boiler 9 Drum – Trip Type 3	TCLC001418	0
64	Calculation of Fatigue Life Boiler 9 Drum – Trip Type 4	TCLC001419	0
65	Calculation of Fatigue Life Boiler 9 Drum – Cold Starts	TCLC001420	0
66	Feed water, Economizer and Main Steam Pipe Work Minimum Wall Thickness Calculation	TCLC001076	1
67	Main Steam Pipe Work Creep Calculation	TCLC001352	1
68	Boiler Drain Pipe Work Minimum Wall Thickness Calculation	TCLC001404	0

6.1.3 Boiler Draft Plant

Sub reports			
No.	Document	Doc. No.	Rev.

1	Final Report by Howden	AD05-071 B 2 of 2	3
2	Desktop Study Report		1
3	Preliminary Report Boiler and Auxiliaries (SE)	064079-T-STD-001-00	0
Test and Inspection Reports			
4	U3 Air heater assessment		
5	U3 Air heater FEA		1
6	U3 FD and ID Fans assessments		
7	U3 FD Fan FEA		1
8	U3 PA Fans assessment		
9	U3 & U7 FD Fan foundation assessments		1
10	U3 FFP, foundation and structural steel assessments		1
11	U9 Air heater assessments		
12	U6 -- U10 Proposed sootblower arrangement drawings		1
13	U9 FD Fans assessment		
14	U9 ID Fans assessment		

6.2 Turbine Plant Area

6.2.1 Turbine Centreline

Sub reports			
No.	Document	Doc. No.	Rev.
1	Final Report for Main Steam Turbine and Boiler Feed Pump Turbine	E1A1069120	G
2	Desktop Study Centreline	1CW0068535	A
3	Preliminary Report Turbine Centreline (SE)	064079-T-STD-005-00	0
Test and Inspection Reports			
4			

6.2.2 Turbine Auxiliary

Sub reports			
No.	Document	Doc. No.	Rev.
1	Siemens Life-ex Report	AG 2007	
2	RKES Life-ex Preliminary Report	Hendrina Turbine Aux Preliminary report rev 30 final 23 may 2014	Rev 30
3	RKES Life-ex Final Report (Final Draft)	Hendrina Turbine Aux Preliminary report rev 01 final 23 may 2014 AD05-062A	Rev 01

4	RKES Life-ex Desktop Study	Hendrina Turbine Aux Desktop Study AD05-006A	Rev A
Test and Inspection Reports			
1	Eddy Current Inspection Reports	AD 05-003A	Rev 00
2	Wall Thickness Inspection Reports	AD 05-003A	Rev 00
3	Replication Reports	AD 05-003A	Rev 00
4	Visual Inspection Reports	AD 05-003A	Rev 00
5	Magnetic Particle Reports	AD 05-003A	Rev 00
6	Liquid (Dye) Penetrant Reports	AD 05-003A	Rev 00
7	Maintenance Strategy Condensate Plant	HSSTP MM 014 – R0 Maintenance Strategy Condensate Plant	
8	Maintenance Strategy Feedwater Plant	HSSTP MM 015 – R0 Maintenance Strategy Feedwater Plant	
9	Hendrina Power Station Outage Scope of Work for Turbine Auxiliaries	Hendrina Power Station Outage Scope of Work	
10	Hendrina Power Station Outage FAC Scope of Work	Condensate & Feed Heating SOW - FAC Strategy	
11	Hendrina Power Station Outage Scope of Work for Turbine Auxiliaries Valves	GO turbine auxiliary valves SOW	

6.2.3 Pumps

Sub reports			
No.	Document	Doc. No.	Rev.
1	Sulzer Life-ex Preliminary Report	-	11
Test and Inspection Reports			
2	Site Test Procedure	No Information	0
3	KSB Report for Life-ex Report	No Information	-

6.3 C&I Plant Area

Sub reports			
No.	Document	Doc. No.	Rev.
1	EPIE Life-ex Study Final Report C&I	QA - 01 - 003	2
2	Preliminary Report C&I (SE)	064079-T-STD-003-00	0
Test and Inspection Reports			
3	-	-	-

6.4 Electrical Plant Area

6.4.1 Electrical

Sub-reports			
No.	Document	Doc. No.	Rev.
1	Hendrina Life X Study Final Report Auxiliary Transformers	JS1101/0530V4	
2	Desktop Study Based on Oil Test Reports	JS1101/0528V3 (Annexure D)	
3	Hendrina Life X Study Final Report Generator Busduct	JS1101/0429V1	
4	Hendrina Life X Study Final Report Low Voltage Motors	S1101/0409V7	
5	Hendrina Life X Desktop Study Low Voltage Motors	JS1101/0122V1	
6	Hendrina Life X Study Final Report Medium Voltage Cables	JS1101/0714V1	
7	Preliminary Report Electrical (Martec) (SE)	064079-T-STD-007-00	0
Test and Inspection Reports			
8	Data Requested	JS1101/120112V3 (Annexure A)	
9	Interview Notes	JS1101/120112V2 (Annexure B)	
10	Oil Test Reports	JS1101/0530V4 (Annexure C)	
11	Additional Assessment Report	JS1101/120218V3 (Annexure E)	
12	Oil Assessment Criteria	JS1101/0530V3 (Annexure F)	
13	Transformer Condition Summary	JS1101/0530V4 (Annexure G)	
14	Transformer Listing	JS1101/0530V4 (Annexure H)	
15	Comparison of Options	JS1101/120112V2 (Annexure I)	
16	Data Requested	JS1101/0429V1 (Annexure A)	
17	Interview Notes	JS1101/120112V2 (Annexure B)	
18	Insulator Inspection and Test Reports	JS1101/0429V1 (Annexure C)	
19	Station Busduct Investigations	JS1101/0429V1 (Annexure D)	
20	Summary of Inspections and Test Results	JS1101/0429V1 (Annexure E)	
21	Costs and Scheduling	JS1101/0429V1 (Annexure F)	
22	Busduct Maintenance Plan	JS1101/0429V1 (Annexure G)	
23	Data Requested	JS1101/120112V3 (Annexure A)	
24	Interview Notes	JS1101/120112V2 (Annexure B)	
25	Failure Investigation	S1101/0409V7 (Annexure C)	
26	Ultrasound and Thermography Survey	JS1101/120119FV1 (Annexure D)	
27	Ultrasound and Thermography Analysis	S1101/0409V7 (Annexure E)	
28	Spare Motor Test Report	JS1101/120218V4 (Annexure F)	

29	LV Motor Repair Costs	S1101/0409V7(Annexure G)	
30	Criticality Ranking	S1101/0409V7 (Annexure H)	
31	Data Requested	JS1101/120112V3 (Annexure A)	
32	Cable Schedules and Code	JS1101/0714V1 (Annexure B)	
33	Single Line Diagrams	JS1101/0714V1 (Annexure C)	
34	Failure Investigations	JS1101/0714V1 (Annexure D)	
35	Prior Assessments	JS1101/0714V1 (Annexure E)	
36	Cable Replacement Projects	JS1101/0714V1 (Annexure F)	
37	CableWISE Reports	JS1101/0714V1 (Annexure G)	
38	Cable Condition Summary	JS1101/0714V1 (Annexure H)	
39	Laboratory Assessment	JS1101/0714V1 (Annexure I)	
40	Costs and Scheduling	JS1101/0714V1 (Annexure J)	
41	MV Cable Maintenance Plan	JS1101/0714V1 (Annexure K)	

6.4.2 Generators

Sub-reports			
No	Document	Doc. No.	Rev.
1	Life-ex Report 2014 – Turbogenerators of Hendrina PP	064079-T-STD-100-01Error! Reference source not found.	01
2	Aging Characteristics of Paper Insulated Stator Cores_2009	Presentation	20/10/2009
3	Condition assessment for Life-ex_Hendrina 9_Wei_26-05-2014	EF PR GN QM AE / 2014 / 1029	0
4	FQP 1365C RELEASED	1365C	0
5	Modernization_of_Generator_Auxiliary_Systems_at_Hendrina_2008_09_25	Presentation	25/09/2008
6	StaticStartPolicyR4	None - Extract	None
7	TRST-2008-0241	ST-2008-0241	0
Test and Inspection Reports			
2			

6.5 Common Plant Area

Sub-reports			
No.	Document	Doc. No.	Rev.
1	Hendrina-Life-ex-Study Final Report	OK110552	0
2	Preliminary Report Common Plant	064079-T-STD-002-00	0
3	Ash dam Report	474-9565	1

Test and Inspection Reports			
3	DPA-	OK110552-	01