Newfoundland and Labrador Hydro, a Nalcor Energy Company

Holyrood Condition Assessment & Life Extension
Public Utility Board Technical Review Oct 13, 2011

Agenda - AMEC

1. Safety Moment
2. AMEC Introductions
3. AMEC Overview
4. AMEC Holyrood CALE Team
5. Key Highlights

APPENDIX

A. Project Scope and Basis
B. EPRI Condition Assessment Method

Safety Moment – Travel Planning

AMEC Introductions

AMEC Introductions

Blair Seckington

- Director, Power & Process Consulting, 36 years power experience
- AMEC - Mechanical/Project Manager. Life management/capital plan – Burrard GS. Condition assessment – Holyrood TGS. Project screening and pre-feasibility lead for various power projects
- OPG - Senior Fossil Technology Advisor – Fossil business capital plan and project reviews for executive office. Led OPG selective catalytic NOx control and revenue metering corporate programs

Andrew DuPlessis

- Electrical Engineer/Project Manager. AMEC Power Utility Leader for Atlantic Canada. Lead Electrical Engineer for various Power Projects for NB Power, OPG and NSPI. Over 20 years experience in power.

AMEC Overview

AMEC at a Glance

- FTSE 100 company — **Market cap* US$2.875bn**
- **R**evenues — Approximately **US$5bn**
- Employees — Approximately **27,000**
- Net cash — **Approximately US$1bn**

Aspiring to Operational Excellence

*As at the close, 15 January 2009

Office Locations

Our 27,000 employees operate from more than 40 countries

Our Businesses

Natural Resources
Operates in the oil and gas services, unconventional oil (oil sands), and mining market segments

Power and Process
Operates in the power, industrial process, biofuels, and nuclear market

Environment and Infrastructure
Provides specialist consultancy and engineering services

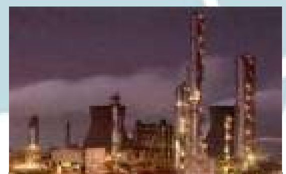
Leading Market Positions – Power and Process

Power Generation
Conventional & Renewables

Process
Forest Industry
Cement

Nuclear
Consulting, engineering and programme management services

Power Transmission



Process
Petrochemical Plants

Process
Gas storage and transmission

Strong Scalable Positions

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Select Power Clients

AES
ALSTOM
Babcock Power Inc.
Bruce Power
Dominion
East Kentucky Power Cooperative
Enbridge
Duke Power
Énergie NB Power
EPCOR
GE
KU an e-on company
Mitsubishi Power Systems
Mirant
newfoundland labrador hydro a nalcor energy company
NVEnergy
Old Dominion Electric Cooperative
Ontario Power Generation
Progress Energy
SCE&G A SCANA COMPANY
ScottishPower
Seminole Electric Cooperative, Inc.
Siemens
Santee Cooper
Southern Company
TransAlta
TECO Tampa Electric
TVA
Xcel Energy

AMEC Power and Process Americas

		Highlights
2003	AMEC acquires Kamtech	Construction and Maintenance capabilities
2000	AGRA Simons and AGRA Monenco becomes part of AMEC	The world's largest international design firm (ENR 2001, 2002)
1999	Simons joins AGRA	Canada's largest E&C firm
1968 - 1998	Simons expands globally	Study & design of 125 new paper machines and 60% of world's kraft pulp production
1947 - 1967	Simons builds most of the mills in W. Canada	Responsible for numerous industry "firsts"
1944	HA Simons establishes Vancouver practice	Establishes reputation in pulp & paper for innovative design and project execution
1914	VD Simons establishes Chicago practice	
1907	Monenco founded	

AMEC Holyrood CALE Team

AMEC Project Team

amec

TODD COLLINS
Newfoundland & Labrador Hydro, Project Manager - Engineering Services

BOB LIVET
AMEC OAKVILLE, Project Director, VP – Power & Process

BLAIR SECKINGTON
AMEC Oakville, Study Manager, Steam & Power, Generating Systems

IAN LEACH
Specialist
Plant Maintenance & Operation

VISHAN SHARMA
Specialist
Steam Turbine & Auxiliaries

DR. M. NATARAJAN
Specialist
Boiler & Auxiliaries
Thermal Power

DAVID ENNIS & SCOTT BENNETT
AMEC ATLANTIC
Mechanical Specialist
Diesel & GT Power

BOB JEFFREYS
Generator/Elect Equipment
Electrical Generators

DAVID JONES (BILL CALDWELL)
AMEC ATLANTIC
Specialist (Supervisor) Electrical & Instrumentation

DAVID McNABB
AMEC NSS
Specialist
Mechanical & Life Analysis

NOEL RYAN (BILL TUCKER)
AMEC ATLANTIC
Structural (Specialist)

GLEN CLEMENTS
AMEC ATLANTIC
Specialist
Water & Waste Water

SUPPORT STAFF & GROUPS
Civil, Electrical, I&C, Mechanical - Support Staff in Oakville, Newfoundland & Halifax
B&W (Unit 3 Data); GE Site Rep; Alstom Site Rep

SUPPORT EXTERNAL
NSS Toronto, B&W, Alstom, GE

Project Team

- Blair Seckington – Mechanical/Process Engineer/Project Manager. OPG Fossil Technology. AMEC Director, Power Technology. Over 36 years experience in power.
- Ian Leach – Operations and Maintenance Specialist. Over 41 years experience in Ontario and Alberta. A key member of BC Hydro Burrard studies and led Holyrood Fire Emergency procedure
- Vishan Sharma – Steam Turbine/Mtce Expert. Over 39 Years power experience including OPG and Monenco. Led the Point Lepreau turbine Efficiency assessment. Some involvement in Holyrood design.
- Bob Jeffreys – Turbine-Generator Electrical Specialist. 40+ years power experience (Nant/Lakeview/SaskPower Synch Cond Exp)
- David McNabb (NSS) – Power Plant Mechanical Systems; Life Cycle and Asset Management. 35+ Years of mechanical systems, high pressure water/steam analysis

Project Team

- Scott Bennett - 32 years in mechanical system designs for commercial, institutional, industrial and residential infrastructure sectors, and as a senior engineering manager and project manager
- David Jones – 40+ years of engineering and operations experience on power, instrumentation and control systems for marine offshore equipment facilities, steel and paper mills, hydroelectric plants, transmission, distribution and terminal station systems
- David Ennis – 10 Years of industrial and commercial mechanical engineering for commercial facilities, marine offshore equipment facilities, and steel and paper mills.

Project Team – Additional Support

- Dr. M Natarajan – 40+ years in power generation: feasibility studies, environmental control technologies, plant condition assessments and life extension, plant performance audits, EPCM and EPC projects. Installation and commissioning work on Holyrood Units 1, 2 and 3 plus boiler studies, fuel conversion and site repowering. Worked with Nova Scotia Power (Tuft's Cove design, Pt Tupper oil to coal conversion, Lingan design, Trenton fuel studies, and Pt Aconi CFBC operational studies) and with New Brunswick Power (Coleson Cove senior technical advisor from conceptual design stage up to and including the FGD addition and ESP retrofit to the 3 X 350 MW oil fired units, Belledune design and planning studies)
- Bill Caldwell - 29 years design experience in industrial power systems and hydroelectric projects from 20 MW to 1000 MW, including electrical machinery, power distribution and transmission, protection, instrumentation and control, power electronics and material handling. PE in Newfoundland, Quebec and Ontario.
- Bill Tucker – 25+ years in marine and structural design, project management, structural design, stability analysis and repair recommendations on hydro projects in Newfoundland

Project Team - NSS

AMEC NSS Specialist Resources – Boiler & High Pressure Piping

- David McNabb (NSS) – Power Plant Mechanical Systems; Life Cycle and Asset Management. 35+ Years of mechanical systems, high pressure water/steam analysis
- Tahir Mahmood (NSS) – Engineer, Life Cycle and Asset Management. 5+ Years of mechanical systems, high pressure water/steam analysis
- Avik Sarkar (NSS) – Senior Engineer, Life Cycle and Asset Management. 10 Years of mechanical systems, high pressure water/steam analysis
- Ming Lau (NSS) – Senior Technical Expert, Performance Engineering; Life Cycle and Asset Management. 20+ Years of mechanical systems, high pressure water/steam analysis

Key Highlights

NLH Basis

Primary Study Focus (for 2020 Generation & 2041 Synchronous Condensing):

- Generators;
- Switch gear and switchyard;
- Control system associated with generators;
- Station auxiliary systems;
- Buildings and building M and E system;
- Cooling water system associated with generators;
- Transformers;
- Gas turbine and diesel gensets;
- Hydrogen and carbon dioxide;
- Compressed air; and
- Generator lube oil.

NLH Basis

Reduced Study Emphasis (Maintain Reliable Generation to 2020):

- Fuel Systems (light and heavy oil)
- Boiler System
  - Boilers; feed water system; heat exchangers; condensers
  - Deaerators; FD fans; air preheaters; Stacks
  - DCS associated with steam systems
  - Electrical & instrumentation associated with steam systems
- Steam turbines;
- Cooling water system associated with steam systems;
- Waste water treatment facility;
- Water treatment system; and
- (Marine terminal)

EPRI Condition Assessment Method

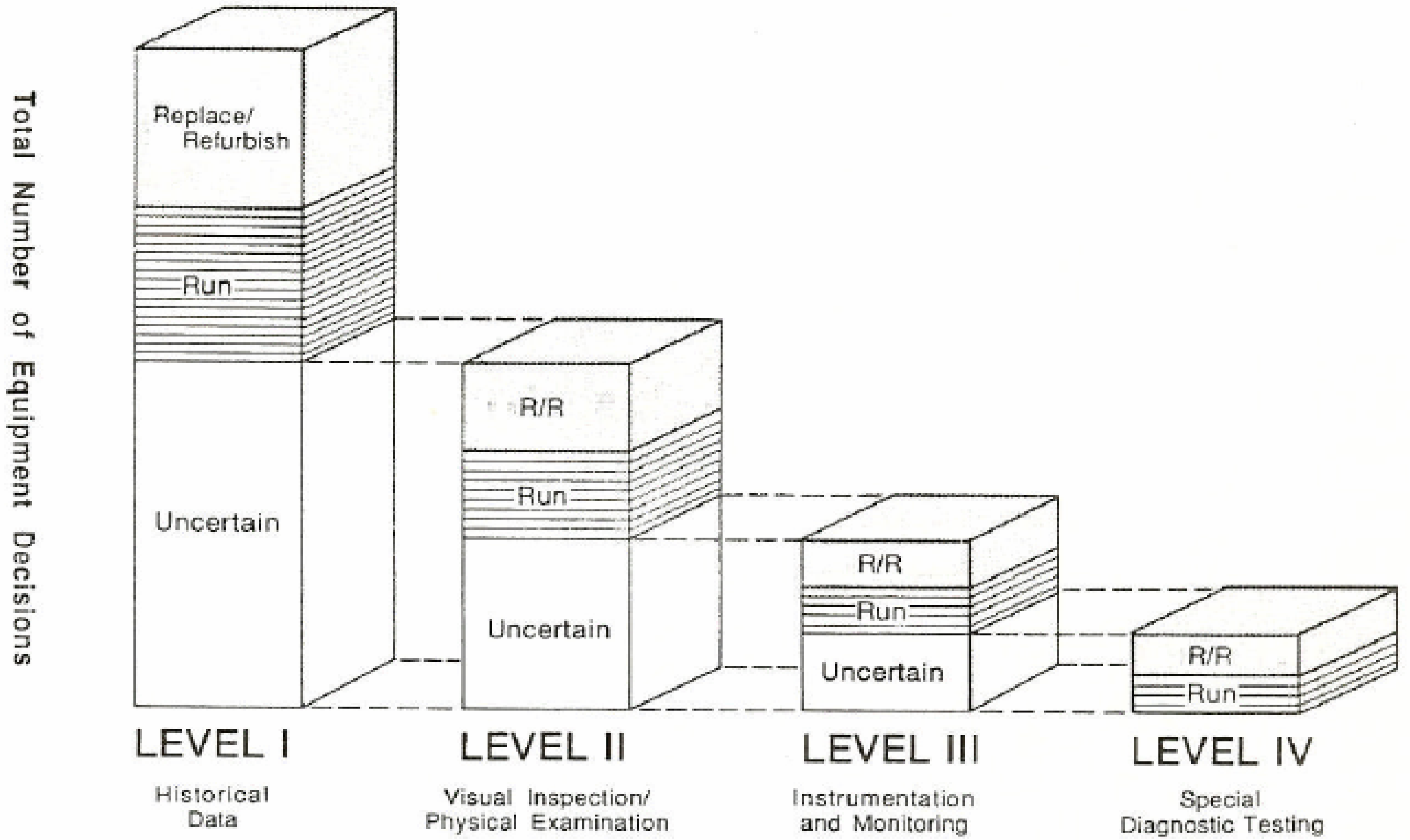


Figure 1-3. Four-Level Electrical Component Life Assessment

Source: Cambrias and Rittenhouse (9)

Source: EPRI GS6724

Boiler Condition Assessment Guide

Condition Assessment

Technical Risk Assessment

<u>Likelihood of Failure Event:</u>

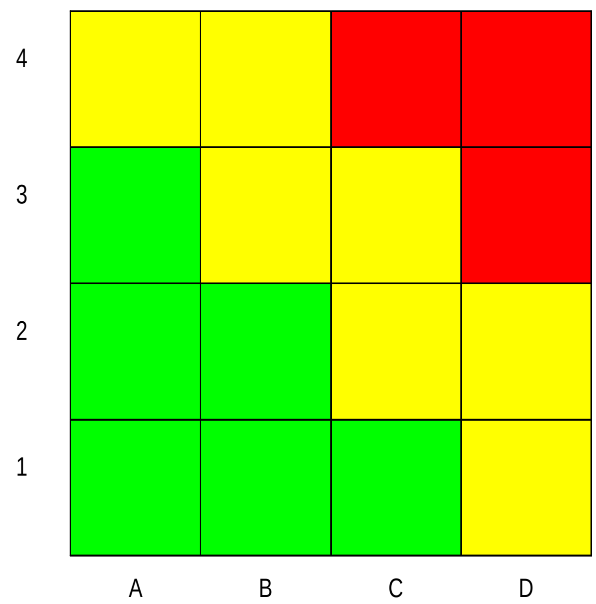
1. Greater than 10 years
2. 5 to 10 years
3. 1 to 5 years
4. Immanent (< 1 year)

<u>Consequence of Failure Event:</u>

A. Minor ($10k-$100k or derating/1 day outage)
B. Significant ($100k-$1m or 2-14 days outage)
C. Serious ($1m-$10m or 15-30 days outage)
D. Major (>$10m or >1 month outage)

<u>Actions:</u>

- Items that do not apply are not ranked
- Low Risk: Monitor long term (within 5 years)
- Medium Risk: Investigate and monitor short term. Take action where beneficial
- High Risk: Corrective action required short term



Condition Assessment

Safety Risk Assessment

<u>Likelihood of Safety Incident Event:</u>

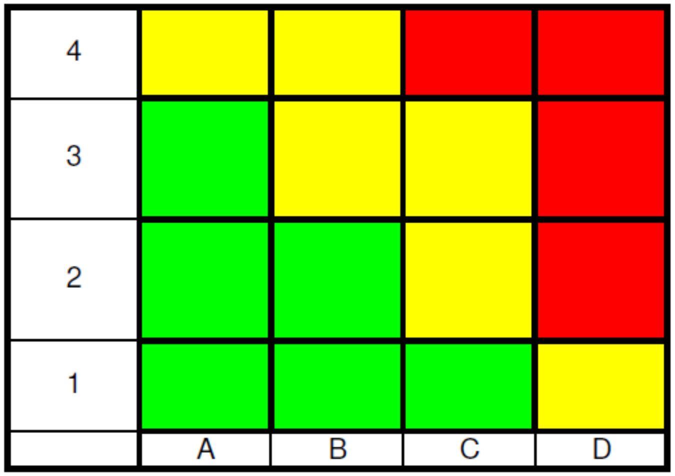
1. Improbable – so that it can be assumed not to occur
2. Unlikely to occur during life of specific item/process
3. Will occur once during life of specific item/process
4. Likely to occur frequently

<u>Consequence of Safety Incident Event:</u>

A. Minor - will not result in injury, or illness
B. Marginal - may cause minor injury, or illness
C. Critical - may cause severe injury, or illness
D. Catastrophic - may cause death

<u>Actions</u>:

- Items that do not apply are not ranked;
- Low Risk: Monitor, take action where beneficial;
- Medium Risk: Investigate and monitor short term. Take action where beneficial; and
- High Risk: Unacceptable. Corrective action required short term



Priority Assessment

Priority assigned to the “Recommended Actions”, “Level 2 Inspections”, and “Capital Enhancements”.

Scale of “1” to “4”. “1” is the highest priority - this activity should definitely be undertaken and where practical in or about the timing identified. “4” is the lowest priority - the item is low risk/impact and may be much more readily delayed or undertaken in some other fashion.

Ranking is subjective relative ranking by AMEC, meant to be an aid to Hydro in allocating resources and assessing trade-offs and program delays. Ranking takes into consideration a number of aspects such as:

1. The impact (likely/worst case) on achieving the end of life (EOL) goal, on plant operation health and safety, and on environmental and regulatory requirements;
2. The urgency of the need for action;
3. The degree of certainty of the requirement;
4. The experience at Holyrood and in the broader industry context;
5. The ability to mitigate or address the issue in other ways;
6. The timing of the recommended response;
7. The cost relative to others; and
8. The ability of existing and planned or ongoing actions to resolve in a timely and successful manner.

Priorities should be taken in the context of its recommended timing. An item can be a “1”, but be scheduled for a later date if it is deemed that sufficient information exists to be confident of the minimal likely impact of the deferral (usually to tie in with a planned major activity such as an overhaul).

Plant Ops & Mtce

Asset Management & Maintenance Strategy: a “Best Practices” approach, implemented through a combination of in-house resources and external resources for major equipment technical support, overhauls, and external contracting for specialized services. Uses long term asset management and short term maintenance implementation model to ensure that both long term goals and short term needs are addressed. In most areas of the operation, the maintenance strategy and the asset management program are well implemented and consistent with other thermal generating stations across North America.

Staffing/Training: plant staffing is reasonable. Plant operators experience significant operating time and some starts and stops as on-the-job training. Some training programs run periodically on issues that may arise during operation. It is thought that some “what do you do if this happens”, and “why is it done that way” scenario training might be useful. Otherwise, the training program for all plant staff seems consistent with other thermal generating facilities. Modern simulators provide opportunities to train operators for critical scenarios.

Plant Ops & Mtce

PM Program: active computer-based PM program being revised to make it more practical, including the development of additional predictive approaches. Seen as very positive given the resources, role, and maintenance approach. A more user-friendly documentation system would be helpful.

Inspections: a strong commitment to align with regulatory requirements, insurance requirements, and industry practices. Generally very thorough in implementation of PM, inspections, overhauls, and equipment replacement . High pressure piping inspections and boiler hanger inspections required. The duration between major inspections and overhauls of the steam turbines can reasonably remain at nine years subject to the findings of each overhaul, but for the generators should be reduced back to six years.

Work Management: Hand written Work Orders (WO's) should be replaced with electronic WO's. Records management (also historical design information, operations and maintenance history) document control system should be implemented.

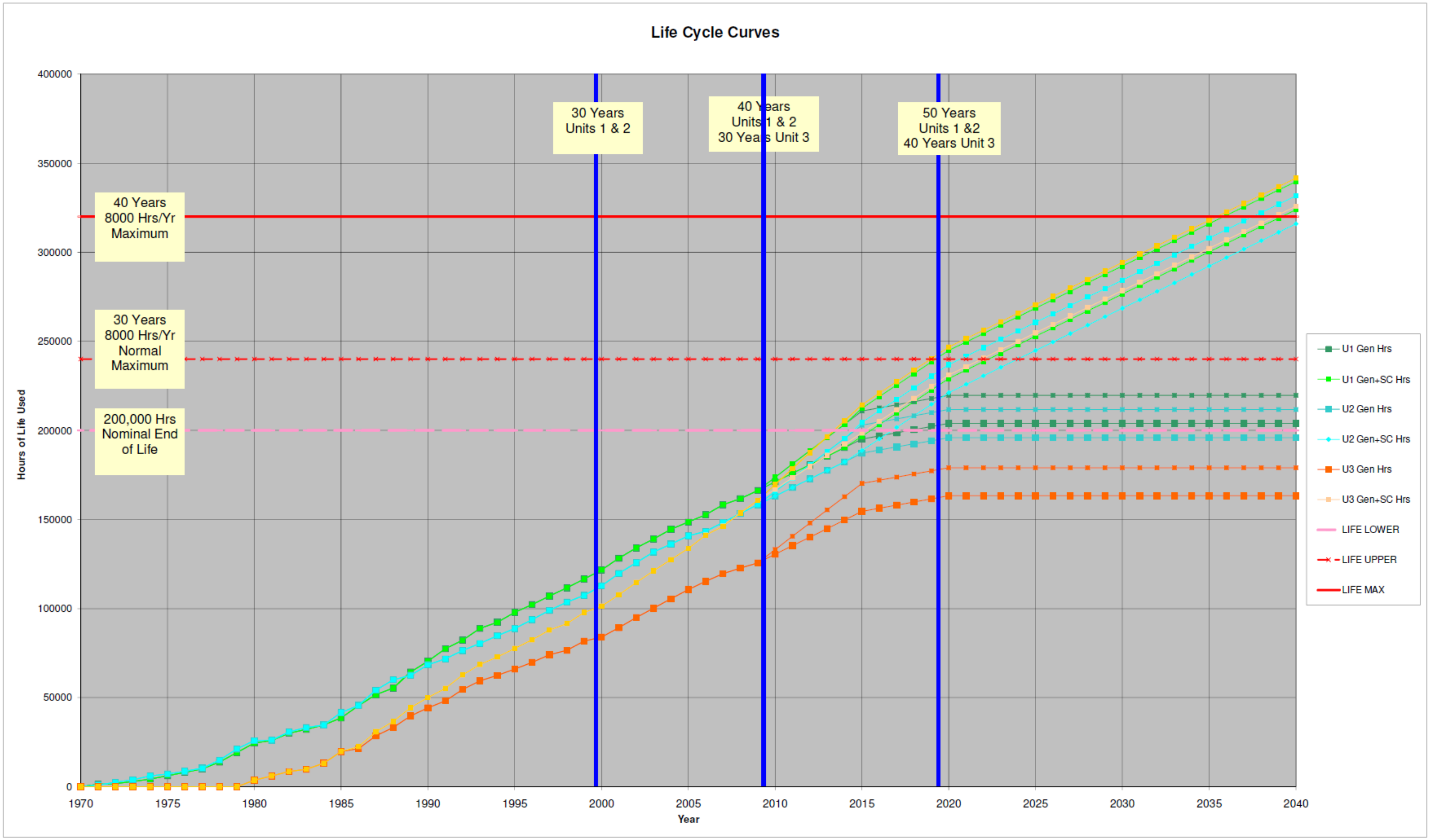
Overall Plant Condition

Fossil plants of the same era as Holyrood were designed with an economic life of 30 years. For practical purposes, this meant at least a 40 year or 200,000 operating hour technical life. Most were designed only for base load operation. In the United States, there are still plants that are in active service and quite functional, even at 60 years of age (typically older, small units in non-critical role). There are other plants being decommissioned or repowered, typically at 30+ years.

Holyrood Units 1 2, and 3 are approximately 42, 41, and 32 years old. Given their historical seasonal, and base but lightly loaded service, the operational age for some equipment and systems is more like 21, 20, and 17 years (Unit 3 including synchronous condensing is equivalent to about 20 years).

The plant has been well managed and maintained. The units have also seen minimum service at either their maximum continuous rating (let alone over-pressure/over-temperature) or at extreme minimum load. The units tend to operate between 70 and 140 MW (40% and 80% load) and most often around 110 to 125 MW (65-70%). Unit 3 has seen modest synchronous condensing operation since its retrofit in 1986.

Overall Plant Condition



Overall Plant Condition

Units 1 & 2 were uprated from 150 to 175 MW in 1987. Replaced components have a longer remaining life, and support a longer station life expectation.

The boiler and its major elements were major reliability and life issues. The original high sulphur (2.5% S) and high vanadium fuel oil caused significant corrosion and fouling problems that led to frequent washings and upgrades to some of the boiler heat transfer surfaces. The change in 2009 to a higher quality, lower sulphur (0.7%) fuel oil significantly improved boiler reliability and efficiency and has already had a positive life impact .

The plant can continue to generate electricity reliably to the year 2020 and if and when Units 1 and 2 are converted to synchronous condensers to provide system support should be able to fulfill that role to 2041. There are several pre-requisites to this, including continued and enhanced inspection and maintenance programs, planned major equipment refurbishment such as generator stator and rotor rewinds, transformer monitoring, controls and alarms upgrades, and switchgear and breaker refurbishments and replacements.

Overall Plant Condition

The key to extending plant life to 2020 for generation and to 2041 for synchronous condensing operation will be the generators, transformers, and switchgear and associated systems.

Units 1, 2, and 3 have major generator inspections scheduled for 2012, 2014, and 2016 respectively and have a near term need for stator and/or rotor rewinds.

Transformers are at the point in their lifecycle where significant degradation also occurs. More frequent or continuous monitoring of their condition is required to forewarn of any problems arising.

Existing switchgear is in many cases at or near end of life and refurbishment and replacement is required.

Overall Plant Condition

Single contingency systems, given age and failure history should be addressed:

- The failure of fresh/raw water supply from Quarry Brook Pond;
- The failure risk of the clarifier at least until 2020; and
- The 42 year age and condition of the black start gas turbine (reliability, parts obsolescence)

If Hydro addresses the key issues and maintains a vigorous maintenance and inspection program, there is no technical reason that the plant cannot reach its 2020 generation and 2041 synchronous condensing life targets.

The gas turbine generator and balance of plant is in need of a more comprehensive condition assessment.

APPENDIX

- Project Scope & Basis
- EPRI Condition Assessment Method

Project Scope & Basis

NLH Basis

Basis: Condition Assessment, Life Extension

- Identify measures to ensure high reliability as a TGS to 2015 (CF= 30% to 75%), as a standby generating plant to 2020, and as a synchronous condensing station to 2041.

As of Jan 31, 2009, the operating hours for each unit are as follows:

Unit 1	162,482 hrs
Unit 2	154, 161 hrs
Unit 3	123, 432 hrs
Unit 3 (as a synchronous condenser)	30,956 hrs

- Plant may be required to generate seasonally base loaded after 2015, requiring a more extensive study to assess the cost of extending the operating life

Study Basis

- 2010 to 2015 Generation Life
  - ACF/Pattern: capacity factor between 30% and 75% until 2015
  - Reliability: High, similar to current
  - Implementation Schedule:
    - 2010 Study→ 2011 Phase 2 →2012-2013 Implementation → ??
- 2015-2020 Generation Standby
  - Capacity required
  - Operating Pattern
  - Hot/Cold Standby – Time to Return
  - Reliability/Availability of Generation
- Synchronous Condensing 2015-2041
  - Capability Less Defined – generator, transformers, system
  - Operating Pattern and Requirements
- Subsequent Equipment Condition Analyses – Timing/Scope

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  - DCS associated with steam systems
  - Electrical & instrumentation associated with steam systems
- Steam turbines;
- Cooling water system associated with steam systems;
- Waste water treatment facility;
- Water treatment system; and
- (Marine terminal)

Subsystems (Holyrood Asset Register)

STEAM GENERATOR

- Superheater Tubing
- Reheater Tubing
- Waterwall Tubing
- Superheater Headers
- Reheater Headers
- Drums (Steam and Lower)
- Waterwall Headers
- Economizer Inlet Headers
- Main Steam Piping
- Hot Reheat Piping

TURBINE

- Steam Chest
- Valve Casings
- Turbine Casing and Shells
- HP/IP Rotor
- LP Rotor
- Blades

GENERATOR

- Rotating Field
- Retaining Rings
- Stator Windings
- Stator Insulation
- Cooling System,
  Housing Auxiliaries

BALANCE OF PLANT

- Condensers
- Feedwater Heaters
- Deaerators
- Cables
- Station Main Transformers
- Auxiliary Switchgear

AMEC Scope & Methodology

Condition Assessment & Life Extension

- Site visit & develop Asset Register
- Site review and equipment/facility inspections
- Review the Holyrood Plant Maintenance Program - existing Information/background data; interview staff
- The AMEC team will review and analyse the information and data gained with respect to Holyrood through:
  - Existing studies on condition assessment, life expectancy, previous studies of life extension, and the associated costs (capital and O & M) of such programs

AMEC Scope & Methodology

Condition Assessment & Life Extension

- Physical inspection reports of equipment
- Equipment Lost Time Analysis data
- Interviews and discussions with N&L Hydro Management
- Interviews/discussions with Holyrood Operations and Maintenance personnel
- Analysis of power demands vs Holyrood generation capabilities

- Analysis of the impact and value of capital upgrades and operational and maintenance improvements?

AMEC Scope & Methodology

Condition Assessment & Life Extension

- Determine remaining equipment and facility life - existing information, experience, OEM consultations, and develop life cycle curves for major critical equipment and facilities.
- Conduct an equipment risk of failure analysis for major plant components, equipment, systems, and the entire facility and identify any components or systems that require further investigation; and make recommendations for work that will be required to extend the plant's useful life into the future with the same high degree of reliability as experienced in the past.

NLH Basis

Generation to 2015 ACF–	40%	2016 to2020	ACF–	10%	
Operating Factor –	55%		Operating Factor–	20%	
Syncronous Condensing in 2015	4740	Hrs/Yr	(1500 av to date + 6 mos x 30 days x7d/wk + 75% of time)		

Year	ACF	MWh/Yr	Operating Factor %	Starts Per Year	Generation OP Hrs Cumulative Lifetime	Synch Cond OP Hrs Per Year	Synch Cond OP Hrs Cum	Total OP Hrs Cum Lifetime SC+Gen
2041	0.0%	0	0.0%	5	203925	4740	124740	328665
2040	0.0%	0	0.0%	5	203925	4740	120000	323925
2039	0.0%	0	0.0%	5	203925	4740	115260	319185
2038	0.0%	0	0.0%	5	203925	4740	110520	314445
2037	0.0%	0	0.0%	5	203925	4740	105780	309705
2036	0.0%	0	0.0%	5	203925	4740	101040	304965
2035	0.0%	0	0.0%	5	203925	4740	96300	300225
2034	0.0%	0	0.0%	5	203925	4740	91560	295485
2033	0.0%	0	0.0%	5	203925	4740	86820	290745
2032	0.0%	0	0.0%	5	203925	4740	82080	286005
2031	0.0%	0	0.0%	5	203925	4740	77340	281265
2030	0.0%	0	0.0%	5	203925	4740	72600	276525
2029	0.0%	0	0.0%	5	203925	4740	67860	271785
2028	0.0%	0	0.0%	5	203925	4740	63120	267045
2027	0.0%	0	0.0%	5	203925	4740	58380	262305
2026	0.0%	0	0.0%	5	203925	4740	53640	257565
2025	0.0%	0	0.0%	5	203925	4740	48900	252825
2024	0.0%	0	0.0%	5	203925	4740	44160	248085
2023	0.0%	0	0.0%	5	203925	4740	39420	243345
2022	0.0%	0	0.0%	5	203925	4740	34680	238605
2021	0.0%	0	0.0%	5	203925	4740	29940	233865
2020	10.0%	148920	20.0%	12	203925	4740	25200	229125
2019	10.0%	148920	20.0%	12	202173	4740	20460	222633
2018	10.0%	148920	20.0%	12	200421	4740	15720	216141
2017	10.0%	148920	20.0%	12	198669	4740	10980	209649
2016	10.0%	148920	20.0%	12	196917	4740	6240	203157
2015	40.0%	595680	55.0%	12	195165	1500	1500	196665
2014	40.0%	595680	55.0%	12	190347	0	0	190347
2013	40.0%	595680	55.0%	12	185529	0	0	185529
2012	40.0%	595680	55.0%	12	180711	0	0	180711
2011	40.0%	595680	55.0%	12	175893	0	0	175893
2010	40.0%	595680	55.0%	12	171075	0	0	171075
2009	23.5%	360410	51.6%	12	166257	0	0	166257
2008	19.1%		39.7%	13	161737			
2007	25.5%		64.3%	21	158261			
2006	20.5%		46.5%	19	152632			
2005	28.4%		47.0%	6	148555			
2004	42.2%		61.7%	12	144438			
2003	44.3%		56.9%	7	139034			
2002	55.3%		65.9%	13	134050			
2001	50.2%		74.9%	16	128275			
2000	29.2%		59.5%	11	121715			
1999	25.8%		55.0%	9	116501			
1998	35.4%		53.9%	9	111687			
1997	36.1%		54.2%	7	106970			
1996	35.7%		50.9%	11	102226			
1995	47.3%		63.0%	8	97771			
1994	18.4%		39.0%	9	92250			
1993	48.4%		75.0%	14	88832			
1992	46.3%		55.2%	22	82258			
1991	49.6%		80.2%	13	77420			
1990	48.5%		69.3%	13	70396			
1989	71.9%		102.9%	13	64322			
1988	28.9%		41.3%	13	55311			
1987	49.2%		70.4%	13	51689			
1986	55.9%		80.0%	13	45522			
1985	30.3%		43.4%	13	38512			
1984	20.2%		28.9%	12	34710			
1983	17.4%		24.9%	12	32174			
1982	33.2%		47.4%	13	29994			
1981	10.8%		15.5%	12	25839			
1980	42.2%		60.4%	13	24486			
1979	43.1%		61.7%	13	19193			
1978	30.3%		43.3%	13	13786			
1977	15.4%		22.0%	12	9994			
1976	15.3%		21.9%	12	8070			
1975	15.3%		21.9%	12	6149			
1974	11.4%		16.3%	12	4233			
1973	8.6%		12.4%	12	2805			
1972	2.7%		3.9%	12	1723			
1971	11.0%		15.7%	12	1378			
1970	1.7%		0.0%		0			
1969	0.0%		0.0%					

NLH Basis

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Operating Factor –	55%		Operating Factor–	20%	
Syncronous Condensing in 2016+	4740	Hrs/Yr	(1500 av to date + 6 mos x 30 days x7d/wk + 75% of time)		
Syncronous Condensing in 2011-201	1500	Hrs/Yr			

Year	ACF	MWh/Yr	Operating Factor %	Starts Per Year	Generation OP Hrs Cumulative Lifetime	Synch Cond OP Hrs Per Year	Synch Cond OP Hrs Cum	Total OP Hrs Cum Lifetime SC+Gen
2041	0.0%	0	0.0%	5	163331	4740	167313	330644
2040	0.0%	0	0.0%	5	163331	4740	162573	325904
2039	0.0%	0	0.0%	5	163331	4740	157833	321164
2038	0.0%	0	0.0%	5	163331	4740	153093	316424
2037	0.0%	0	0.0%	5	163331	4740	148353	311684
2036	0.0%	0	0.0%	5	163331	4740	143613	306944
2035	0.0%	0	0.0%	5	163331	4740	138873	302204
2034	0.0%	0	0.0%	5	163331	4740	134133	297464
2033	0.0%	0	0.0%	5	163331	4740	129393	292724
2032	0.0%	0	0.0%	5	163331	4740	124653	287984
2031	0.0%	0	0.0%	5	163331	4740	119913	283244
2030	0.0%	0	0.0%	5	163331	4740	115173	278504
2029	0.0%	0	0.0%	5	163331	4740	110433	273764
2028	0.0%	0	0.0%	5	163331	4740	105693	269024
2027	0.0%	0	0.0%	5	163331	4740	100953	264284
2026	0.0%	0	0.0%	5	163331	4740	96213	259544
2025	0.0%	0	0.0%	5	163331	4740	91473	254804
2024	0.0%	0	0.0%	5	163331	4740	86733	250064
2023	0.0%	0	0.0%	5	163331	4740	81993	245324
2022	0.0%	0	0.0%	5	163331	4740	77253	240584
2021	0.0%	0	0.0%	5	163331	4740	72513	235844
2020	10.0%	131400	20.0%	12	163331	4740	67773	231104
2019	10.0%	131400	20.0%	12	161579	4740	63033	224612
2018	10.0%	131400	20.0%	12	159827	4740	58293	218120
2017	10.0%	131400	20.0%	12	158075	4740	53553	211628
2016	10.0%	131400	20.0%	12	156323	4740	48813	205136
2015	40.0%	525600	55.0%	12	154571	1500	44073	198644
2014	40.0%	525600	55.0%	12	149753	1500	42573	192326
2013	40.0%	525600	55.0%	12	144935	1500	41073	186008
2012	40.0%	525600	55.0%	12	140117	1500	39573	179690
2011	40.0%	525600	55.0%	12	135299	1500	38073	173372
2010	40.0%	525600	55.0%	12	130481	1500	36573	167054
2009	19.1%	251130	33.6%	4	125663	35073	35073	160736
2008	23.6%		35.1%	5	122717	30956		
2007	29.4%		49.3%	11	119643	26656		
2006	24.7%		53.6%	9	115322	25904		
2005	38.7%		59.0%	14	110627	23204		
2004	44.8%		59.2%	9	105455	22076		
2003	48.4%		60.2%	12	100272	20922		
2002	58.6%		65.3%	15	94998	19622		
2001	42.8%		59.8%	11	89282	18468		
2000	13.0%		26.5%	4	84043	17314		
1999	26.0%		59.2%	6	81726	16159		
1998	22.6%		28.3%	4	76541	15005		
1997	33.6%		49.3%	10	74066	13851		
1996	28.6%		42.1%	9	69745	12697		
1995	30.1%		41.3%	20	66058	11542		
1994	18.3%		34.0%	21	62436	10388		
1993	35.0%		55.1%	13	59461	9234		
1992	42.8%		73.3%	12	54633	8080		
1991	28.2%		44.8%	8	48216	6925		
1990	39.5%		52.3%	12	44294	5771		
1989	56.5%		74.7%	15	39717	4617		
1988	39.9%		52.8%	12	33174	3463		
1987	61.8%		81.6%	16	28552	2308		
1986	14.6%		19.2%	8	21402	1154		
1985	56.0%		73.9%	15	19716			
1984	29.6%		39.1%	10	13240			
1983	11.5%		15.2%	8	9814			
1982	21.2%		28.0%	9	8481			
1981	20.8%		27.5%	9	6028			
1980	31.1%		41.0%	11	3623			
1979	0.2%		0.3%	6	29			
1978	0.0%		0.0%		0			
1977	0.0%		0.0%		0			
1976	0.0%		0.0%		0			
1975	0.0%		0.0%		0			
1974	0.0%		0.0%		0			
1973	0.0%		0.0%		0			
1972	0.0%		0.0%		0			
1971	0.0%		0.0%		0			
1970	0.0%		0.0%		0			
1969			0.0%					

EPRI Condition Assessment Method

Condition Assessment, Life Extension

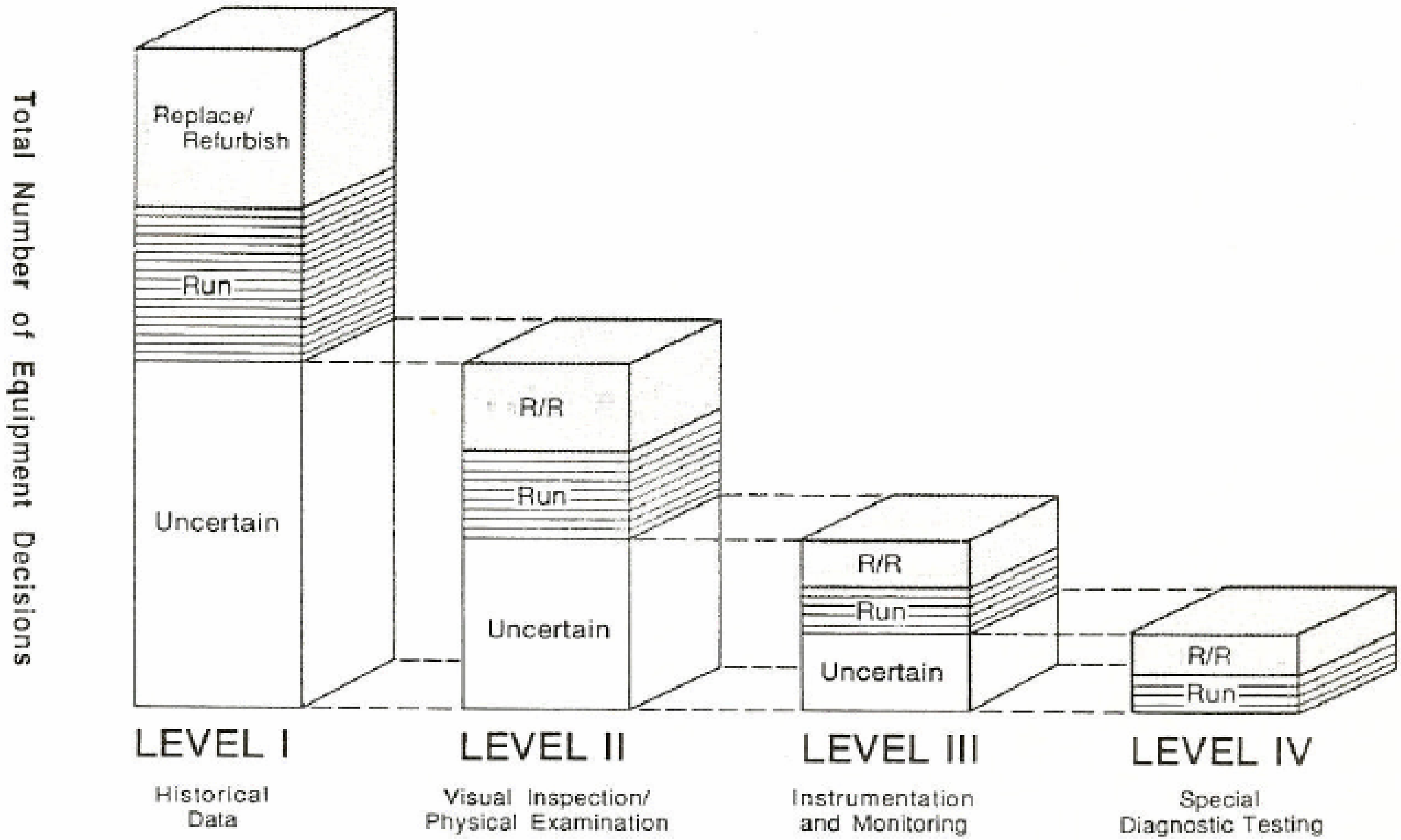


Figure 1-3. Four-Level Electrical Component Life Assessment

Source: Cambrias and Rittenhouse (9)

Source: EPRI GS6724

Boiler Condition Assessment Guide

Condition Assessment, Life Extension

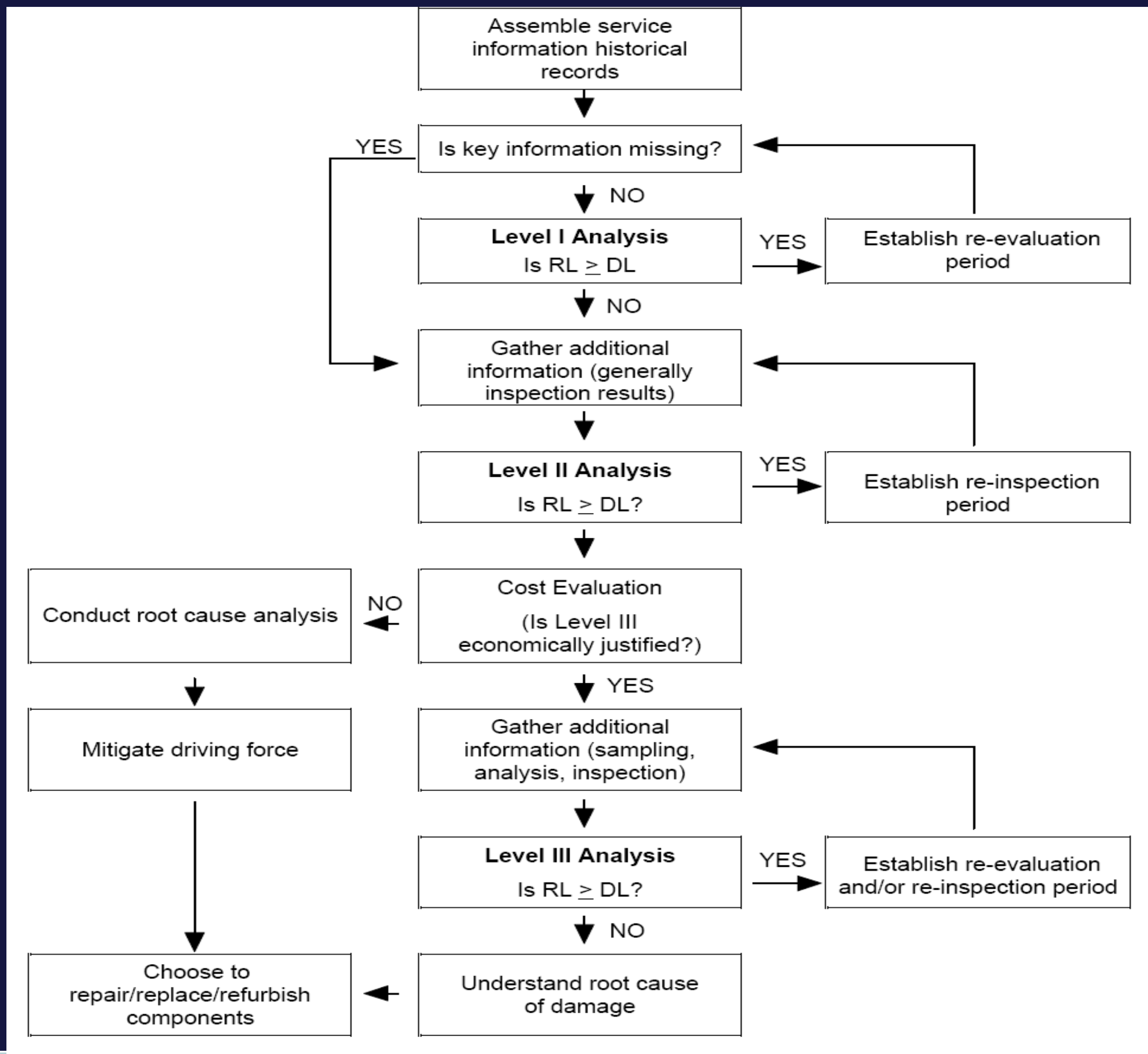
Level 1 Analyses

Level I Analysis. For the initial evaluation, or Level I, only design or overall service parameters need to be examined to ascertain if, on the basis of the most conservative considerations, the component has residual life greater than the anticipated extended-service period (or interval to the next inspection, whichever is less). Although it is possible to conduct this evaluation without reference to measurements or service information, the effectiveness of the assessment will be enormously improved by incorporating such information from the outset. Elementary service factors that should contain (but not be limited to) the following information:

- Unit running hours
- Number of hot, warm and cold starts and applicable ramp rates
- Unit load records
- Past failure history and failure analysis reports
- Maintenance activity
- Specifics of past component repairs or replacements
- Composition checks on materials of construction
- Dimensional checks
- Steam-temperature records
- Design parameters

Source: EPRI GS6724 Data Requirements For the Multi-Level Component Life Assessment

Condition Assessment, Life Extension



Source: EPRI GS6724

Generic Procedure for mechanical Component Life Assessment

Condition Assessment, Life Extension

Technical Risk Assessment

<u>Likelihood of Failure Event:</u>

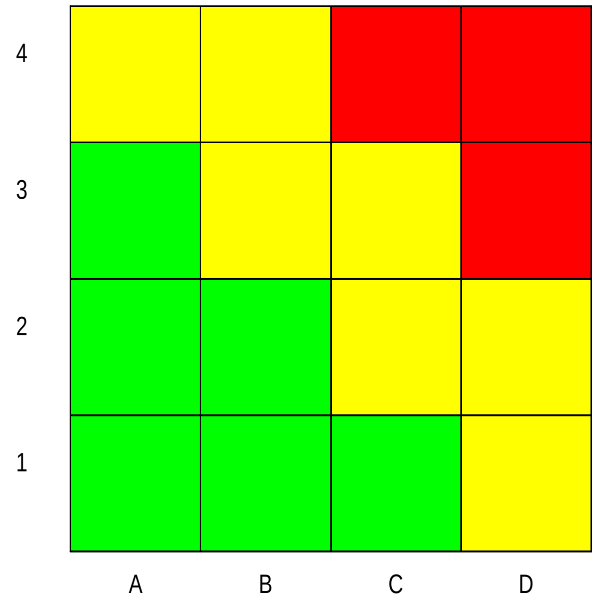
1. Greater than 10 years
2. 5 to 10 years
3. 1 to 5 years
4. Immanent (< 1 year)

<u>Consequence of Failure Event:</u>

A. Minor ($10k-$100k or derating/1 day outage)
B. Significant ($100k-$1m or 2-14 days outage)
C. Serious ($1m-$10m or 15-30 days outage)
D. Major (>$10m or >1 month outage)

<u>Actions:</u>

- Items that do not apply are not ranked
- Low Risk: Monitor long term (within 5 years)
- Medium Risk: Investigate and monitor short term. Take action where beneficial
- High Risk: Corrective action required short term



Condition Assessment, Life Extension

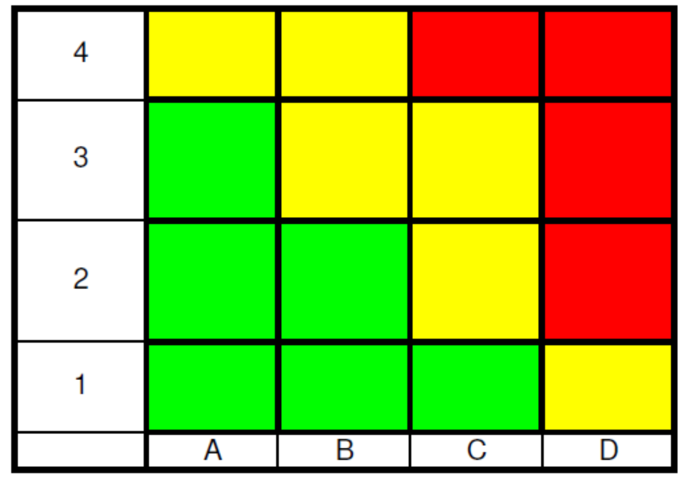
Safety Risk Assessment

<u>Likelihood of Safety Incident Event:</u>

1. Improbable – so that it can be assumed not to occur
2. Unlikely to occur during life of specific item/process
3. Will occur once during life of specific item/process
4. Likely to occur frequently

<u>Consequence of Safety Incident Event:</u>

A. Minor - will not result in injury, or illness
B. Marginal - may cause minor injury, or illness
C. Critical - may cause severe injury, or illness
D. Catastrophic - may cause death



<u>Actions</u>:

- Items that do not apply are not ranked;
- Low Risk: Monitor, take action where beneficial;
- Medium Risk: Investigate and monitor short term. Take action where beneficial; and
- High Risk: Unacceptable. Corrective action required short term

Condition Assessment, Life Extension

Priority Assessment

Priority assigned to the "Recommended Actions", "Level 2 Inspections", and "Capital Enhancements".

Scale of "1" to "4". "1" is the highest priority - this activity should definitely be undertaken and where practical in or about the timing identified. "4" is the lowest priority - the item is low risk/impact and may be much more readily delayed or undertaken in some other fashion.

Ranking is subjective relative ranking by AMEC, meant to be an aid to Hydro in allocating resources and assessing trade-offs and program delays. Ranking takes into consideration a number of aspects such as:

1. **The impact (likely/worst case) on achieving the end of life (EOL) goal, on plant operation health and safety, and on environmental and regulatory requirements;**
2. **The urgency of the need for action;**
3. **The degree of certainty of the requirement;**
4. **The experience at Holyrood and in the broader industry context;**
5. **The ability to mitigate or address the issue in other ways;**
6. **The timing of the recommended response;**
7. **The cost relative to others; and**
8. **The ability of existing and planned or ongoing actions to resolve in a timely and successful manner.**

Priorities should be taken in the context of its recommended timing. An item can be a "1", but be scheduled for a later date if it is deemed that sufficient information exists to be confident of the minimal likely impact of the deferral (usually to tie in with a planned major activity such as an overhaul).

Condition Assessment, Life Extension

Mechanical Systems

Feature	Level I	Level II	Level III
Failure History	Plant records	Plant records	Plant records
Dimensions	Design or nominal	Measured or nominal	Measured
Condition	Records or nominal	Inspection	Detailed inspection
Temperature and pressure	Design or operational	Operational or measured	Measured
Stresses	Design or operational	Simple calculation	Refined analysis
Material properties	Minimum	Minimum	Actual material
Material samples required?	No	No	Yes

More rigorous assessment →

More accurate operation data required →

More accurate estimate of equipment RL →

Source: EPRI GS6724 Data Requirements For the Multi-Level Component Life Assessment

Level 1 Analyses

The information reviewed as part of the Level I process is to answer the following key questions for the component to be analyzed:

- Has operation exceeded the design parameters (typically temperature and/or pressure) for significant times or extents?
- Will the desired future service exceed pertinent design parameters (e.g. increased cycling duty)?
- Have the design philosophy or materials choices been shown to be unconservative since the unit went into operation?
- Has the failure history been excessive?
- Are steam temperature records inadequate or not available for assessment of those components that function at elevated temperatures?

If the answer to any of these key questions is 'yes', or if the component is found to have under Level I assessment less remaining life than the desired amount, the evaluation will have to move to a Level II assessment.

Source: EPRI GS6724 Data Requirements For the Multi-Level Component Life Assessment

Mechanical Systems Example – High Temp Steam Headers

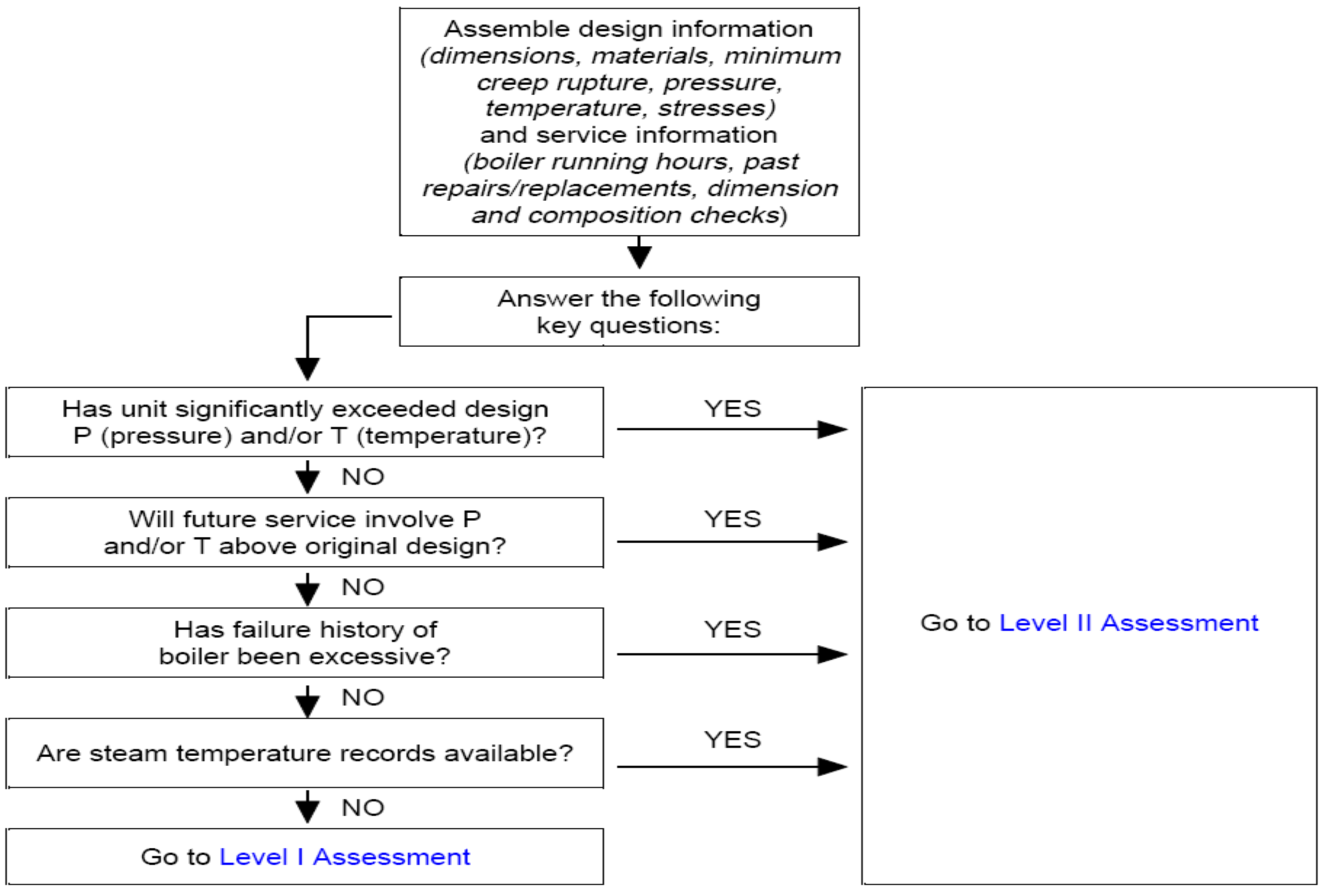


Figure 3-1
General Roadmap for High-Temperature Steam Headers

Source: EPRI GS6724 Data Requirements For the Multi-Level Component Life Assessment

Condition Assessment, Life Extension – Levels of Detail

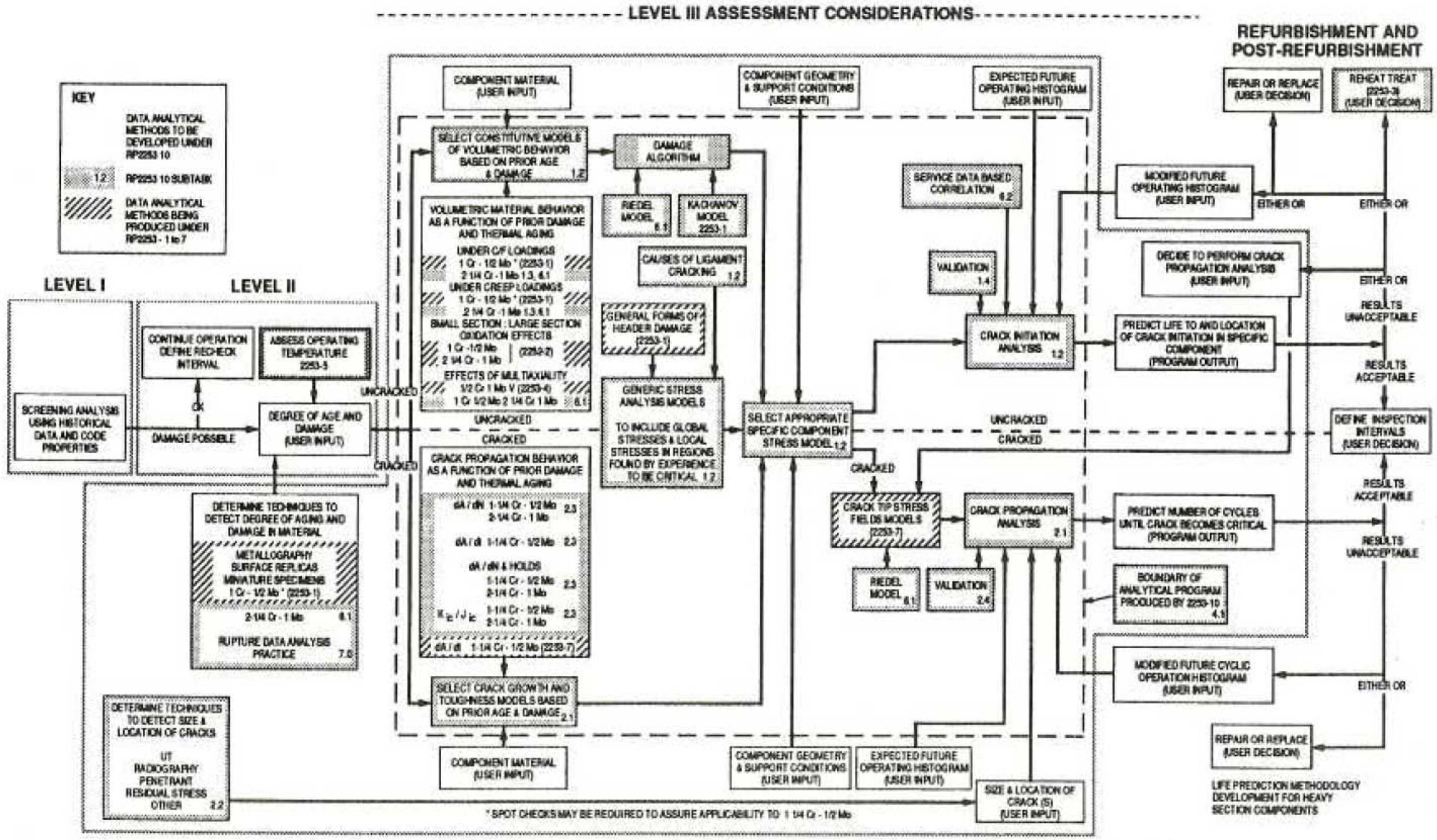


Figure 1-2. Life Assessment of Thick-Section Pressure Parts Illustrating Relative Detail of Various Portions of Multi-Level Assessments

Source: EPRI GS6724 Data Requirements For the Multi-Level Component Life Assessment

amec

Key Boiler Pressure Components and Damage Mechanisms

Component	Creep	Fatigue	Corrosion	Erosion
Waterwall tubing	X	X	X	X
Superheater (SH)/ reheater (RH) tubing	X	X	X	X
Economizer tubing		X	X	X
Superheater headers	X	X	X	
Reheater headers	X	X	X	
Main steam piping	X	X		
Hot reheat piping	X	X		
Cold reheat piping		X	X	X
Economizer inlet header		X	X	
Drums		X	X	
Downcomers		X	X	
Waterwall headers		X	X	
Attemperator	X	X		

Source: EPRI GS6724

Boiler Condition Assessment Guide

Condition Assessment, Life Extension

Materials Failure Modes

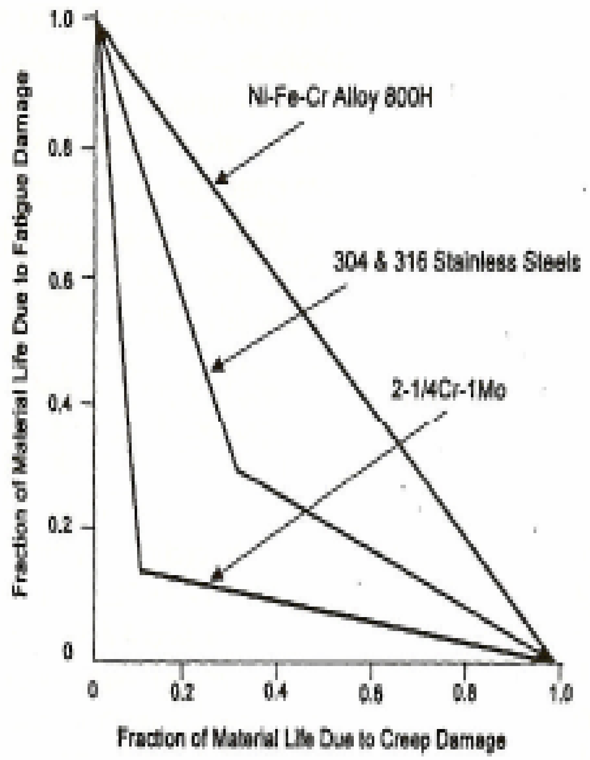


Fig 3-2 Creep-fatigue curves for some of the high-temperature al

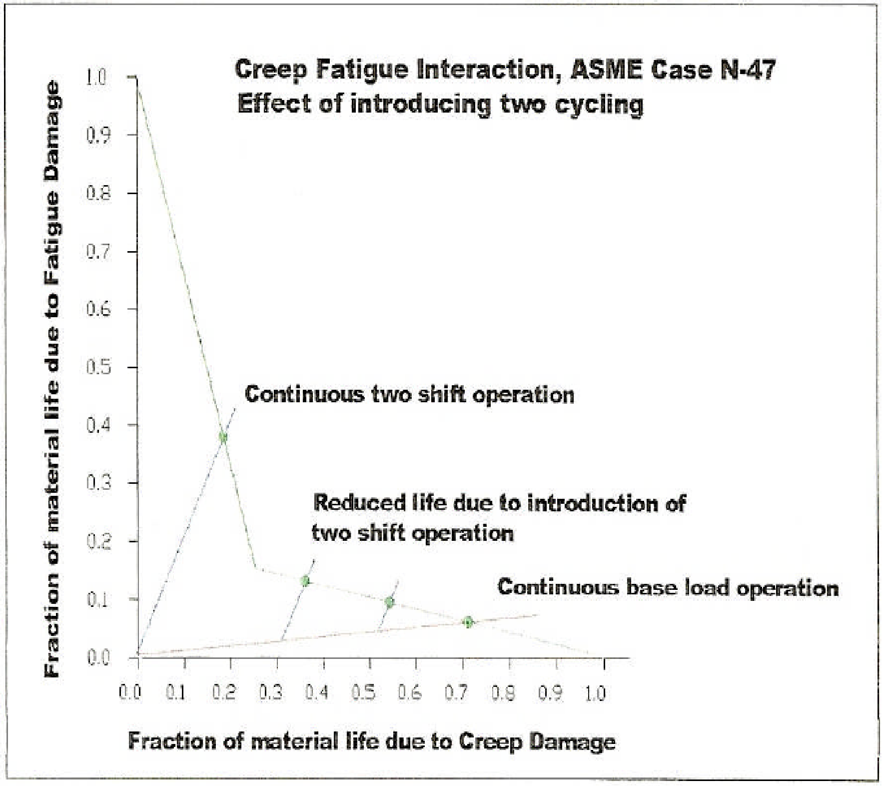


Figure 3-1 Demonstrates the interaction and consequences of creep and fatigue (based on ASME N-47) for a typical power plant steel (2.25Cr1Mo)

Source:

Condition Assessment, Life Extension

Issues

- ID of key equipment included/excluded
- ID recent improvements/changes – fuel, major mods, etc.
- Information Availability – data room vs hunting
- Level of detail of investigation
- Vendor inputs and costs
- Current/planned station budgets and plans
- Timing of changes –likelihood %
- Staffing, OMA plans

NLH Provided Information

- Criteria for operation & operating parameters
- Major Equipment to be considered
- Design and operating data - e.g. temperatures, vibration data, cooling water and oil temperatures, etc. at typical load points
- Facility drawings as required
- Maintenance data for major equipment, especially last major maintenance outage. Details of known limitations, and operating concerns
- Details of major repairs made on major equipment

Condition Assessment, Life Extension

NLH Information

- Station operating hrs and cold/warm/hot starts by unit and year
- Station operating hrs and cold/warm/hot starts by unit and month from Jan 2007 to present
- Major Station outages and associated reports (planned, major maintenance) since 2000 by unit (especially the last major outage)
- Major plant equipment and system changes (i.e. major fuel change, equipment change-out, major boiler surface replacement, steam turbine modifications, generator modifications) since in-service (particularly in last 10 years)

Condition Assessment, Life Extension

NLH Information

- Major inspections (and associated reports) on key equipment and systems since 1997 - including timing of the inspections and scope
- Unit performance - capacity, heat rate, availability since 2000
- Current budget and business plan information details
- Information where the actual operating conditions (temperature, pressure) exceeded the equipment design conditions: