International Energy Agency (IEA)
8th International conference on Clean Coal Technologies,
Cagliari, 8-12, May 2017

Session: Power plant operation 09/05/1972

Supercritical Power Plant Life assessment Methodology and A case study on Boiler Life Assessment

Saravana Bavan Balakrishnan
Bob Denison
Steve Mould

WSP | PARSONS BRINCKERHOFF

OUTLINE OF THE PRESENTATION

- **Introduction**
  - Need for assessment
- **Methodology**
  - Desk top review
  - Site visit
  - Inspection and Testing of components
  - Risk review and assessment
  - KKS numbering system
- **Boiler life assessment- case study**
  - Material selection
  - Standard life
  - Physical checks
  - Creep
  - Fatigue
- **Identification of key issues**
- **Preparation report**
- **Conclusion & Recommendations**

WSP | PARSONS BRINCKERHOFF

INTRODUCTION

WSP | PARSONS BRINCKERHOFF

COAL FIRED SUPERCRITICAL POWER PLANT

- **Coal-fired supercritical power plants are beneficial for the following:**
  - Plants provide higher plant efficiency,
  - They emits very low emissions compared with subcritical power plants
  - Provide better cost effectiveness per MW
  - Plants are capable for combustion of indigenous coal and imported coals
  - Provide stable loads for plant availability and reliability
- **Many plants are operating in India, China and Europe**
- **Supercritical power plants are relatively new**

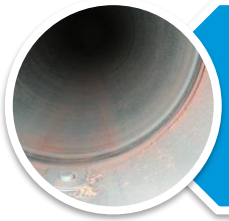
NEED FOR LIFE ASSESSMENT

- **Private sector participation leads plant acquisitions and mergers of corporations**
- **Careful review of plant status is required for cost benefits of the plant acquisitions**
- **It requires a technical analysis for identifying plant conditions**
- **Life assessment studies helps in making informed decisions**
- **Provides confidence to the plant operator for the remaining life time**
- **Helps in decision for major plant overhaul and scheduled maintenance**

LIFE ASSESSMENT METHODOLOGY

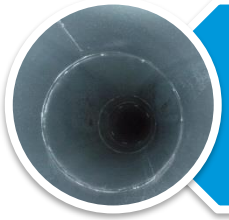
WSP | PARSONS BRINCKERHOFF

LIFE ASSESSMENT METHODOLOGY

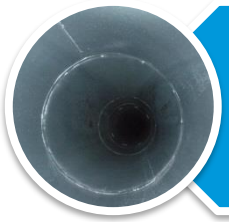


Desktop Review

Site Visit



Testing and inspection - NDE / NDT Inspection



Risk Review and Life Extension Assessment

WSP | PARSONS BRINCKERHOFF

1. DESK TOP REVIEW

- **The desktop review involves:**
  - Examination of critical plant information.
  - Documents review of design details, operating data, performance data
  - Desktop evaluation of plant condition based on recent plant performance and inspection reports.
- **The plant owner provides many relevant documents, electronically to assist in this process**
- **WSP | Parsons Brinckerhoff submit a review comment and a list of missing information for consideration and collation.**
- **Subsequent most key documentation from owner will be reviewed further**

WSP | PARSONS BRINCKERHOFF

2. SITE VISIT

- Following the initial review, the project team visits the site
- Site visit depends on the volume of work roughly for five working days.
- During the visit the team carry out a series of activities including data collection, site examination and discussions with power station staff.
- All key details, assumptions and issues arising are documented in the report
- Identified risks are scored to help prioritise the severity of the risks
- Risk scoring frame work has been developed based on WSP| Parsons Brinckerhoff experience
- The scores are identified against business interruption, safety and environmental subject areas.

KEY FINDINGS OF THE SITE VISIT

- **Gathering the details of original design life, operating regime and current condition of the components are analysed by WSP| Parsons Brinckerhoff subject experts,**
- **Understanding individual plant items' for their satisfactory condition.**
- **Any capital investment on components and material to meet the new life expectancy specified by the owner**
- **Predicting future operation pattern and associated key components**

3. TESTING OF COMPONENTS INCLUDING NDE / NDT INSPECTION

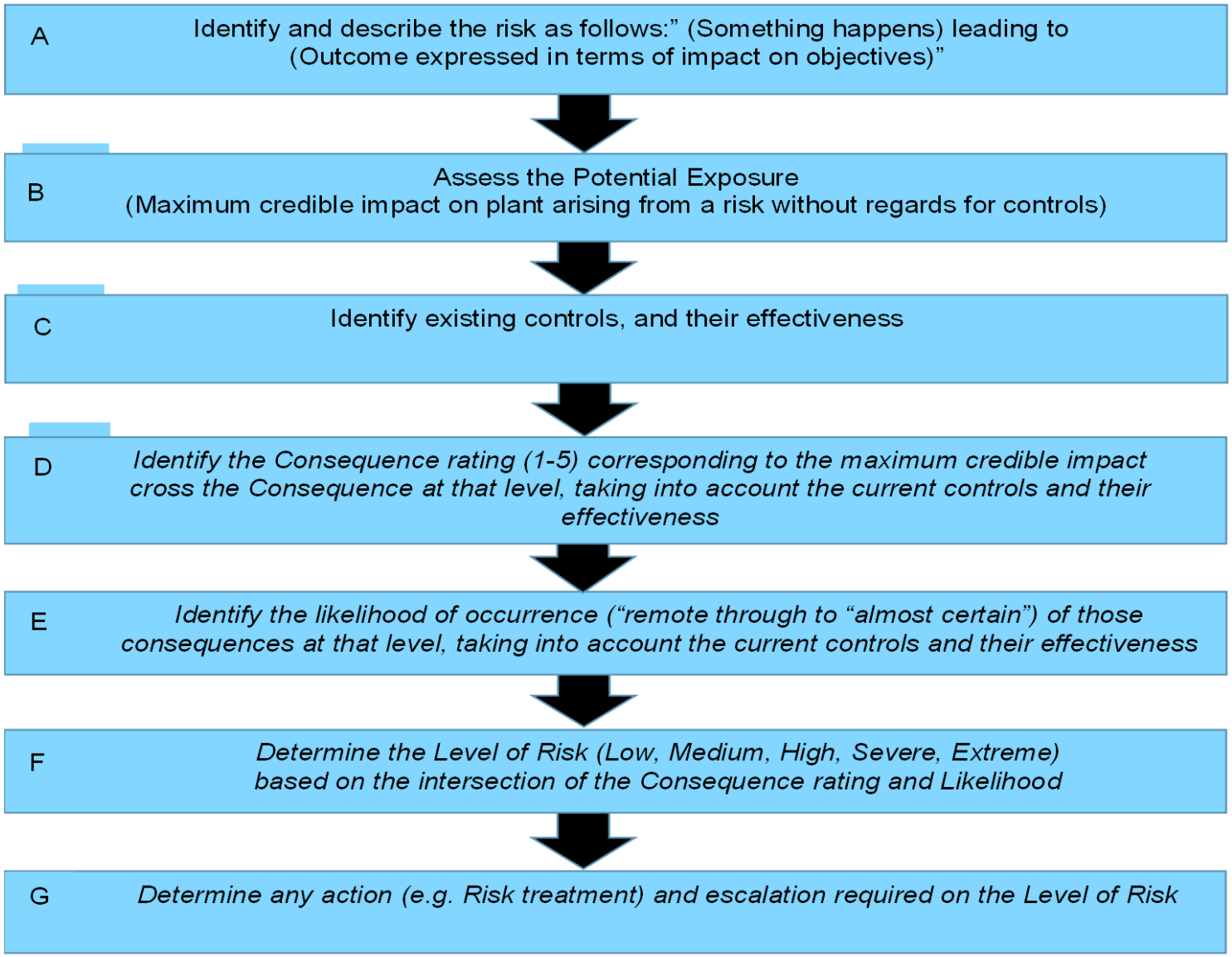
- **During site visit observation warrants to**
- **Based on mechanical maintenance, review of key component inspection reports**
- **NDE/ NDT inspection reports and if not available further checks on these tests to be carried out.**

4. RISK REVIEW AND LIFE EXTENSION ASSESSMENT

- **During site visit observation warrants to**
- **Based on mechanical maintenance, review of key component inspection reports**
- **NDE/ NDT inspection reports and if not available further checks on these tests to be carried out.**

RISK ASSESSMENT

STEPS:



WSP | PARSONS BRINCKERHOFF

Business Interruption - Loss of Production

Category	Score	Remarks
Insignificant	1	Incident event without causing production loss Financial loss (compensation, fines, cost to repair, plant damage) of less than €10k
Minor	2	Production loss or delay up to 1 week Financial loss (compensation, fines, cost to repair, plant damage) of >€10k - < €100k
Moderate	3	Production loss or of one week to one month Financial loss (compensation, fines, cost to repair, plant damage) of >€ 100k – < €1M
Major	4	Production loss or delay of over 1 month Financial loss (compensation, fines, cost to repair, plant damage) of > €1M - <€10M
Catastrophic	5	Loss of licence to operate or ability to produce indefinitely. Financial loss (compensation, fines, cost to repair, plant damage) of greater than > €10M

Environmental impact

Category	Score	Remarks
Insignificant	1	Occasional damage by erosion, or of flora and fauna.
Minor	2	Minor impacts on fauna/flora and habitat, but no negative impacts on ecosystem
Moderate	3	Significant changes in flora / fauna populations and habitat.
Major	4	Continuous and serious damage by erosion or to flora and fauna. Major destruction of significant habitat.
Catastrophic	5	Long term and significant change in population (e.g. eradication of endangered species)

Safety

Category	Score	Remarks
Insignificant	1	Minor injuries which may require self-administered first aid. Injured personnel can continue to perform normal duties.
Minor	2	Injuries requiring onsite treatment by medical practitioner. Personnel unable to continue to perform duties.
Moderate	3	Serious injuries requiring off site treatment by medical practitioner or immediate evacuation to hospital. Potential long term or permanently disabling effects.
Major	4	Single fatality.
Catastrophic	5	Multiple fatalities

PROBABILITY OF AN EVENT

Descriptor	Likely Frequency		Probability
	Environment	Health & Safety	
Almost Certain	Continuous or will happen frequently	Occurs frequently	5
Likely	2 or 3 times per year	Occurs several times per year	4
Possible	2 or 3 times every ten year	Has occurred more than once	3
Unlikely	2 times every fifteen years	Has occurred	2
Rare	Once in twenty-five years	Never occurred	1

PROBABILITY RISK MATRIX

Probability	Consequence				
	Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Catastrophic (5)
Rare (1)	1	2	3	4	5
Unlikely (2)	2	4	6	8	10
Possible (3)	3	6	9	12	15
Likely (4)	4	8	12	16	20
Almost Certain (5)	5	10	15	20	25
15-25	Extreme Risk	Activity or Industry should not proceed in current form			
10-12	High Risk	Activity or Industry should be modified to include remedial planning and action and subject to detailed HSE assessment.			
4-9	Moderate Risk	Activity or Industry can operate subject to management and or modification			
1-3	Low Risk	No action required, unless escalation of risk is possible.			

WSP | PARSONS BRINCKERHOFF

PLANT COMPONENT IDENTIFICATION SYSTEM

- **KKS numbering system is employed for plant component level identification**
- **All power plant components are listed and there life assessment are individually analysed**
- **This approach helps in covering entire plant system**
- **Individual component risks are separately identified**

WSP | PARSONS BRINCKERHOFF

BOILER LIFE ASSESSMENT

WSP | PARSONS BRINCKERHOFF

PLANT OVERVIEW

- The details of the power plant is not disclosed due to confidentiality
- Power Station is a supercritical coal-fired power station with two supercritical boilers design and constructed from China
- Plant has a combined installed capacity of 1,200MW and supporting Flue Gas Desulphurisation.
- The two generating units in the Power Station were commissioned in September 2007 and January 2008, respectively.
- The two units were then re-rated to 630 MW after evaluation with the equipment suppliers and the authorities.
- The station consumes a wide range of coal mostly imported from Indonesia

PLANT OVERVIEW CONT.

- The plant comprises of two similar and independent coal-fired units, each consisting of::
  - One natural coal-fired boiler with maximum steaming capacity of 541kg/s @ 571 degrees Celsius and 254 bar pressure;
  - One triple pressure steam turbine manufactured in China, comprising a single HP cylinder with 6 stages of blading, single flow IP cylinder with 8 stages of blading and two double LP cylinders, each with 7 stages of blading;
  - Balance of plant including pulverised fuel milling plant and fans to support combustion and electrostatic precipitators to capture particulate emissions.
  - Raw town's water is drawn from a nearby reservoir with local supplies with backup diesel generators securing supply.
  - Cooling water is drawn from the local bay close to the coal unloading jetty where the water depth has been increased to allow large coal ships to unload close to the station.

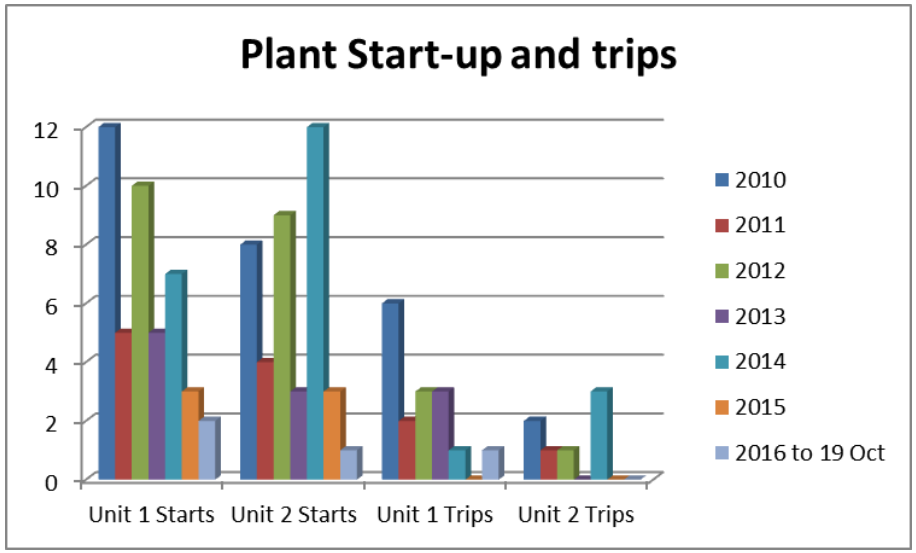
BOILER MAINTENANCE INTERVAL

Boiler Inspection	Minor Inspection	Intermediate Inspection	Major Inspection
Type	C	B	A
Frequency Months	Twice before B. Once before A On	30	60
Duration (days)	25	45	60

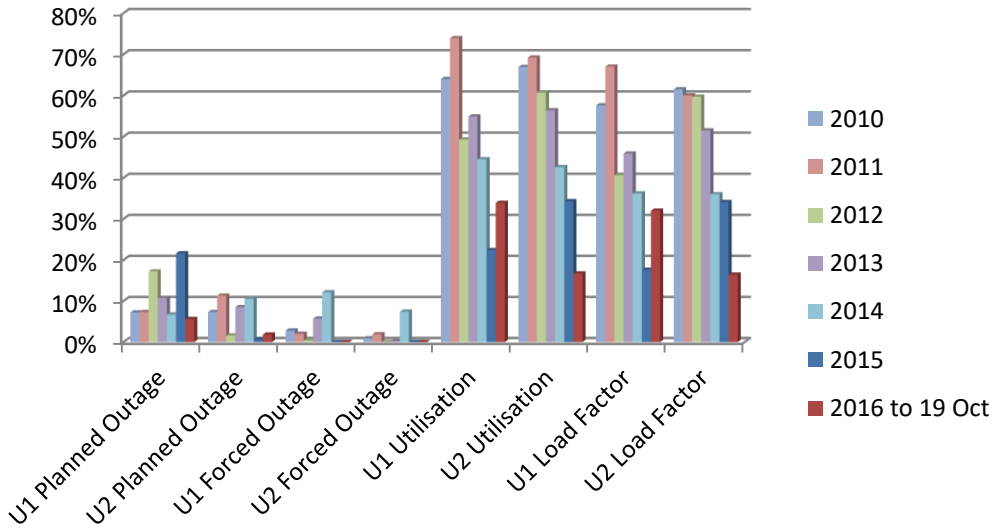
BOILER MAINTENANCE YEARLY PLANS

	2017	2018	2019	2020	2021	2022	2023	2024	2025
Unit 1	A	C	C	B	C	A	C	C	B
Unit 2	C	A	C	C	B	C	A	C	C

WSP | PARSONS BRINCKERHOFF



Plant outage and utilisation data



WSP | PARSONS BRINCKERHOFF

SAMPLE REVIEW DATA SHEET: HOT REHEATER

Description: **Hot Reheat Piping System**	***Plant KKS Code:*** **LBB**			
Assessment of Major Plant Items/Systems	***Risk Scores - Consequence x Likelihood***			
	Business Interruption	***Safety***	***Environmental***	
Manufacturer:	**5 x 1 = 5**	**5 x 1 = 5**	**1 x 1 = 1**	
Design or Type:				
Modification Status: As Built				
Date Originally Installed: Unit 1 commissioned 2007 – Unit 2 commissioned 2008	**Analysis Total 5 + 5 + 1 =**			**11**

Overview (Including Design Life Comment):

The hot reheat piping system delivers the reheat steam from the boiler final reheater to the IP steam turbine. The details of the isometric drawings for the piping and supports are required for further review and preparation of comments. The material of construction is SA 335 P91. This material is subjected to creep and therefore creep monitoring system is recommended
The hot reheat pipe shall be subject to a sample NDT examination on welds in every 5 year overhaul

Current Condition and Area(s) of Risk:

The hot reheat piping systems on both Units are considered to be in good condition up to date

Potential Improvement Measures:

No potential improvements required

.

Costs:

Recognise the on-going requirement for inspection

Lead Time to Manufacture

N / A

Installation time

N/ A

WSP | PARSONS BRINCKERHOFF

BOILER AREA SCORING MATRIX

		BI			Safety			Environmental			Analysis
KKS	Plant Area	C	P	Score	C	P	Score	C	P	Score	Rating
HAH	Superheater	4	2	8	1	1	1	1	1	1	10
HAJ	Reheat System	4	2	8	1	1	1	1	1	1	10
HB	Support Structure	1	1	1	1	1	1	1	1	1	3
HCB	Sootblower System	2	3	6	1	3	3	1	2	2	11
HDE	Electrostatic Precipitators	3	2	6	1	1	1	3	2	6	13
HFA / B	Mill Bunkers and Feeders	4	1	4	4	1	4	1	1	1	9
HFC	Mills	2	4	8	3	2	6	1	1	1	15
HFE	PA Fans	2	3	6	4	1	4	5	1	5	15
HHA	Burner System	2	2	4	1	1	1	2	2	4	9
HJ	Ignition System	2	1	2	1	1	1	1	1	1	4
HLB	FD Fan System	3	2	6	1	1	1	2	2	4	11
HLD	Air Heater System	2	3	6	1	3	3	1	3	3	12
HNC	ID Fan System	3	2	6	4	1	4	5	1	5	15
LAA	Storage, de-aeration (incl. feed water tank)	2	2	4	2	2	4	1	2	2	10

WSP | PARSONS BRINCKERHOFF

BOILER AREA SCORING MATRIX CONTD.

		BI			Safety			Environ mental			Analysis
KKS	Plant Area	C	P	Score	C	P	Score	C	P	Score	Rating
LAB	Feedwater piping system, excl. feedwater pump & feedwater heating sys	4	1	4	4	1	4	1	1	1	9
LAC	Feedwater pump system (Valves, Pump, Motor and Control)	4	1	4	2	1	2	1	1	1	7
LAD	HP Feedwater heating system	3	1	3	2	1	2	1	1	1	6
LAE	HP de-superheating header and spray system	5	1	5	3	1	3	1	1	1	9
LBA	Main steam piping system	5	1	5	5	1	5	1	1	1	11
LBA	Main Steam Isolating Valves / Boiler Stop Valves	5	1	5	4	1	4	2	1	2	11

WSP | PARSONS BRINCKERHOFF

BOILER AREA SCORING MATRIX CONTD.

		BI			Safety			Environmental			Analysis
KKS	Plant Area	C	P	Score	C	P	Score	C	P	Score	Rating
LBB	Hot Reheat Piping System	5	1	5	5	1	5	1	1	1	11
LBC	Cold Reheat Piping System	5	1	5	5	1	5	1	1	1	11
LBF	Overpressure suppression & safety device incl. injection & hydraulic station for safety function	5	1	5	5	1	5	1	1	1	11

BOILER AREA SCORING MATRIX

		BI			Safety			Environmental			Analysis
KKS	Plant Area	C	P	Score	C	P	Score	C	P	Score	Rating
LBG	Auxiliary steam piping system	4	1	4	4	1	4	1	1	1	9
LCA	Main Condensate Piping System	3	1	3	2	1	2	1	1	1	6
LCB	Main condensate pump system	3	1	3	2	1	2	1	1	1	6
LCC	Main condensate heating system	3	1	3	3	1	3	1	1	1	7

WSP | PARSONS BRINCKERHOFF

RESULTS AND DISCUSSIONS

- Application of risk bask methodology for predicting life assessment provides cost effective solution
- It covers all aspects of safety and business perspectives
- Identifies the actual key components contributing the plant life
- Reasonable maintenance interval can be technically established based on plant operating history
- Key components can be given focus instead of the whole plant
- Availability and reliability of the plant can be foreseen with much confidence
- Adequate controls and instrumentation are required
- Life assessment should be embedded with maintenance for sustainable business value of the plant
- Recommended for implementation of ISO 55000 – Physical Asset Management system

RESULTS AND DISCUSSIONS. CONT.

→ **Boiler life assessment concludes the following:**

- Need for maintaining high risk components and increase the maintenance interval for mills, PF and ID fans
- There are no suite of creep life assessment components such as creep pips on HP Superheater and Reheater Headers.
- Requires improvement in thermo couple monitoring of critical areas
- Currently high degree of manual operator controls are applied and this requires modernisation
- Fatigue affected components shall be verified with NDT/NDE techniques

Thank you

Dr Saravana Bavan Balakrishnan
Principal Engineer – Boilers
Energy
WSP| Parsons Brinckerhoff
Manchester Technology Centre
Oxford Road
Manchester M1 7ED
Phone 0161-200-2173
bavan.balakrishnan@pbworld.com