Systematic Approach to Prioritizing Durability Improvements

Hemant Urdhwareshe

Institute of Quality and Reliability

ASQ Fellow

ASQ CRE, CMBB, CSSBB, CQE, CMQ/OE

Email: hemant@world-class-quality.com

Objective

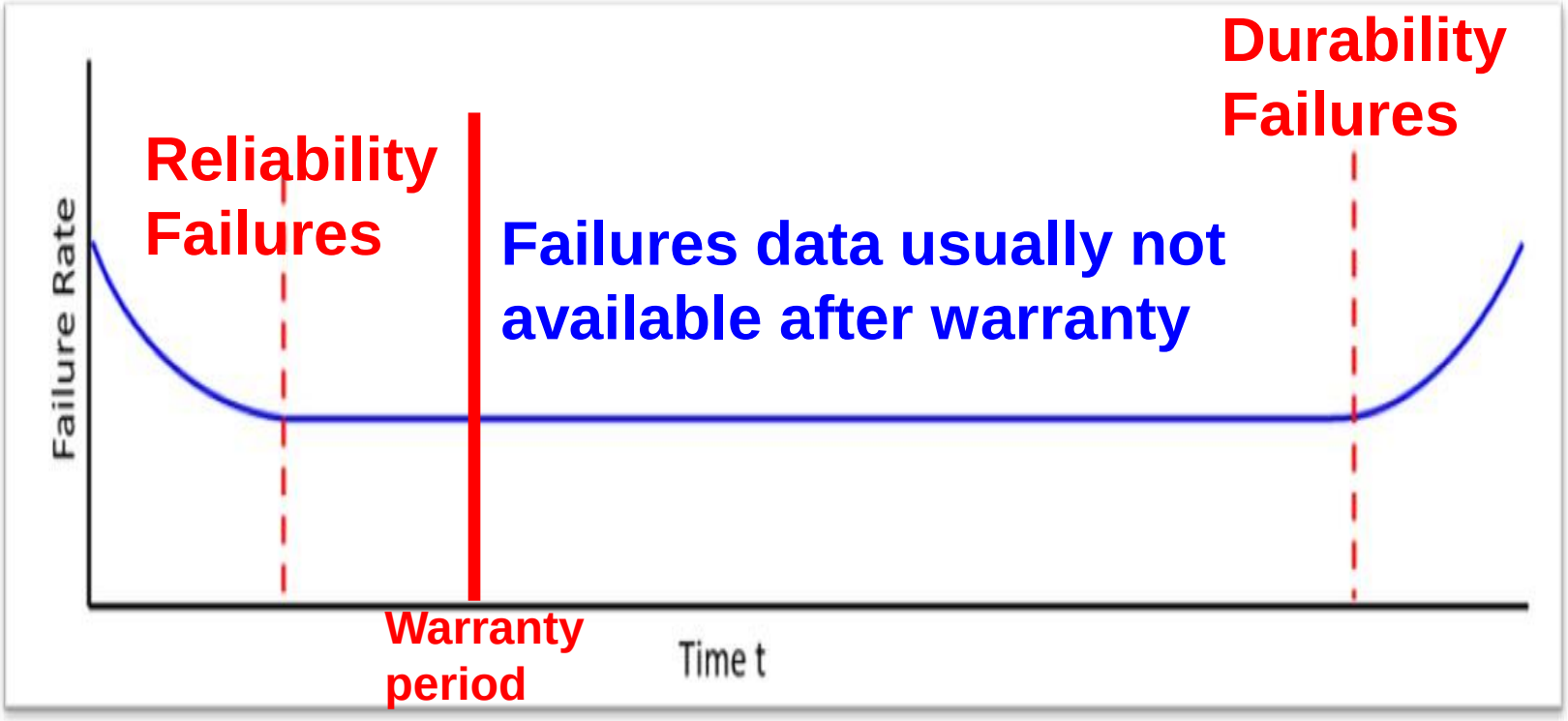
- In this paper, I will explain approach for data collection, analysis and improvement strategy to prioritize improvements for durability failures which typically occur after the warranty period is over.

Outline

- **Warranty failures typically are attributable to manufacturing defects and usually require improvement actions in the manufacturing processes**
- **Analysis of such failures within warranty can be done using Nevada Chart format and life data analysis.**
- **However, failures occurring after warranty period are usually not captured in the data as usually there is no mechanism to do so.**
- **Therefore, additional efforts are needed to collect and analyse data of post-warranty failures.**
- **Another important aspect of such data is that most of these failures would need design improvement.**
- **These projects can be prioritised based on the analysis of post-warranty life data.**
- **In this presentation, I would share a case study to explain the approach for durability improvement**

Introduction

- **In the company where I worked for many years, we had a clear definition of durability failures.**
- **These are the failure which require a major rectification in a workshop.**



Introduction

- Thus, failure modes on diesel engines such as main and connecting rod bearings, camshaft pitting, crankshaft failures, gear failures, cylinder head failures etc. were considered as ‘durability failures’ as engine would be brought to the service center for a major repair (overhaul)
- Cost of repairs of such failures would be generally borne by the user customer as these failure modes would typically occur after the warranty period
- Improvement of durability is usually responsibility of engineering and design function

Methodology

- As data of failures after warranty is not readily available in the system, special efforts were required to collect data
- Resources and budget needs to be approved by the management considering the potential benefits
- After the data collection, life data analysis was performed using software to estimate B1, B10 life to prioritize the durability improvement projects
- Wherever possible, using multiple failure modes can be efficient way analysis of data

Data Collection

- As data of durability failures is not usually captured in the warranty database, additional efforts are required to collect data of durability failures and need to be planned and budgeted.
- One good idea is to take a sample of failure data with various failure modes.

Data Collection

- In the case study that I wish to present, data of primary failure mode of 80 units was collected for the *first major failure that required overhaul of the unit*.
- Let us say that there are multiple failure modes possible which we call A, B, C,D, E ..etc.
- Please note that failure of unit for primary failure mode ‘A’ at time t is complete data for that failure mode ‘A’ while as it is right censored data for all other failure modes B, C, D, .. etc.
- This idea was used for collecting and analyzing the data.

Data Collection

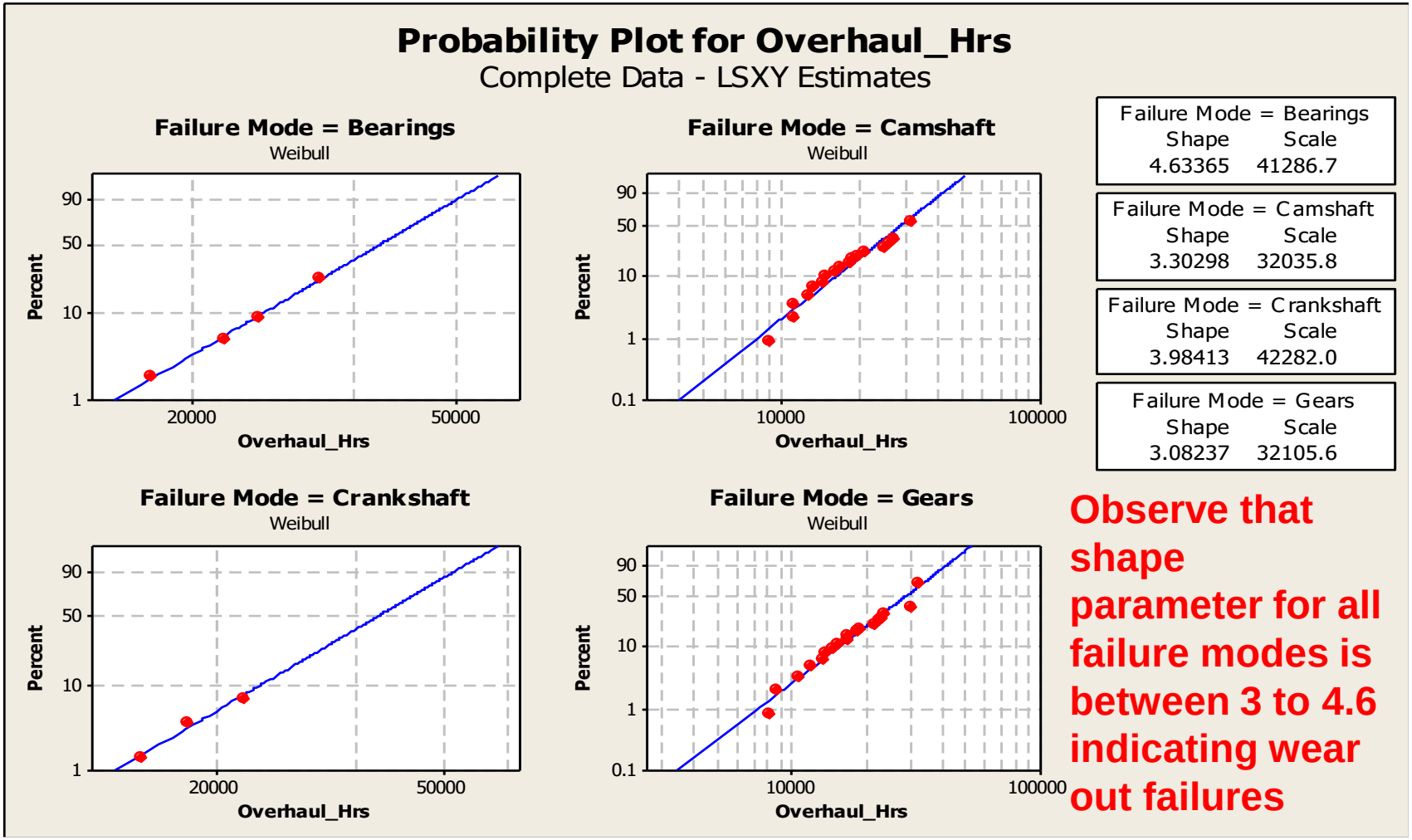
- Partial data of the 80 units is shown in the table here.
- The first unit failed at 31995 hours for failure mode ‘Gears’. But understand that the other components HAD NOT FAILED at that time! Thus, we can consider that 31995 hours is right censored data for all other failure modes under consideration!
- Similarly, for the second unit, Camshaft failed at 31677 hours and therefore this is right censored data point for all other failure modes!
- And so on..!

Overhaul Hours	Failure Mode
31995	Gears
31677	Camshaft
31597	Head
31205	PC
31087	Bearings
30543	PC
30247	PC
29750	Gears
29252	Head
28753	Head
28579	Head

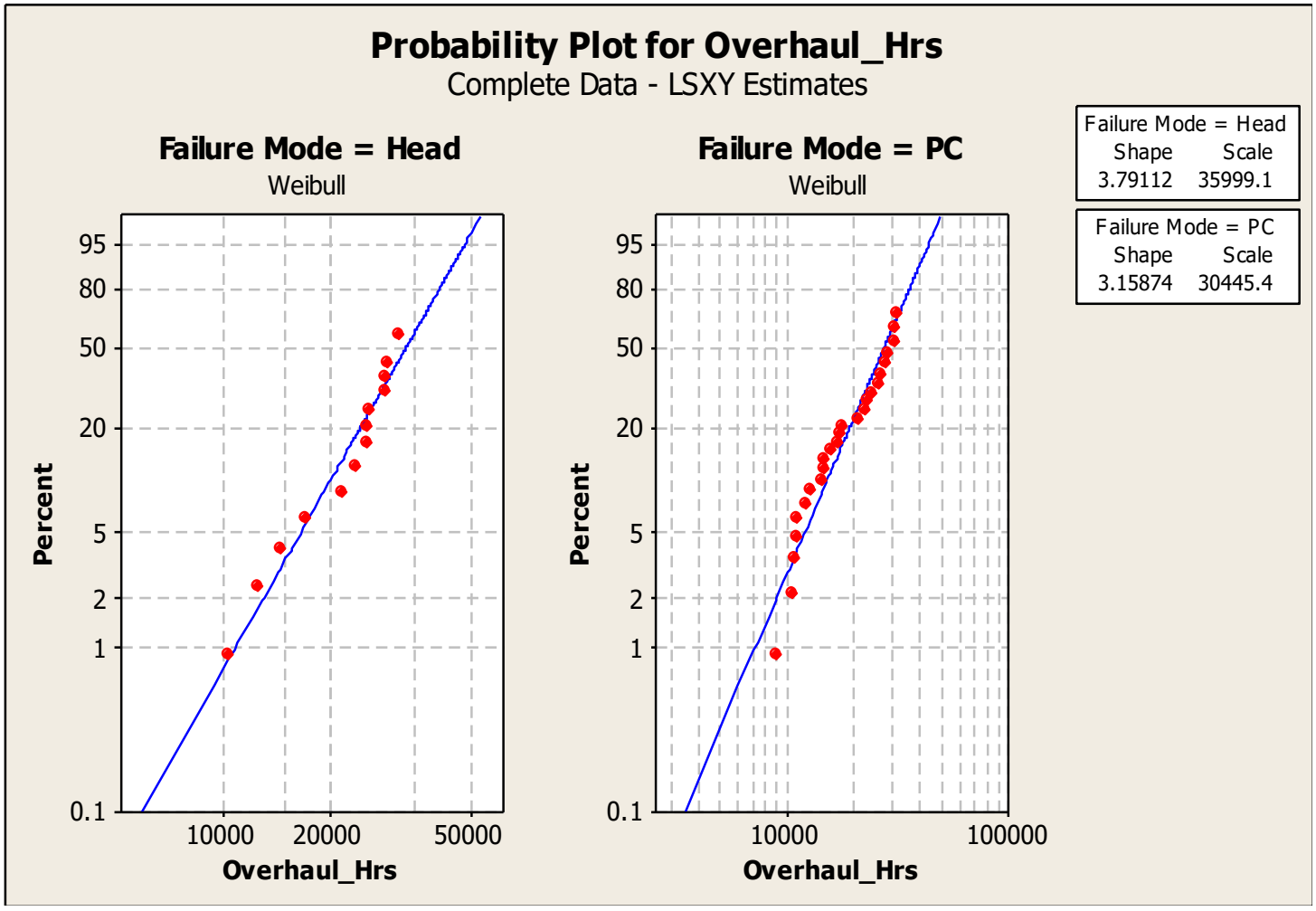
Analysis

- Analysis of data of 80 units brought to the repair shop for the primary failure mode was performed using Minitab software.
  - Alternately, other software also could be used.

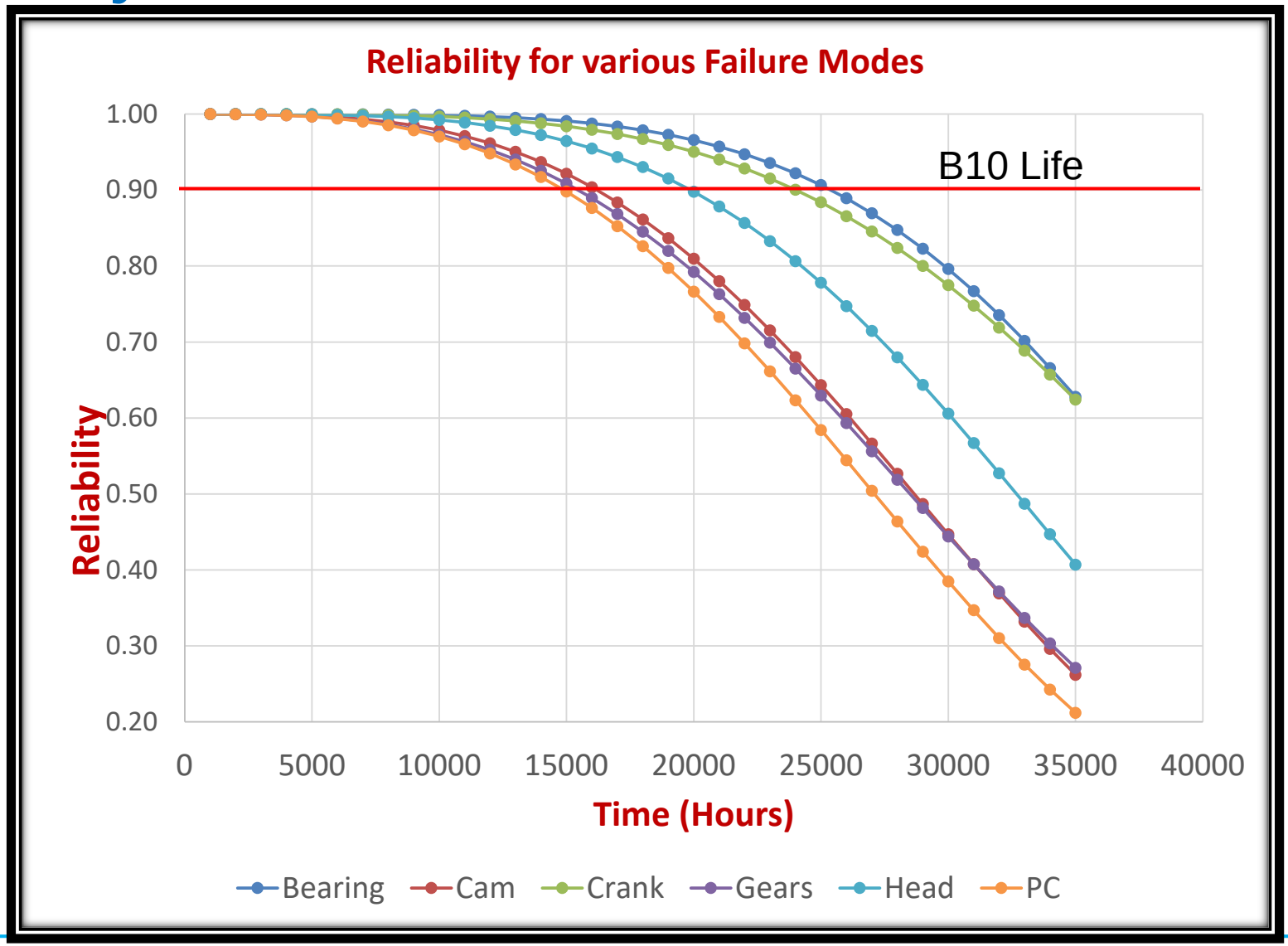
Analysis


Probability Plot for Overhaul_Hrs
Complete Data - LSXY Estimates
Failure Mode = Bearings
Weibull
Percent
90
50
10
1
20000
50000
Overhaul_Hrs
Failure Mode = Camshaft
Weibull
Percent
90
50
10
1
0.1
10000
100000
Overhaul_Hrs
Failure Mode = Crankshaft
Weibull
Percent
90
50
10
1
20000
50000
Overhaul_Hrs
Failure Mode = Gears
Weibull
Percent
90
50
10
1
0.1
10000
100000
Overhaul_Hrs
Failure Mode = Bearings
Shape Scale
4.63365 41286.7
Failure Mode = Camshaft
Shape Scale
3.30298 32035.8
Failure Mode = Crankshaft
Shape Scale
3.98413 42282.0
Failure Mode = Gears
Shape Scale
3.08237 32105.6
Observe that shape parameter for all failure modes is between 3 to 4.6 indicating wear out failures

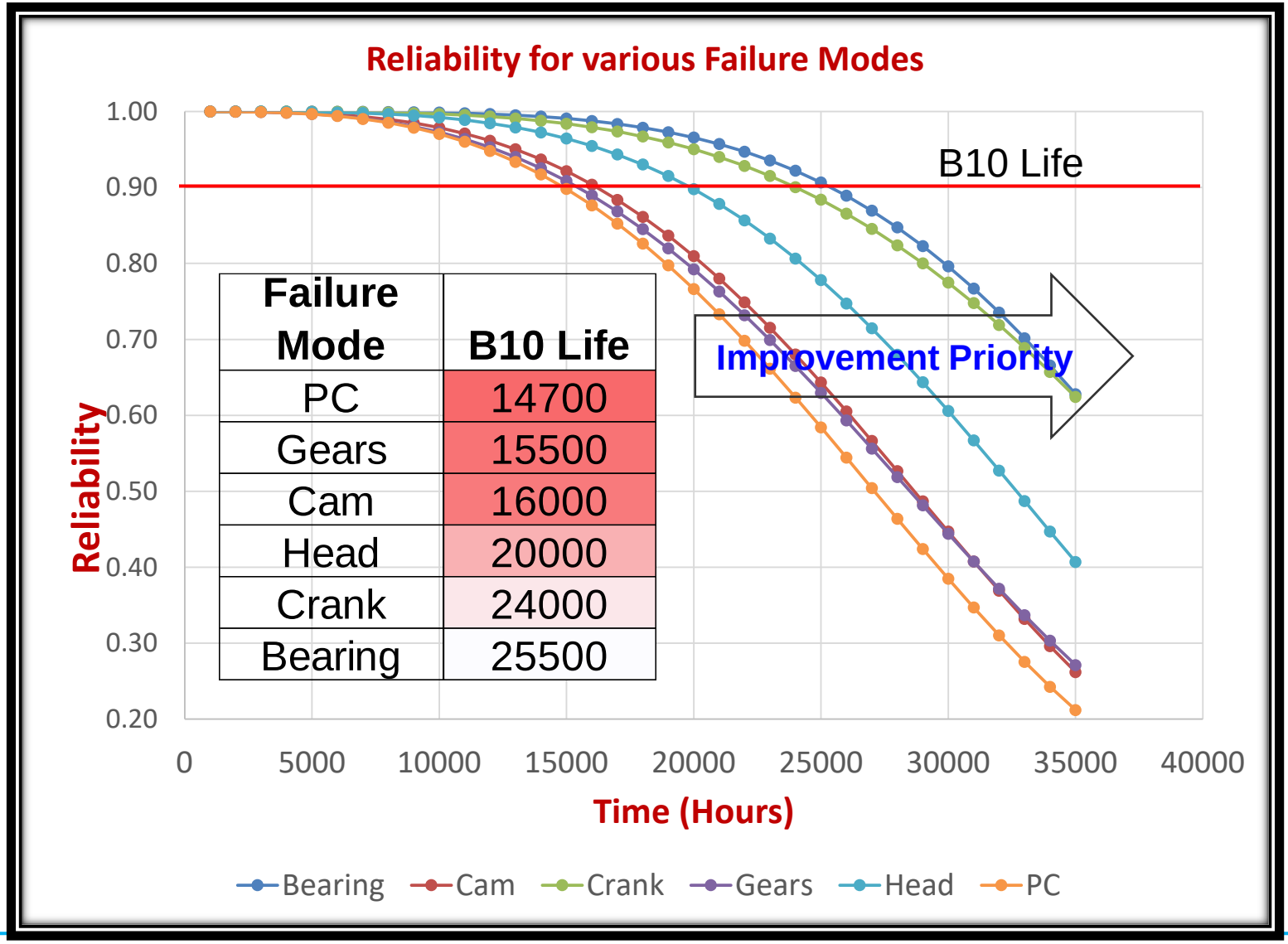
Analysis


Probability Plot for Overhaul_Hrs
Complete Data - LSXY Estimates
Failure Mode = Head
Weibull
Failure Mode = PC
Weibull
Failure Mode = Head
Shape Scale
3.79112 35999.1
Failure Mode = PC
Shape Scale
3.15874 30445.4
Percent
95
80
50
20
5
2
1
0.1
10000
20000
50000
100000
Overhaul_Hrs

Analysis


Reliability for various Failure Modes
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
Reliability
B10 Life
0
5000
10000
15000
20000
25000
30000
35000
40000
Time (Hours)
Bearing
Cam
Crank
Gears
Head
PC

Analysis



Failure Mode	B10 Life
PC	14700
Gears	15500
Cam	16000
Head	20000
Crank	24000
Bearing	25500

Conclusions

- Durability Failure Data collection requires special efforts
- Durability Improvement is usually responsibility of Engineering and Design functions
- Life Data Analysis may be possible with software using multiple failure modes
- Durability Improvement projects can be identified by prioritizing low B10 life (or similar consideration)

Further Actions!

- Projects to be taken up as per the priority identified
- The camshaft failures, for example, we re due to contact fatigue and was taken up as a DFSS project with a target to double the B10 life
- The power cylinder and Gear Failure project could also be taken up as DFSS to improve the B10 life.
- Customer expectation and performance of the competition can play important role in the project identification

References

- The New Weibull Handbook by Dr. Robert B. Abernethy
- Practical Reliability Engineering by Patrick D.T.O Connor and Andre Kleyner
- Minitab Software Help

Acknowledgement

- Institute of Quality and Reliability


Thank You !