Welcome

Determination of Asset Useful Life and Decision Making for Better Asset Performance Management

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POWERING A THRIVING FUTURE

CONTENTS

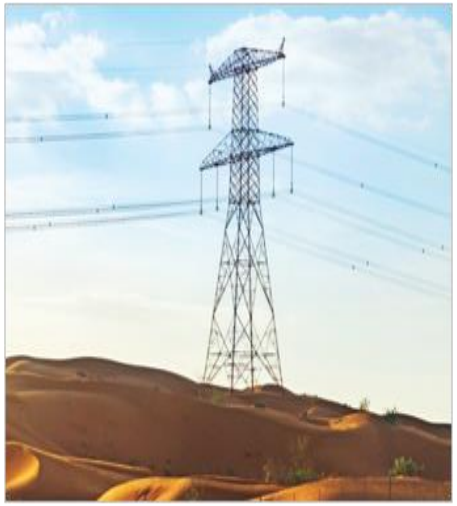
Introduction

Motivation

An effective digital transformation approach not available to maximize the asset performance and calculate the end of useful life of an asset

The asset life data captured in Maximo could be analysed and provide insights for enhancing the asset performance objectives

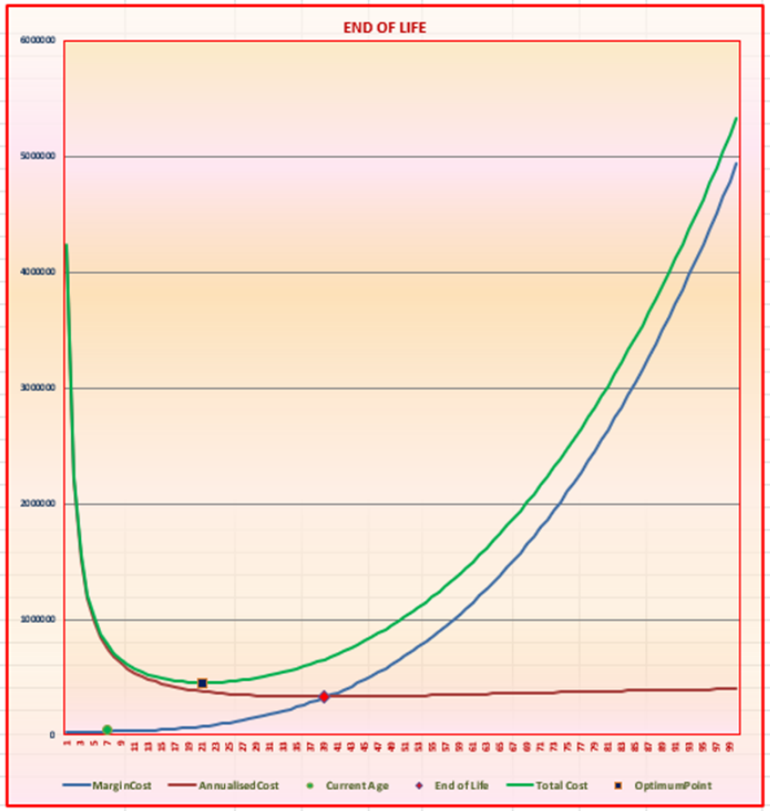
Mandatory requirement of ddevelopment of a strategy based on the calculations of failure rate, probability of failure ,calculation of end of useful life.



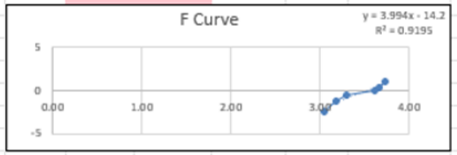
Overview of Asset useful life Tool

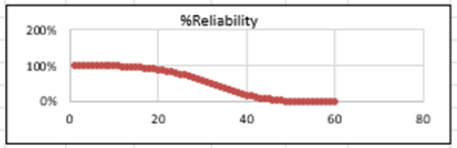
END OF ASSET LIFE ANALYSIS

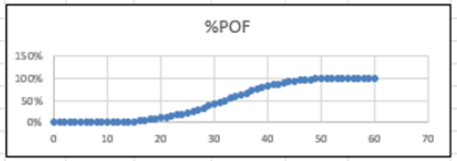
ASSET INFORMATION	
REGION	AD
ASSET CLASS	SCMS
SS NAME	SSHA-132
FEEDER NAME	MP-SSHA-132-CRL-SCM
INPUTS	
SCENARIO 1	
Current Age	7
Capital Cost	4,000,000
CI COST (RSB, Env etc..)	30,000
LIKELIHOOD	80%
ASSOCIATED DAMAGE	150,000
REPAIR COST	2,000,000
ENERGY LOST MW	5
ADDITIONAL COST	20,000
MAINTENANCE COST	30,000
Shape	4
Scale	35
Total ConSequence Cost	1,856,000
Rate of Failure	0.092%
OUTPUTS	
Minimum Annualized Cost	332,189
Current Age Risk Cost	1,711
Margin Cost	31,711
Actual Age at Replacement	39
Remaining Economic Value at EOF	9,379
End Of Life Consequence Cost	1,856,000
Optimum Year of Replacement	21
Cost of Delay	13,679
Benefit of Delay	240,000
Benefit/Cost Ratio	0.0
Minimum of Total Cost to Company	454,359
Age at Replacement	39
End of Life Cycle	39
Years to Replacement	32

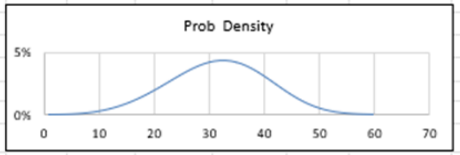


Rank	Year	Time to failure	Mrel	X axis ln TF	Y axis ln ln (1-
1	2015	21	0.08333	3.04	-2.4417164
2	2021	24	0.25	3.18	-1.2458993
3	2016	27	0.41667	3.30	-0.6180462
4	2020	37	0.58333	3.61	-0.1329358
5	2017	39	0.75	3.66	0.32663426
6	2018	42	0.91667	3.74	0.91023509









Weibull parameters	
β (Shape)	3.994
Intercept	-14.200
α (Scale)	35
R-square	92.0%

Year	t (age)	%Reliability	%POF	Hazard Rate	ProbDen
2023	0	100%	0%	0	0%
2024	1	100%	0%	0	0%
2025	2	100%	0%	0	0%
2026	3	100%	0%	0	0%
2027	4	100%	0%	0	0%
2028	5	100%	0%	0	0%
2029	6	100%	0%	0	0%
2030	7	100%	0%	1	0%
2031	8	100%	0%	1	0%
2032	9	100%	0%	1	0%
2033	10	99%	1%	2	0%
2034	11	99%	1%	2	0%
2035	12	99%	1%	3	0%
2036	13	98%	2%	4	1%
2037	14	97%	3%	5	1%
2038	15	97%	3%	6	1%
2039	16	96%	4%	7	1%
2040	17	95%	5%	9	1%
2041	18	93%	7%	10	1%
2042	19	92%	8%	12	2%
2043	20	90%	10%	14	2%
2044	21	88%	12%	16	2%
2045	22	86%	14%	19	2%
2046	23	83%	17%	22	3%
2047	24	80%	20%	24	3%
2048	25	77%	23%	28	3%
2049	26	74%	26%	31	3%
2050	27	70%	30%	35	4%
2051	28	66%	34%	39	4%
2052	29	62%	38%	43	4%
2053	30	58%	42%	48	4%
2054	31	54%	46%	53	4%
2055	32	50%	50%	58	4%
2056	33	45%	55%	64	4%
2057	34	41%	59%	69	4%
2058	35	37%	63%	76	4%
2059	36	33%	67%	82	4%
2060	37	29%	71%	90	4%
2061	38	25%	75%	97	4%
2062	39	21%	79%	105	3%
2063	40	18%	82%	113	3%
2064	41	15%	85%	122	3%
2065	42	13%	87%	131	2%

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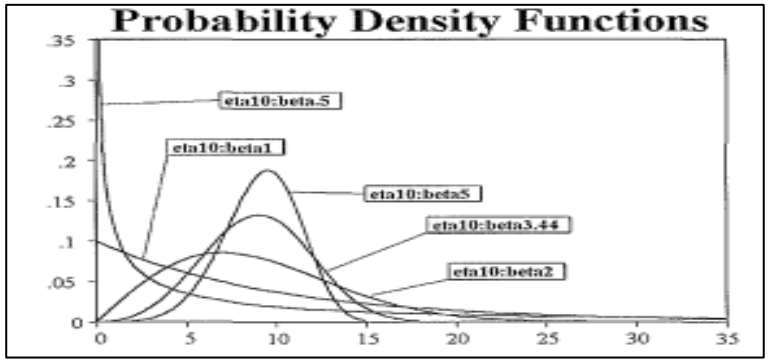
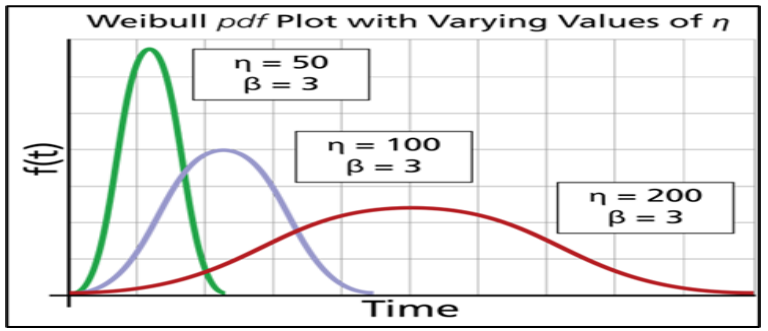
Steps of Useful life Determination

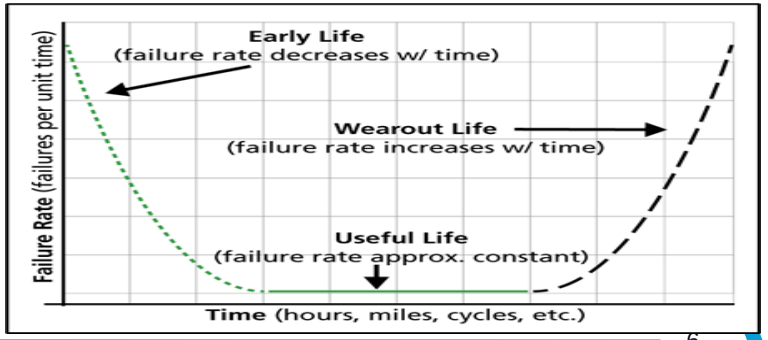
- Analyses the CM records, cost information.
- Calculate the Weibull parameters like shape and scale (Beta and Yeta) and predict the probability of failure using Weibull analysis.
- Calculate the annualised cost using the initial purchase price and the rate of yearly depreciation.
- Estimate the consequence cost considering the cost for environment, regulatory repair, damage , energy lost and legal aspects
- Calculate risk cost by multiplying consequence cost with hazard rate and adjusted to NPV.
- Finally, perform the analysis to determine the asset useful life.

Brief introduction to Weibull analysis

- Weibull analysis provides a reasonably approximated asset life data analysis and failure forecasts even though the sample sizes are small.
- The value of the slope parameter beta β describes the nature of the failure rate
- For a value of beta β<1 indicates the Asset infant mortality.
- If the beta β>1and less than 3 indicates normal useful life
- If the beta β>3 Wear and tear failures.
- The Eta parameter describes the characteristics life.



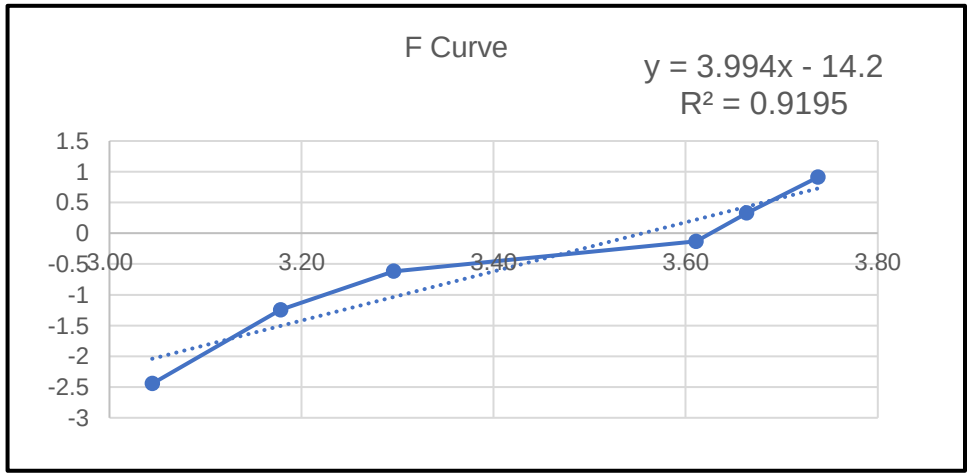




Capturing the Asset life data (Failure Times)

- The beta(β)slope and scale eta(η) parameters are calculated from the best fit curve using linear regression method .
- The R square value returns the square of the Pearson product moment correlation coefficient through data points in known X's and computed Y's.
- The r-squared value can be interpreted as the proportion of the variance in y attributable to the variance in x.
- The best fit failure curve of life data with reasonable value of r square around 90% will be good enough to provide useful information and failure predictions.

Rank	Year	F_Time	Median rank	X axis ln	Y axis ln ln (1-(1/M))
1	2015	21	0.083	3.04	-2.44
2	2021	24	0.25	3.18	-1.24
3	2016	27	0.41	3.30	-0.61
4	2020	37	0.58	3.61	-0.13
5	2017	39	0.75	3.66	0.32
6	2018	42	0.91	3.74	0.91



Calculation of Weibull Parameters

- Slope which is β (Shape) of the failure plot line is calculated using the formulae.

$$b = \frac{\sum (x - \bar{x})(y - \bar{y})}{\sum (x - \bar{x})^2}$$

- The slope parameter is calculated considering all the points the x axis and Y axis. The β (Shape) value 3.994 is the indication of the wear and tear failures for this type of failure curve.

- The intercept calculates the point at which a line will intersect the y-axis by using existing x-values and y-values. The intercept point is based on a best-fit regression line plotted through the known x-values and known y-values of the table.

- Using the slope and the intercept values the eta η characteristics life is calculated using the formulae. The eta η characteristics life and the scale parameter are then calculated using the formulae.

eta η = exp (- Intercept / Beta β)

Weibull parameters	
β (Shape)	3.994
Intercept	-14.200
α (Scale)	35
R-square	92.0%

Weibull Illustrations

- These two parameters of Weibull distribution are used for life data analysis. The Weibull cumulative distribution function (CDF) provides the probability of failure, F(t) up to time (t)

$$F(t) = 1 - e^{-(t/\eta)^{\beta}}$$

- The Weibull probability density function PDF is defined as bel shaped curve plotted using the formulae.

$$f(t) = (\beta/\eta)(t/\eta)^{\beta-1}\, e^{-(t/\eta)^{\beta}}$$

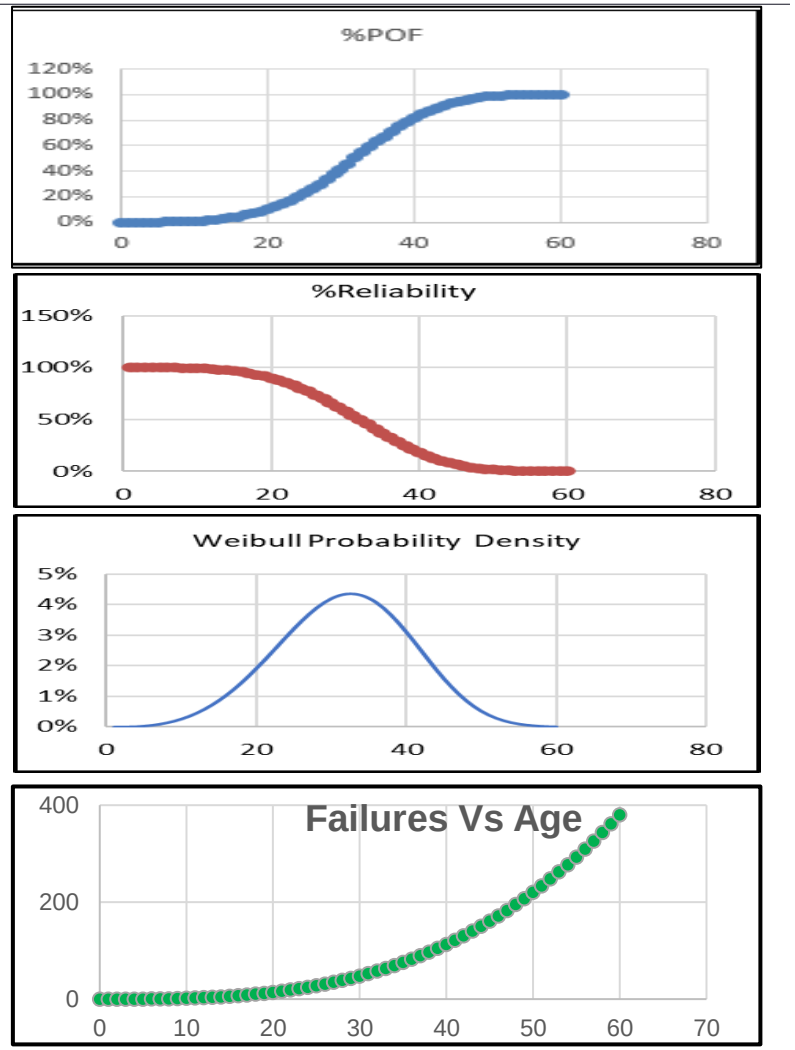
Where: F(t)= fraction of failure times up to time t . t = failure time β= shape ,η = scale parameter

- The reliability is calculated and plotted using the formulae below

$$R(t) = e^{-(t/\eta)^{\beta}}$$

- h(t) is the Hazard rate function which is used for risk cost quantification

$$h(t) = (\beta/\eta)(t/\eta)^{\beta-1}$$



Useful Asset life Analysis using Cost based Model

- Calculate the annualised cost using the PMT function with use of initial purchase price and the rate of depreciation for asset age of 100 years.
- Calculate the risk cost using estimated consequence cost multiplied with Hazard rate and adjusted to NPV for asset age of 100 years.
- Plot both the annualised cost and risk cost against asset age
- Sum up the annualized cost and risk cost and plot against asset age.
- The age at which the annualized cost curve and risk cost curve are crossing is marked as the end of economic life of an asset.
- Optimum replacement age of an asset is the age at which the sum of asset cost (NBV) and the consequence (Risk) cost are minimum.

Rank	Year	Time to failure (years)	Median rank	X axis ln TF	Y axis ln(ln (1-(1/MR))
1	2015	21	0.0833	3.04	-2.441
2	2021	24	0.25	3.18	-1.245
3	2016	27	0.416	3.30	-0.618
4	2020	37	0.583	3.61	-0.132
5	2017	39	0.75	3.66	0.326
6	2018	42	0.916	3.74	0.910

INPUTS	
SCENARIO 1	
Current Age	7
Capital Cost	6,000,000
CI COST (RSB, Env. etc..)	50,000
LIKELIHOOD	70%
ASSOCIATED DAMAGE	20,000
REPAIR COST	2,000,000
ENERGY LOST MW	5
ADDITIONAL COST	40,000
MAINTENANCE COST	25,000
Shape	4
Scale	35
Total Consequence Cost	1,617,000
Rate of Failure	0.36%

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Results of the calculations

END OF ASSET LIFE ANALYSIS

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REGION	AD
ASSET CLASS	SCMS
SS NAME	SSHA-132
FEEDER NAME	MP-SSHA-132-CRL-SCM
INPUTS	
SCENARIO 1	
Current Age	7
Capital Cost	4,000,000
CI COST (RSB, Env etc..)	30,000
LIKELIHOOD	80%
ASSOCIATED DAMAGE	150,000
REPAIR COST	2,000,000
ENERGY LOST MW	5
ADDITIONAL COST	20,000
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Total ConSequence Cost	1,856,000
Rate of Failure	0.092%
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Minimum of Total Cost to Company	454,359
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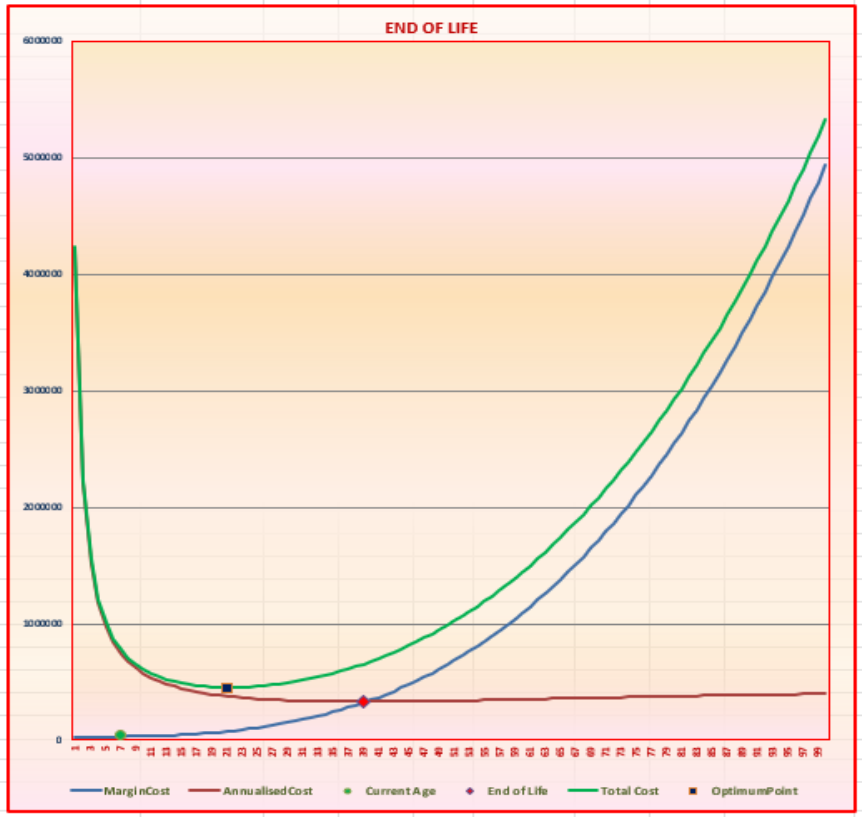

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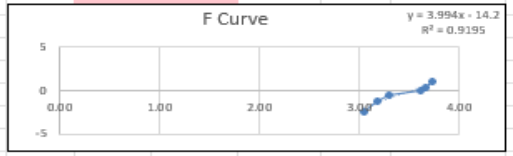

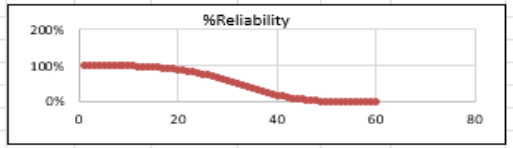

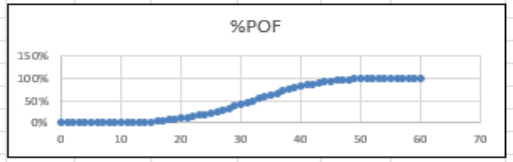

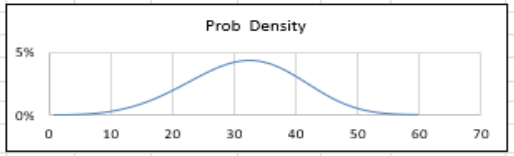

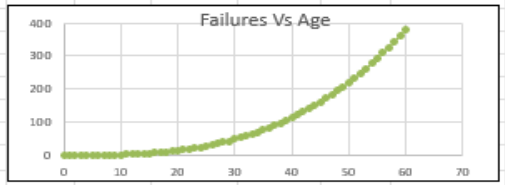

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Conclusions

- Determined the asset useful life and the optimum age for CAPEX intervention.
- Provides a framework for RCM decision making.
- Demonstrates the power of Weibull analysis.
- For better results, It is mandatory to have high degree of asset life data accuracy.
- This tool effectively saves 600 Man hours in a year (25 working days).

Thank you