System Reliability Center
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MTBF Confidence Limits

When a product's failure rate is considered constant, The Chi-Square distribution may be used to calculate confidence intervals around a measured mean time between failures (MTBF), the total test time among all tested products divided by the number of failures. The calculation differs depending on whether the test data truncates on the last failure or at a time after the last failure. The formulas used are:

	For time truncated tests		**For failure truncated tests**	
One-sided Confidence interval (MTBF lower limit)	$\frac{2T}{X^2(\alpha, 2n+2)}$		$\frac{2T}{X^2(\alpha, 2n)}$	
Two-sided Confidence intervals	$\frac{2T}{X^2(\alpha/2, 2n+2)}$,	$\frac{2T}{X^2(1-\alpha/2, 2n)}$	$\frac{2T}{X^2(\alpha/2, 2n)}$,	$\frac{2T}{X^2(1-\alpha/2, 2n)}$
MTBF limit:	Lower	Upper	Lower	Upper

Where T is the total test time
α is the acceptable risk of error (1- desired confidence)
n is the number of failures observed

The following table is derived from the formulas: http://www.kekaoxing.com

(Assumption of Exponential Distribution)

d	Lower Limit: 99% Two-Sided / 99-1/2% One-Sided	98% Two-Sided / 99% One-Sided	95% Two-Sided / 97-1/2% One-Sided	90% Two-Sided / 95% One-Sided	80% Two-Sided / 90% One-Sided	60% Two-Sided / 80% One-Sided	Upper Limit: 60% Two-Sided / 80% One-Sided	80% Two-Sided / 90% One-Sided	90% Two-Sided / 95% One-Sided	95% Two-Sided / 97-1/2% One-Sided	98% Two-Sided / 99% One-Sided	99% Two-Sided / 99-1/2% One-Sided
2	0.185	0.217	0.272	0.333	0.433	0.619	4.47	9.462	19.388	39.58	100.0	200.0
4	0.135	0.151	0.180	0.210	0.257	0.334	1.21	1.882	2.826	4.102	6.667	10.00
6	0.108	0.119	0.139	0.159	0.188	0.234	0.652	0.909	1.221	1.613	2.3077	3.007
8	0.0909	0.100	0.114	0.129	0.150	0.181	0.437	0.573	0.733	0.921	1.212	1.481
10	0.0800	0.0857	0.0976	0.109	0.125	0.149	0.324	0.411	0.508	0.600	0.789	0.909
12	0.0702	0.0759	0.0856	0.0952	0.107	0.126	0.256	0.317	0.383	0.454	0.555	0.645
14	0.0635	0.0690	0.0765	0.0843	0.0948	0.109	0.211	0.257	0.305	0.355	0.431	0.500
16	0.0588	0.0625	0.0693	0.0760	0.0848	0.0976	0.179	0.215	0.251	0.290	0.345	0.385
18	0.0536	0.0571	0.0633	0.0693	0.0769	0.0878	0.156	0.184	0.213	0.243	0.286	0.322
20	0.0500	0.0531	0.0585	0.0635	0.0703	0.0799	0.137	0.158	0.184	0.208	0.242	0.270
22	0.0465	0.0495	0.0543	0.0589	0.0648	0.0732	0.123	0.142	0.162	0.182	0.208	0.232
24	0.0439	0.0463	0.0507	0.0548	0.0601	0.0676	0.111	0.128	0.144	0.161	0.185	0.200
26	0.0417	0.0438	0.0476	0.0513	0.0561	0.0629	0.101	0.116	0.130	0.144	0.164	0.178
28	0.0392	0.0413	0.0449	0.0483	0.0527	0.0588	0.0927	0.106	0.118	0.131	0.147	0.161
30	0.0373	0.0393	0.0425	0.0456	0.0496	0.0551	0.0856	0.0971	0.108	0.119	0.133	0.145
32	0.0355	0.0374	0.0404	0.0433	0.0469	0.0519	0.0795	0.0899	0.0997	0.109	0.122	0.131
34	0.0339	0.0357	0.0385	0.0411	0.0445	0.0491	0.0742	0.0834	0.0925	0.101	0.113	0.122
36	0.0325	0.0342	0.0367	0.0392	0.0423	0.0466	0.0696	0.0781	0.0899	0.0939	0.104	0.111
38	0.0311	0.0327	0.0351	0.0375	0.0404	0.0443	0.0656	0.0732	0.0804	0.0874	0.0971	0.103
40	0.0299	0.0314	0.0337	0.0359	0.0386	0.0423	0.0619	0.0689	0.0756	0.0820	0.0901	0.0968

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Notes: 1. Multiply value shown by total part hours to get MTBF figure in hours.
2. d = 2 x (# of failures accumulated at test termination).
3. For the lower limit on tests truncated at a fixed time where the number of failures occurring is less than the total number of items placed on test initially, use: d = 2 x (# of failures accumulated at test termination +1).

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Source:

- RAC Publication, CPE, *Reliability Toolkit: Commercial Practices Edition*.

For More Information:

- RAC Publication, STAT, *Practical Statistical Tools for the Reliability Engineer*, Sept. 1999.

http://www.kekaoxing.com http://www.kekaoxing.com/club/