

CRWMS/M&O

Calculation Cover Sheet

Complete only applicable items.

1. QA: L

Page: 1 Of: 7

2. Calculation Title
Cumulative Distribution Functions for the Temperature Threshold for the Onset of Carbon Steel Corrosion

3. Document Identifier (including Revision Number) B00000000-01717-0210-00015 REV 00	4. Total Pages 7
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10. Remarks
Uses TBV-311.
For TSPA-VA Rev. 00 and Rev. 01.

Revision History

11. Revision No.	12. Date Approved	13. Description of Revision
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Title: Cumulative Distribution Functions for the Temperature Threshold for the Onset of Carbon Steel Corrosion

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Title: Cumulative Distribution Functions for the Temperature Threshold for the Onset of Carbon Steel Corrosion
File: *J:\WAPDEG STORAGE\QA\TSPA-VA00\TTHRESH-00.DOC*

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1.0 Purpose

The purpose of this calculation is to process the cumulative distribution functions (CDFs) characterizing the temperature threshold for the onset of corrosion provided by expert elicitation and minimize the set of values to 200 points for use in WAPDEG.

2.0 Method

The method of calculation is based on interpolation of expert elicited CDF distributions provided by Geomatrix, Inc. (TBV-311) resulting from the Waste Package Degradation Expert Elicitation Project (WPDEEP) to obtain a CDF with 200 points.

The following is an outline of the method:

- (1) The supplied CDFs from the expert elicitations are read.
- (2) 200 cumulative probabilities evenly distributed between 0 to 1 are generated and,
- (3) Temperature values in the supplied CDFs are linearly interpolated to provide the desired temperature value to pair to the 200 points found in (2).

For this file to be used as a CDF table in WAPDEG, the first line must contain the number of lines in the CDF file and the maximum CDF probability must be 1.

3.0 Assumptions

- 3.1 Temperature values were interpolated linearly between values. The basis for this assumption is that values are well approximated with little loss of information.

4.0 Use of Computer Software

4.1. Software Approved for QA Work

4.2. Software Routines

The software used was Mathcad 7 Professional. The type of computer used was a Dell PowerEdge 2200 with a Pentium II - 266 MHz chip, 128 MB of RAM, in a Windows 95 operating system.

Mathcad 7 is an appropriate application because it provides a wide variety of mathematical functions that are necessary for the calculations used to generate a CDF. Also, the program provides ease of display of equations and rationale employed in the analytical model, which eliminates the need to attach extra explanation and justification for the specific methodology.

The software was only used with the range of validation and was obtained from the Software Configuration Manager in accordance with appropriate procedures.

One particular routine used within Mathcad is the spreadsheet program Microsoft Excel 97. Microsoft Excel 97 is only an inlay within Mathcad 7 and is used for data input. The spreadsheet is not used to perform any calculations.

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5.0 Calculation Inputs

5.1. Description

See Attachment I.

5.2. Procedure

See Attachment I.

6.0 Results

TThresh.cdf

200	2		
95	0		
96.04780293396264	0.005025125628140704	99.41143155607773	0.2412060301507538
96.44130082705728	0.01005025125628141	99.44474980956953	0.2462311557788945
96.70112230517356	0.01507537688442211	99.47778764773824	0.2512562814070352
96.8990648209716	0.02010050251256281	99.51067660054109	0.2562814070351759
97.06079769169163	0.02512562814070352	99.54336672302443	0.2613065326633166
97.19917248454711	0.03015075376884422	99.57585000510782	0.2663316582914573
97.3201249121711	0.03517587939698492	99.60822004919918	0.271356783919598
97.42864456530062	0.04020100502512563	99.64041340714283	0.2763819095477387
97.52723928717325	0.04522613065326633	99.6724685784064	0.2814070351758794
97.61789668165531	0.05025125628140704	99.70444032675249	0.2864321608040201
97.70218720721175	0.05527638190954774	99.7362590162234	0.2914572864321608
97.78060077500044	0.06030150753768844	99.76799679816125	0.2964824120603015
97.8547204739554	0.06532663316582915	99.79967308174761	0.3015075376884422
97.92453278073492	0.07035175879396985	99.83124144606744	0.3065326633165829
97.99112081795305	0.07537688442211056	99.86277225883366	0.3115577889447236
98.05461018693737	0.08040201005025126	99.89424972483974	0.3165829145728643
98.11524212480408	0.08542713567839196	99.92568439478329	0.321608040201005
98.17354774427355	0.09045226130653267	99.95710212669856	0.3266331658291458
98.22973651505548	0.09547738693467336	99.98849464283573	0.3316582914572864
98.28399062354934	0.1005025125628141	100.0198408025368	0.3366834170854272
98.33648777706307	0.1055276381909548	100.0511560366765	0.3417085427135678
98.3873732926665	0.1105527638190955	100.0823645079538	0.3467336683417086
98.43679133664534	0.1155778894472362	100.1135331407738	0.3517587939698493
98.48486191876829	0.1206030150753769	100.1446500111336	0.3567839195979899
98.53169969232597	0.1256281407035176	100.1757238735063	0.3618090452261307
98.57741312671436	0.1306532663316583	100.2067815115495	0.3668341708542713
98.62209076828364	0.135678391959799	100.2378130649294	0.3718592964824121
98.66581650346987	0.1407035175879397	100.2688443855707	0.3768844221105528
98.70866959504588	0.1457286432160804	100.2998755556984	0.3819095477386935
98.75071169266957	0.1507537688442211	100.3309392053239	0.3869346733668342
98.79183383365272	0.1557788944723618	100.3620221595875	0.3919597989949749
98.8322564685663	0.1608040201005025	100.3931355620278	0.3969849246231156
98.87204146319927	0.1658291457286432	100.4243170177902	0.4020100502512563
98.91123737679244	0.1708542713567839	100.4555363004735	0.407035175879397
98.94988921609819	0.1758793969849246	100.4868419835005	0.4120603015075377
98.98781449129913	0.1809045226130653	100.5182264687136	0.4170854271356784
99.02527830828964	0.185929648241206	100.5496680896725	0.4221105527638191
99.06231416149996	0.1909547738693467	100.5812768345723	0.4271356783919598
99.09893456951136	0.1959798994974875	100.6129630352697	0.4321608040201005
99.13497838551825	0.2010050251256282	100.6447591757143	0.4371859296482412
99.17068899087498	0.2060301507537689	100.6767411004969	0.4422110552763819
99.20608454694832	0.2110552763819096	100.7088254837426	0.4472361809045226
99.24105702640479	0.2160804020100502	100.7410845618182	0.4522613065326633
99.27568028204907	0.221105527638191	100.7735410062978	0.457286432160804
99.31005759474273	0.2261306532663317	100.8061298947196	0.4623115577889447
99.34413409799188	0.2311557788944724	100.8389674143441	0.4673366834170855
99.37787862729768	0.2361809045226131	100.8720202003856	0.4723618090452261
		100.9052383900825	0.4773869346733669
		100.9387615763943	0.4824120603015075

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100.9725379576405	0.4874371859296482	103.9033936094244	0.7487437185929649
101.0065210460169	0.492462311557789	104.0087774898281	0.7537688442211056
101.040840986108	0.4974874371859296	104.1162188925446	0.7587939698492463
101.0754906578337	0.5025125628140703	104.2255149806546	0.7638190954773869
101.1103990830321	0.507537688442211	104.3364415979739	0.7688442211055276
101.1456388874343	0.5125628140703518	104.4487937420598	0.7738693467336684
101.1813268522496	0.5175879396984925	104.5624095415676	0.7788944723618091
101.2173321298981	0.5226130653266332	104.6770625770752	0.7839195979899498
101.2536718854396	0.5276381909547738	104.7925673644721	0.7889447236180904
101.290524329947	0.5326633165829146	104.9088189368089	0.7939698492462312
101.3278277887934	0.5376884422110553	105.026745664637	0.7989949748743719
101.3655441275748	0.542713567839196	105.1484758431924	0.8040201005025126
101.4036971680166	0.5477386934673367	105.2697908903243	0.8090452261306533
101.442459919896	0.5527638190954775	105.3908330948538	0.8140703517587939
101.4817841247889	0.5577889447236181	105.5117108431173	0.8190954773869347
101.5216408852891	0.5628140703517588	105.6325383046811	0.8241206030150754
101.5620675830512	0.5678391959798995	105.7534290409095	0.8291457286432161
101.6031038228773	0.5728643216080402	105.8745020806328	0.8341708542713568
101.6448830811635	0.577889447236181	105.9958610495914	0.8391959798994975
101.68741005535	0.5829145728643216	106.1176489076424	0.8442211055276382
101.7306593923052	0.5879396984924623	106.2399636938105	0.8492462311557789
101.7746788333121	0.592964824120603	106.3629508936903	0.8542713567839196
101.8195229340073	0.5979899497487438	106.4867362255944	0.8592964824120604
101.8652428084041	0.6030150753768845	106.6114686169095	0.864321608040201
101.9118884117811	0.6080402010050251	106.7373029122893	0.8693467336683417
101.9595260425497	0.6130653266331658	106.8644079438119	0.8743718592964824
102.0082041962299	0.6180904522613065	106.9929518223182	0.8793969849246232
102.0579954928312	0.6231155778894473	107.1231749531017	0.8844221105527639
102.1089695177982	0.628140703517588	107.2552420396374	0.8894472361809045
102.1611816359239	0.6331658291457286	107.3894752045882	0.8944723618090452
102.2147139968997	0.6381909547738693	107.5261401986601	0.8994974874371859
102.2696234205669	0.6432160804020101	107.6655426912691	0.9045226130653267
102.3259956135802	0.6482412060301508	107.8080791007219	0.9095477386934674
102.3838981015023	0.6532663316582915	107.9542341754945	0.914572864321608
102.443406490326	0.6582914572864321	108.1045623383478	0.9195979899497487
102.5046947864322	0.6633165829145729	108.2597502073474	0.9246231155778895
102.5679311350135	0.6683417085427136	108.4206334141457	0.9296482412060302
102.6330262393958	0.6733668341708543	108.5882399658067	0.9346733668341709
102.700048879538	0.678391959798995	108.7640620031106	0.9396984924623115
102.7694909158584	0.6834170854271356	108.9499174144759	0.9447236180904522
102.8410190181589	0.6884422110552764	109.1487397703384	0.949748743718593
102.9150013025307	0.6934673366834171	109.364750558878	0.9547738693467337
102.9913897431767	0.6984924623115578	109.6046228003124	0.9597989949748744
103.0704289501953	0.7035175879396985	109.8819538657578	0.964824120603015
103.1519686250848	0.7085427135678392	110.2275183138885	0.9698492462311558
103.2364092409455	0.7135678391959799	110.7192406908576	0.9748743718592965
103.3235488018916	0.7185929648241206	111.6979105972903	0.9798994974874372
103.4134347036166	0.7236180904522613	113.7313477788198	0.9849246231155779
103.5060878978761	0.7286432160804021	116.5413677742219	0.9899497487437187
103.6014993933648	0.7336683417085427	121.5772466433112	0.9949748743718593
103.6996042330781	0.7386934673366834		
103.8002732031501	0.7437185929648241		

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7.0 References

N/A.

8.0 Attachments

ATTACHMENT	TITLE	NUMBER OF PAGES
I	Temperature Threshold CDF Calculations	2
II	T-NS.SCD	10
III	T-NSR1.SCD	10

Temperature Threshold CDF Calculations

The following equations calculate the TThresh.cdf file used in WAPDEG

The following table of values is from Geomatrix Consultants, Inc (TBV-311). Since the table provided contained repeat probability values, these entries were removed (first repeating value entry kept) to create a proper lookup table. This table is shown in Attachment III. The values removed were not in the range of any values used for this calculation.

Mi :=	T (°C)	CDF value
	1.483500000E+02	9.99998900E-01
	1.484000000E+02	9.99999000E-01
	1.484500000E+02	9.99999100E-01
	1.485000000E+02	9.99999200E-01
	1.486000000E+02	9.99999300E-01
	1.487000000E+02	9.99999500E-01
	1.488000000E+02	9.99999600E-01
	1.489500000E+02	9.99999700E-01
	1.490500000E+02	9.99999800E-01
	1.493000000E+02	9.99999900E-01
	1.500000000E+02	1.00000000E+00

rows(Mi) = 1077

cols(Mi) = 2

This is an Excel inlay showing only a partial listing of the 1077 nonrepeating values. The original table of 1101 values is shown in Attachment II. The table of 1077 nonrepeating values is shown in Attachment III.

$$N := 199 \quad ii := 0..N \quad p_{ii} := ii \cdot \frac{1}{N}$$

The vector of cumulative probabilities, p, contains N+1 = 200 equally spaced probabilities, i.e. 0, 1/199, 2/199, . . . , 1.

$$k(p, M, r) := \begin{cases} \min(M) & \text{if } r < 0 \\ \max(M) & \text{if } r > 1 \\ \text{linterp}(p, M, r) & \text{otherwise} \end{cases}$$

k is a function that returns a Temperature corresponding to the percentile, r, through linear interpolation. M is the vector of Temperatures, and p is the percentile vector.

The output matrix, Mo, has the temperatures (interpolated from the input matrix, Mi) in the first column and the cumulative probabilities, from the vector p, in the second column.

$$Mo_{ii,0} := k(Mi^{<1>}, Mi^{<0>}, p_{ii}) \quad Mo_{ii,1} := p_{ii}$$

Create the CDF table using the print functions.

WRITEPRN("TThresh.cdf") := (rows(Mo) cols(Mo))

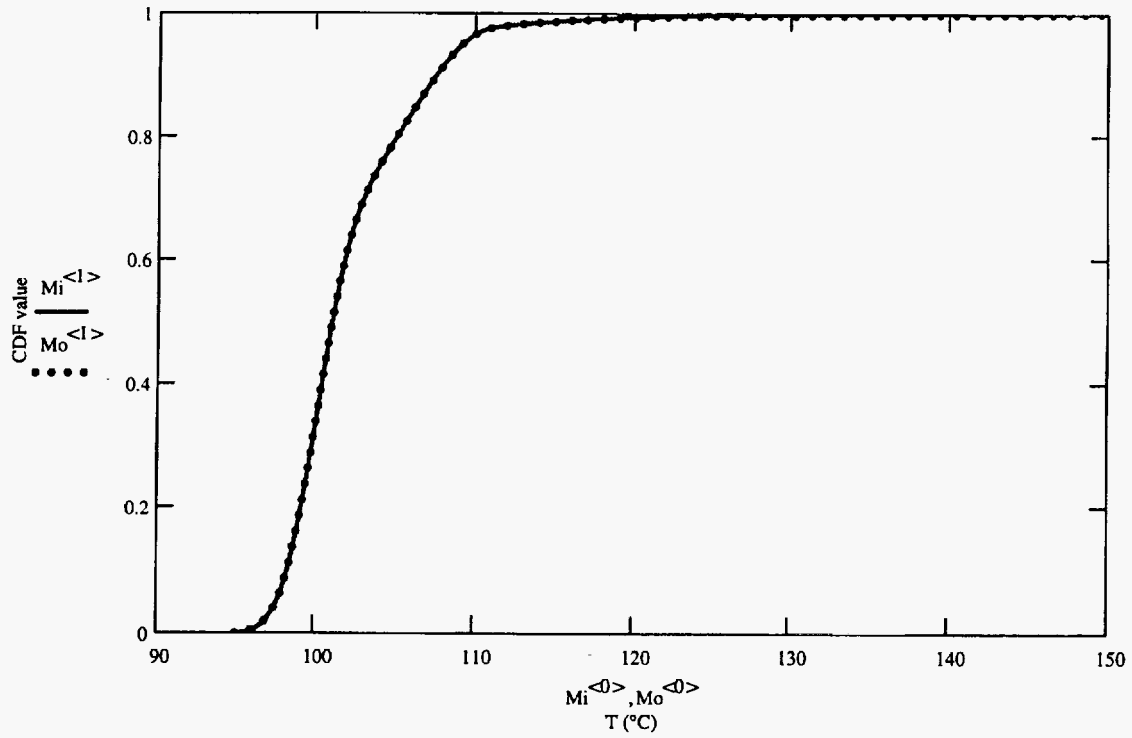
APPENDPRN("TThresh.cdf") := Mo

Create Attachment III using the print functions.

WRITEPRN("T-nsr1.scd") := (rows(Mi) cols(Mi))

APPENDPRN("T-nsr1.scd") := Mi

Below is a graph showing the similarity between the input and output of this procedure:



Temperature threshold for corrosion of CAM w/o salts

```

1101
0.950000E+02 0.000000E+00
0.950500E+02 0.9303730E-04
0.951000E+02 0.1947284E-03
0.951500E+02 0.3058121E-03
0.952000E+02 0.4270099E-03
0.952500E+02 0.5591639E-03
0.953000E+02 0.7031140E-03
0.953500E+02 0.8597476E-03
0.954000E+02 0.1030080E-02
0.954500E+02 0.1215087E-02
0.955000E+02 0.1415912E-02
0.955500E+02 0.1633682E-02
0.956000E+02 0.1869574E-02
0.956500E+02 0.2124946E-02
0.957000E+02 0.2401073E-02
0.957500E+02 0.2699466E-02
0.958000E+02 0.3021580E-02
0.958500E+02 0.3368935E-02
0.959000E+02 0.3743285E-02
0.959500E+02 0.4146244E-02
0.960000E+02 0.4579739E-02
0.960500E+02 0.5045596E-02
0.961000E+02 0.5545702E-02
0.961500E+02 0.6082255E-02
0.962000E+02 0.6657219E-02
0.962500E+02 0.7272975E-02
0.963000E+02 0.7931731E-02
0.963500E+02 0.8635743E-02
0.964000E+02 0.9387672E-02
0.964500E+02 0.1018981E-01
0.965000E+02 0.1104501E-01
0.965500E+02 0.1195581E-01
0.966000E+02 0.1292481E-01
0.966500E+02 0.1395513E-01
0.967000E+02 0.1504931E-01
0.967500E+02 0.1621062E-01
0.968000E+02 0.1744190E-01
0.968500E+02 0.1874597E-01
0.969000E+02 0.2012632E-01
0.969500E+02 0.2158566E-01
0.970000E+02 0.2312758E-01
0.970500E+02 0.2475506E-01
0.971000E+02 0.2647102E-01
0.971500E+02 0.2827919E-01
0.972000E+02 0.3018225E-01
0.972500E+02 0.3218398E-01
0.973000E+02 0.3428728E-01
0.973500E+02 0.3649499E-01
0.974000E+02 0.3881089E-01
0.974500E+02 0.4123738E-01
0.975000E+02 0.4377821E-01
0.975500E+02 0.4643599E-01
0.976000E+02 0.4921317E-01
0.976500E+02 0.5211339E-01
0.977000E+02 0.5513844E-01
0.977500E+02 0.5829182E-01
0.978000E+02 0.6157554E-01
0.978500E+02 0.6499137E-01
0.979000E+02 0.6854253E-01
0.979500E+02 0.7222990E-01
0.980000E+02 0.7605641E-01
0.980500E+02 0.8002325E-01
0.981000E+02 0.8413111E-01
0.981500E+02 0.8838257E-01
0.982000E+02 0.9277724E-01
0.982500E+02 0.9731736E-01
0.983000E+02 0.1020027E+00
0.983500E+02 0.1068330E+00
0.984000E+02 0.1118095E+00
0.984500E+02 0.1169308E+00
0.985000E+02 0.1221976E+00
0.985500E+02 0.1276086E+00
0.986000E+02 0.1331619E+00
0.986500E+02 0.1388577E+00
0.987000E+02 0.1446928E+00
0.987500E+02 0.1506668E+00
0.988000E+02 0.1567768E+00
0.988500E+02 0.1630193E+00
0.989000E+02 0.1693933E+00
0.989500E+02 0.1758938E+00
0.990000E+02 0.1825192E+00
0.990500E+02 0.1892650E+00
0.991000E+02 0.1961261E+00
0.991500E+02 0.2031003E+00
0.992000E+02 0.2101810E+00
0.992500E+02 0.2173654E+00
0.993000E+02 0.2246475E+00
0.993500E+02 0.2320208E+00
0.994000E+02 0.2394819E+00
0.994500E+02 0.2470230E+00
0.995000E+02 0.2546402E+00
0.995500E+02 0.2623262E+00
0.996000E+02 0.2700737E+00
0.996500E+02 0.2778783E+00
0.997000E+02 0.2857309E+00
0.997500E+02 0.2936274E+00
0.998000E+02 0.3015594E+00
0.998500E+02 0.3095188E+00
0.999000E+02 0.3175009E+00
0.999500E+02 0.3254963E+00
0.100000E+03 0.3335000E+00
0.100050E+03 0.3415224E+00
0.100100E+03 0.3495733E+00
0.100150E+03 0.3576479E+00
0.100200E+03 0.3657360E+00
0.100250E+03 0.3738328E+00
0.100300E+03 0.3819297E+00
0.100350E+03 0.3900181E+00
0.100400E+03 0.3980936E+00

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