NELSON RECURRENT EVENTS (RE) ANALYSIS IN SuperSMITH(R) SOFTWARE

The SuperSMITH® Visual (SSV) program has a simple implementation of Nelson RE analysis developed by Dr. Wayne Nelson. It is included in the Visual program, and not the Weibull program, because the resulting plot is not a probability plot. Standard RE analysis is non-parametric and does not require special probability scaling.

Suppose you have 3 pieces of equipment with serial number identification SN007, SN008, and SN015. In **SN007** two repairs have occurred at ages [hours] **391** and **643**, and it is **967 hours old now**. In **SN008** two repairs occurred **almost together** at age **622**, and it is **636 hours old now**. In **SN015** one repair occurred at **485** hours, and it is **923 hours old now**. **What is the mean cumulative function (MCF) of repairs vs. age?**

NOTE: "MCF" is defined in Reference 1 listed at the end.

As background, for standard Nelson RE every data value must also be identified with a piece of equipment … "equipment" may be a person or a project in the broader sense. The Nelson RE analysis is age-based and so the data must be put into overall age order before numbers are crunched. The software can put the data in order for you if it is not already in age order. In SuperSMITH software, the first number (X-Value) in the data entry is ALWAYS time or age when working with Weibull-Engineering type data (age) or Crow-AMSAA type data (operating time) or Nelson RE data (age). The second number (after the "x" used as a delimiter) for SSV is the Y-Value. For Nelson RE that Y-Value represents the number of events occurring at precisely that age value (usually 1 for one repair). The Nelson RE input Y-Value is NON-CUMULATIVE data, but the resulting analysis will be in CUMULATIVE form! Also, the Y-Value could be cost at that age value when performing cost analysis. Every individual equipment piece represented by Nelson RE analysis MUST have one suspension entry at the last known age for that equipment. Before suspension that same equipment may have any number of event (or cost) data entries. To enter a suspension, use zero (0) as the Y-Value or put a ">" sign in front of the age. The identifier text is put at the right-hand side using the underline symbol ("_") as the delimiter.

The above data for entry into the software without putting in overall age order is:
391x1_SN007
643x1_SN007
967x0_SN007
622x2_SN008
636x0_SN008
485x1_SN015
923x0_SN015

*SOLUTION***:** Start the SSV program…
   A) Select the blank page icon to reset for a new analysis.
   B) Enter the data above including the "_SN…" for Set 1 as points 1 through 7 (an additional "x1" may be automatically added for each entry).
   C) After finishing data entry, move the cursor over the results box to get the simple X-Y plot (not a Nelson RE analysis yet).
   D) Select the Nelson Recurrent Event (RE) Analysis icon on the main screen to get the RE menu.
   E) Verify that Plot Display Type is set to STEP FUNCTION for both Confidence and MCF.
   F) Select Activate Analysis or select the green check mark … a message about order should appear.
   G) Select Order By X-Value to put the data entries into overall age sequence and solve.
   H) You should get a plot indicating MCF value (on vertical scale) of about 1.833 total repairs/equipment starting at age 643 (on horizontal scale). (See Figure 1 below)

Figure 1 - Age (Hours)
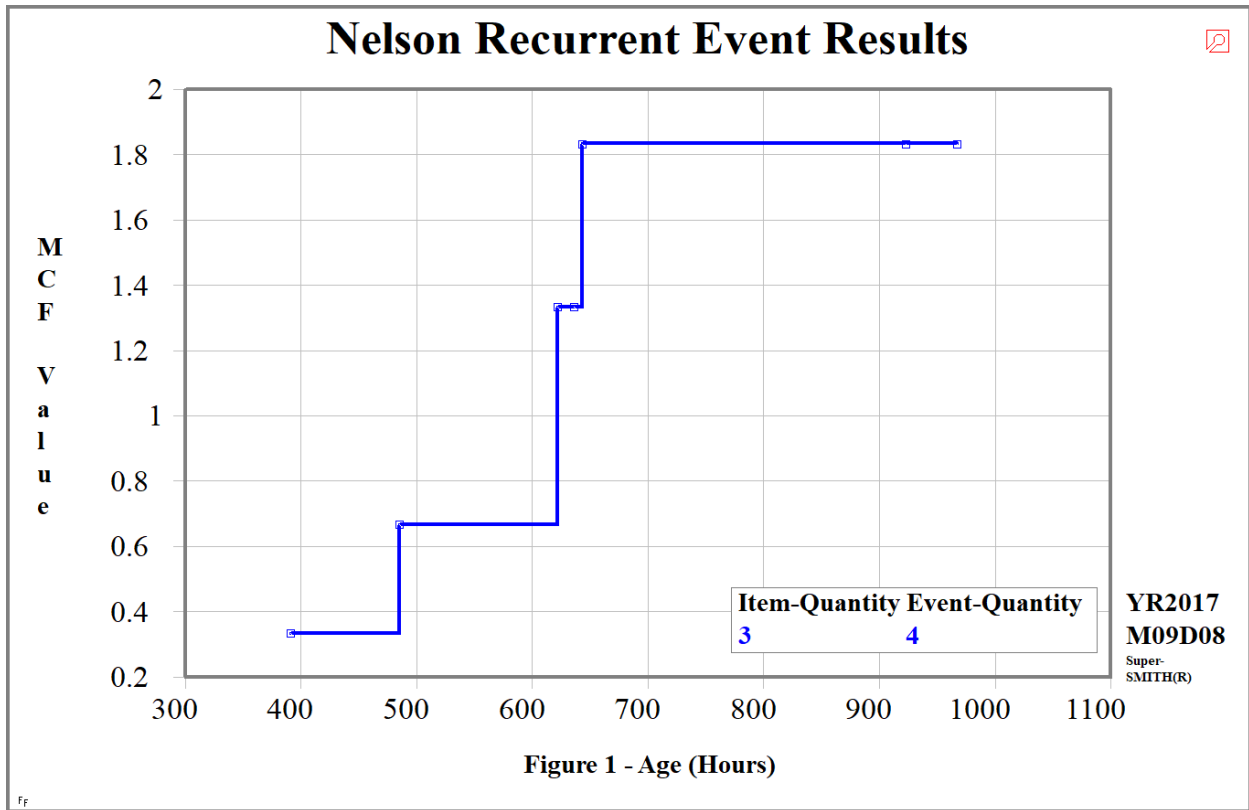
There are many different formats possible for Nelson RE data. The data below from Dr. Nelson is provided in the SuperSMITH® HELP text file (provided in the SMITHDAT subdirectory with the original program files), **SMITHHLP-BENCHMARKING.TXT**, as Benchmark 9V (Format #2). The identification for this input data is now on the left and values afterward are mileage at repair. The trailing "+" indicates suspension. What is the mean cumulative function (MCF)?

Car#	Mi(1)	Mi(2)	Mi(3)
024	7068	26744+	
026	28	13809+	
027	48	1440	29834+
029	530	25660+	
031	21762+		
032	14235+		
034	1388	21133+	
035	21401+		
098	21876+		
107	5094	18228+	
108	21691+		
109	20890+		
110	22486+		
111	19321+		
112	21585+		
113	18676+		
114	23520+		
115	17955+		

116	19507+	
117	24177+	
118	22854+	
119	17844+	
120	22637+	
121	375	19607+
122	19403+	
123	20997+	
124	19175+	
125	20425+	
126	22149+	
129	21144+	
130	21237+	
131	14281+	
132	8250	21974+
133	19250	21888+

SOLUTION: Start the SSV program…

A) Select the blank page icon to reset for a new analysis.
B) Copy the data in the HELP text file (indicated above) into the clipboard.
C) Paste into SSV, and select column format "Format: ID-Label Age1 Age2 … [Nelson RE]"
D) Select the Order By X-Value option
E) Result: MCF plot indicating about 0.303 total repairs/equipment starting at age 19250.
F) NOTE: The Nelson RE icon is selected automatically upon selection of Format. (Figure 2)

Figure 2 - Age (Miles)
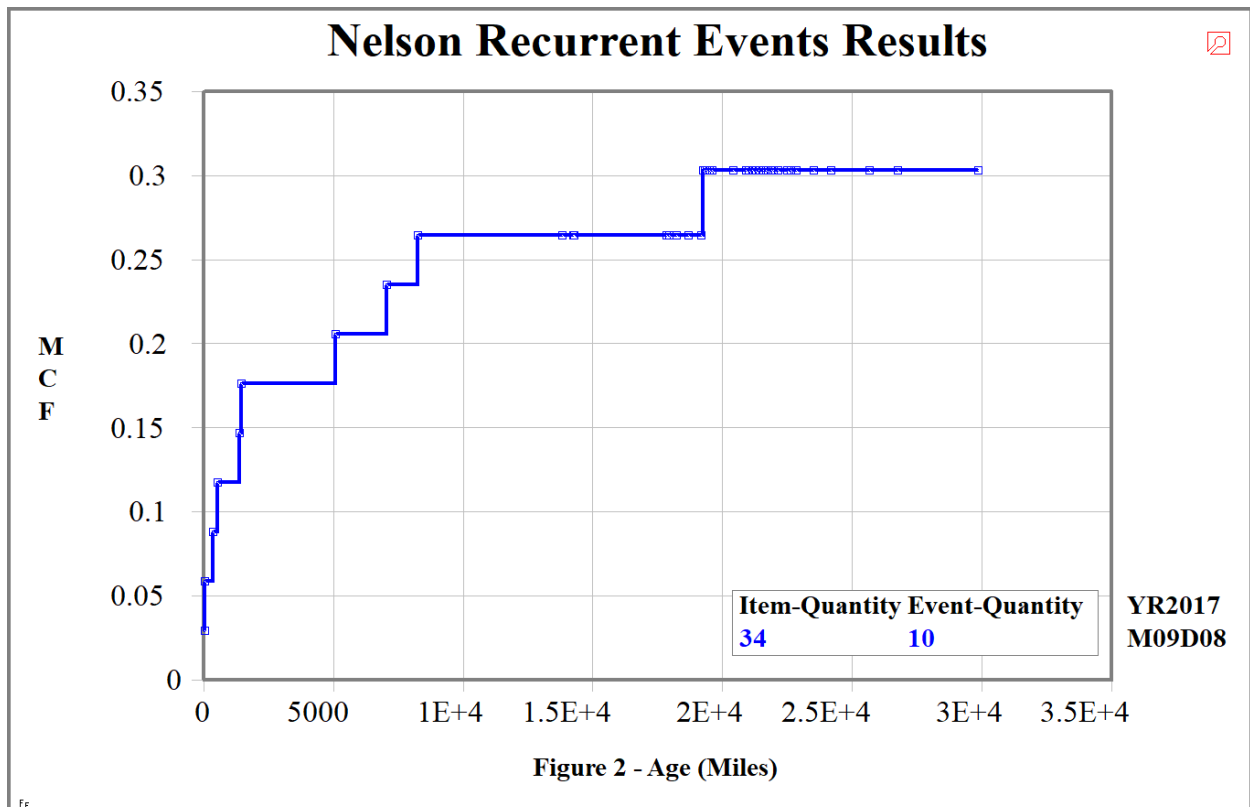
REFERENCE

Nelson, Wayne B., *Recurrent Events Data Analysis For Product Repairs, Disease Episodes, And Other Applications*, SIAM, Jan. 2003, 147 pp., ISBN 0-89871-522-9. Available as a hardcover book and ebook.   http://bookstore.siam.org/sa10/.