



UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
WASHINGTON, D.C. 20555

April 10, 1992

Docket No. 50-390

Tennessee Valley Authority  
ATTN: Dr. Mark O. Medford, Vice President  
Nuclear Assurance, Licensing and Fuels  
3B Lookout Place  
1101 Market Street  
Chattanooga, Tennessee 37402-2801

Dear Dr. Medford:

SUBJECT: WATTS BAR UNIT 1 - NRC STAFF POSITION ON THE QA RECORDS CAP  
(TAC M71923)

After a December 12, 1990, meeting in Region II regarding the QA records for Watts Bar Unit 1, TVA documented the information presented at that meeting in a letter to the NRC dated January 28, 1991. Enclosure 1 to that letter described the Additional Systematic Records Review (ASRR). The enclosure described the sample review process and the population acceptance criteria. The staff commented on the proposed ASRR by letter to TVA dated March 20, 1991, and TVA responded by letter dated May 10, 1991. The response included the first reference to the use of Bayesian sampling. By letter dated July 2, 1991, TVA clarified that it would not use any of the data from previous reviews but would use only the ASRR results in performing the planned analysis. By letter dated October 16, 1991, TVA responded to NRC questions of August 30, 1991, and indicated that a modified Corrective Action Program (CAP) plan for Watts Bar QA records would be submitted at a later date. TVA's letter dated December 6, 1991 submitted Revision 4 of the QA Records CAP plan which incorporated the ASRR as an attachment. Staff questions regarding the revised CAP plan and the ASRR were discussed at a TVA - NRC meeting at NRC headquarters on January 27, 1992, and formally responded to by TVA letter dated February 14, 1992. The QA Records CAP was again discussed at a TVA - NRC meeting in Region II offices on March 9, 1992.

Despite the correspondence and meetings listed above, the staff still has two concerns regarding the method of data analysis proposed by TVA. In a management meeting at the Watts Bar site on March 24, 1992, the staff committed to issue its concerns as a staff position. The enclosed document describes in detail the staff's technical position on the two concerns. In summary, it is the staff's position that:

- (1) TVA should adopt a classical statistical approach to meet the acceptance criteria of 95/5; the Bayesian approach is not acceptable.
- (2) The sampling and rectification procedure proposed by TVA does not meet the acceptance criteria of 95/5, unless the defect types to be rectified are completely specified in advance. Otherwise, TVA should revise its procedure.

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Please respond within 30 days of receipt of this letter. This requirement affects 9 or fewer respondents and, therefore, is not subject to Office of Management and Budget review under P.L. 96-511.

Sincerely,

Original signed by

Peter S. Tam, Senior Project Manager  
Project Directorate II-4  
Division of Reactor Projects - I/II  
Office of Nuclear Reactor Regulation

Enclosure:  
Position paper on QA Records CAP

c w/enclosure:  
See next page

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*See sheet 2  
BST*

(Concurrence sheet 1)

OFC	PDII-4/LA	PDII-4/PM	LPEB	LPEB	LPEB
NAME	MSanders <i>ms</i>	PTam:as <i>PST</i>	JSpraul	LABramson *	AMendiola <i>AM</i>
DATE	4/8/92	4/8/92	4/9/92	4/ /92	4/9/92
OFC	LPEB	DEPO/D	PDII-4/D		
NAME	GZech <i>GZ</i>	JRoe <i>JR</i>	FHebdon <i>PST</i>		
DATE	4/9/92	4/9/92	4/10/92		

\*See concurrence sheet 2

#1 4/9

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NRC STAFF POSITION REGARDING THE  
WATTS BAR QA RECORDS CORRECTIVE ACTION PROGRAM

Classical vs. Bayesian Statistics

TVA proposes using a Bayesian approach to assess the condition of WBN records. For each ANSI record type,  $i$ , this approach depends on the choice of a prior distribution for the true fraction defective,  $f_i$ . Since the choice of a prior is necessarily subjective, the NRC has the difficult task of assessing the validity of the Bayesian approach in demonstrating that the acceptance criteria are met for each of the 186 ANSI record types.

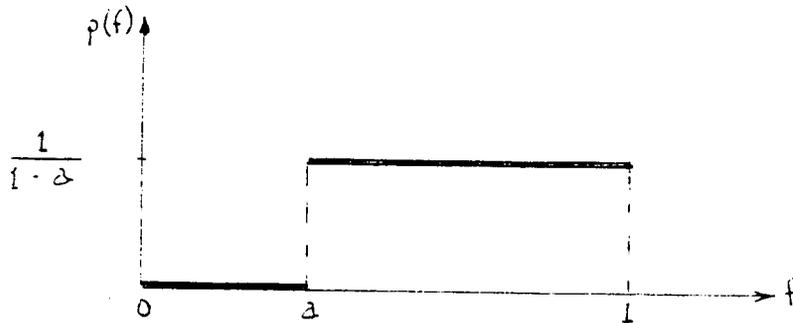
A major difficulty with the Bayesian approach is a conceptual one. The Bayesian approach combines a prior distribution for  $f_i$  with sample data from the population of record type  $i$  to calculate a posterior distribution for  $f_i$ . Since the prior has a "degree of belief" interpretation, so does the posterior. While this interpretation may be meaningful for TVA, it is not clear how the NRC can rely on a degree of belief interpretation in fulfilling its regulatory mandate to protect the public health and safety. In fulfilling this mandate, the NRC must necessarily rely on methods which are as objective as possible.

One method for validating the Bayesian approach is to demonstrate that the choice of prior has little effect on the results of the Bayesian analysis. In such a case, the observed data dominates the prior, so that the results can be considered essentially objective. This validation method consists of a sensitivity study of the posterior as a function of the prior. The Bayesian approach is validated if the posterior remains essentially unchanged as the prior varies over its full plausible range.

As will be demonstrated, one crucial parameter of a prior for  $f_i$  is its lower truncation point. This is a number  $a$ ,  $0 \leq a < 1$ , such that the prior is zero for  $f_i \leq a$ . In other words, the probability is zero that  $f_i \leq a$  and is positive for all  $f_i > a$ . As a simple example, consider the class of flat priors for a defect fraction  $f$  defined by

$$p(f) = \begin{cases} 0 & , 0 \leq f \leq a \\ \frac{1}{1-a} & , a < f \leq 1 \end{cases}$$

This is sketched below.



In conformity with the TVA sampling plan, assume that zero defects are found in a random sample of  $n$  records. Denote this event by  $E_n$ . Using Bayes theorem, the posterior distribution of  $f$  given  $E_n$  is given by  $p_n(f)$ .

$$p_n(f) = \frac{p(f) L(E_n|f)}{\int_0^1 p(f) L(E_n|f) df} \quad (1)$$

where  $L(E_n|f) = (1-f)^n$  is the likelihood of  $E_n$  given  $f$ . Performing the integration in Eq. 1 yields  $p_n(f) = 0$  for  $0 \leq f \leq a$  and

$$p_n(f) = (n+1) \left[ \frac{1-f}{1-a} \right]^n \quad (2)$$

for  $a < f \leq 1$ . The cumulative posterior for  $f$  is given by

$$\begin{aligned} P_n(x) &= \text{Prob} \{f \leq x\} \\ &= \int_0^x p_n(f) df \\ &= 1 - \left[ \frac{1-x}{1-a} \right]^{n+1} \end{aligned} \quad (3)$$

for  $a \leq x \leq 1$ .

The acceptance criteria require that  $f < 0.05$  with 95 percent confidence. In terms of the posterior, this means that

$$P_n(.05) = .95 \quad (4)$$

From Eqs. 3 and 4, the required  $n$  is given by

$$n = \frac{\ln (.05)}{\ln \left[ \frac{.95}{1-a} \right]} - 1 \quad (5)$$

A table of  $n$  (rounded up to the next integer) is given below for selected values of  $a$

a	0	.001	.01	.02	.03	.04	.05
n	58	59	72	96	143	286	$\infty$

The case where  $a = 0$  is the noninformative prior between 0 and 1. (TVA has implied that this "classical" prior is equivalent to a classical confidence interval. This is almost correct, since the Bayesian sample size is one less than the classical sample size.) As the lower truncation point increases, the required sample size increases and approaches infinity as  $a$  approaches 0.05. This makes sense, since the prior probability that  $f < .05$  decreases and approaches zero as  $a$  approaches .05. This implies that the posterior probability that  $f < .05$  also decreases and approaches zero as  $a$  approaches .05.

From these results, it can be seen that the required sample size is a sensitive function of the lower truncation point as it increases towards 0.05. Although the use of a flat prior may not be realistic for the WBN corrective action program, it is clear from this example that the Bayesian sample size will be a sensitive function of the choice of prior. Since the choice of a prior, particularly its lower truncation point, is highly subjective, the NRC will not be able to validate the Bayesian approach.

Thus we conclude that the classical sampling approach should be used to meet the acceptance criteria of 95/5. Since unlimited sampling data are available, a common justification for using the Bayesian approach, i.e., that little data are available, does not apply in this case.

It is the staff's position that TVA should adopt a classical statistical approach to meet the acceptance criteria of 95/5; the Bayesian approach is not acceptable.

#### Sampling and Rectification

TVA has opted to use a sampling plan with an acceptance number of  $c = 0$ . A random sample of 60 is chosen and the population is

accepted if no defects are found. This procedure satisfies the acceptance criteria that call for 95 percent confidence that the true fraction defective  $f \leq 0.05$ . In general, for a target fraction defective  $f_0$  and a confidence level of 100  $(1-\alpha)$  percent, the sample size  $n$  must satisfy

$$(1-f_0)^n \leq \alpha \quad (1)$$

Setting  $f_0 = 0.05$  and  $\alpha = 0.05$  yields  $n \geq 58.4$ , so that a sample size of 60 is adequate if the sample has no defects.

In order to avoid rejecting the population outright if the number of defects is greater than zero, TVA proposes to "rectify" the population by performing an extent of condition (EOC) study to remove all records in the population with the same type(s) of defect(s) identified by the sample. They then draw an additional random sample and accept the population if no further defects are found.

This two-stage procedure differs from the initial one-stage procedure in that there are now two chances to accept a population with  $f > 0.05$ . In order to satisfy the acceptance criteria, the sample sizes must be appropriately chosen. Let

$n$  = size of initial random sample

$m$  = size of second random sample if rectification is carried out

$f$  = initial fraction defective

$f-\Delta f$  = fraction defective after rectification

$P_A$  = probability of accepting the population after either the first or second sample

Since the acceptance number for each sample is zero, it follows that

$$P_A = (1-f)^n + [1-(1-f)^n] [1-f+\Delta f]^m \quad (2)$$

Let  $f^*$  be the fraction defective in the population after the two-stage procedure. If the population is accepted after the initial sample,  $f^*=f$ . Otherwise,  $f^*=f-\Delta f$ . The expected value of  $f^*$  is then

$$\begin{aligned} E(f^*) &= f(1-f)^n + (f-\Delta f) [1-(1-f)^n] \\ &= f - \Delta f[1-(1-f)^n] \end{aligned} \quad (3)$$

Since  $f^*$  is a random variable, the acceptance criteria are modified to require that  $E(f^*) \leq 0.05$  with 95 percent confidence.

This means that  $n$  and  $m$  must be chosen so that  $P_A \leq 0.05$  whenever  $E(f^*) = 0.05$ .

From Eq. 3,  $E(f^*) \approx f - \Delta f$ , since  $(1-f)^n \ll 1$ . Hence  $n$  and  $m$  must be chosen so that  $P_A \leq 0.05$  for  $f = \Delta f + .05$ . From Eq. 2,

$$P_A = (.95 - \Delta f)^n + [1 - (.95 - \Delta f)^n] (.95)^m \quad (4)$$

But  $P_A$  is a decreasing function of  $\Delta f$ . Hence  $P_A$  is a maximum when  $\Delta f = 0$ . From Eq. 4,

$$\max P_A = (.95)^n + [1 - (.95)^n] (.95)^m \quad (5)$$

To assure  $P_A \leq 0.05$  for all  $\Delta f$  means that  $n$  and  $m$  must satisfy  $\max P_A \leq 0.05$ . Rearranging terms in Eq. 5 yields

$$[1 - (.95)^n] [1 - (.95)^m] \geq .95 \quad (6)$$

There are many pairs  $(n, m)$  which satisfy Eq. 6. Note that the minimum size for either the first or second sample is 59. One solution is to have  $n = m = \geq 71.7$ . Accordingly, one way to satisfy the acceptance criteria is to set  $n = m = 72$ . These sample sizes are larger than the original sample size of 60 because there are now two chances to accept a population with 0.05 fraction defectives. If  $\Delta f = 0$  for such a population, both the first and second sample of 72 have a probability of acceptance of 0.025 for a total  $P_A = 0.05$ .

The sampling and rectification procedure described above does not require the type of defects which are rectified to be specified in advance. If, however, the defect type is pre-specified, then the required sample sizes can be reduced:

The procedure is as follows.

1. Assume that the possible defects are classified into two types. A Type I defect, once identified in the sample, can be removed from the population by rectification. All other defects are classified as Type II.
2. The Type I defect(s) must be specified in advance of sampling.
3. Draw a random sample of size  $n$ . Accept the population if no defects occur.
4. Reject the population if one or more Type II defects occur.
5. If one or more Type I but no Type II defects occur, remove all Type I defects from the population by rectification.

6. Draw a second random sample equal to the number of Type I defects found in the first sample of  $n$ . Accept the population only if no Type II defects occur.

The protection provided by this procedure is essentially the same as for a single sample of size  $n$  with an acceptance number of zero. Accordingly, using  $n = 60$  with pre-specified rectification will satisfy the acceptance criteria.

Note that it is allowable for several defect types to be classified as Type I, provided they are all specified in advance. However, if any one of the Type I defects occurs in the sample, then all Type I defects must be removed from the population, even those which did not occur in the sample. Strict adherence to this requirement, as well as pre-specification, is essential for this procedure to satisfy the acceptance criteria.

We have shown two ways to satisfy the acceptance criteria if rectification is performed. If the defect types to be rectified are specified in advance of sampling, then an initial sample of 60 will suffice. Otherwise, the first and second sample sizes must satisfy Eq. 6 (e.g.,  $n = m = 72$ ).

It is the staff's position that the sampling and rectification proposed by TVA does not meet the acceptance criteria of 95/5 unless the defect types to be rectified are specified in advance. Otherwise, TVA should revise its procedure.

Principal contributors:

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Jack Spraul

April 10, 1992