September 30, 1980
CRJ/80/151/ETS

Mr. Charles E. MacDonald, Chief
Transportation Certification Branch
Division of Fuel Cycle and Material Safety
United States Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Docket No. 71-6698

Dear Mr. MacDonald:

As we discussed last week, we will appreciate your informal review
and verbal comments on the following draft of language we will propose
to replace paragraph 14 of Docket No. 71-6698, Certificate of Compliance
No. 6698.

"14. Before inactive casks are returned to service and for active casks
at nominal intervals of six (6) months but no later than seven (7)
months following the first shipment of irradiated fuel under Revi-
sion 9 and later revisions to Certificate of Compliance No. 6698,
the licensee shall perform physical measurements of the inner shell
of each cask at comparable locations to those documented in Appen-
dix C to NAC letter dated June 8, 1979. These measurements are to
be compared with the Reference dimensions of each cask as deter-
mined by the average of at least three measurement replications,
without intervening use of the cask, using separate equipment set-
ups for each replication.

The measured values for cavity dimensions shall agree within a
95/95 confidence interval with the Reference dimensions and any
deviations from the Reference dimensions shall be random. Addi-
tional replications of cavity measurements may be made providing
values from each replication are used to compute average dimen-
sions for comparison with Reference dimensions and to verify
randomness of deviations.

To verify that individual measurements differing from the Reference
dimensions are part of the inherent variability of the measuring
system and do not represent localized dimensional changes in the
cavity, a 'chi-squared test' as described in the attached appendix
shall be performed. This shall consist of comparing the frequency
of individual changes in measured values in each of five axial
segments of the cask with the frequency of individual changes in
measured values observed between the sets of measurements used to

establish the Reference dimensions of the cask. The probability quantity p resulting from the chi-squared test shall lie between 0.1 and 0.9. Should the probability quantity p lie outside of this range, the cask shall be removed from service."

Results of the chi-squared test on the measurements in 1979 and 1980 in the D cask cavity are enclosed. The chi-square bounds are taken from the Figure plot of p as a function of chi-square and degrees of freedom.

Sincerely,

NUCLEAR ASSURANCE CORPORATION

Charles R. Johnson
Vice President
Engineering & Transportation Services

CRJ:cnr

Attachment

THE CHI-SQUARED TEST FOR DIMENSIONAL CHANGES
IN CASK CAVITIES

In establishing Reference dimensions of the inner cavities of the NAC-1 casks, at least three (3) replications of measurements as documented in Appendix C to NAC's letter to NRC dated June 8, 1979 shall be made without intervening use of the cask. The purpose of the replications is twofold: first to provide values from which average dimensions can be established and, second, to provide data from which the variance inherent in the measuring system can be determined. A normal distribution of differences between individual measurements at comparable locations should result if there is no change or bias in the measuring system.

Differences in measured values from comparable locations after the cask has seen service will represent a change in the cavity dimensions unless they can be shown to be a part of the same population as that established by the replicated measurements used for the Reference dimensions. Local differences in cavity dimensions might still be masked by a general statistical comparison of measured values. For this reason, the chi-squared test shall be performed over five axial segments of the cask.

The test consists of comparing the distribution of the frequency of occurrence of diametral changes of 0.001 inch that occurred between the three replicated measurements used to establish the Reference dimensions. In equation form, the test is expressed as:

$$\chi^2 = \sum_{i=1}^{n} \frac{[f(x_i, \Delta x) - p(x_i, \Delta x)]^2}{p(x_i, \Delta x)}$$

where χ^2 is the chi-square value

$f(x_i, \Delta x)$ is the number of diametral differences in the range between x_i and $x_i + \Delta x$

$p(x_i, \Delta x)$ is the number of diametral differences in the range between x_i and $x_i + \Delta x$ predicted by the normal distribution representing the differences noted in establishing the Reference dimensions.

n is the number of measurement locations

The acceptance of the results of the chi-square test is based upon the determination of a quantity p which is defined as 'the probability that, on repeating the series of measurements, larger deviations from the expected values would be observed." Reference 1 also states that if p lies between 0.1 and 0.9, "the assumed distribution very probably corresponds to the observed one, while if p is less than 0.02 or greater than 0.98, the assumed distribution is extremely unlikely and is to be questioned seriously."

Figure 2.1 on page 776 of Reference 1 (attached) presents p as a function of χ^2 and F. F is the number of degrees of freedom which in this case is two less than the number of different values of the diametral differences. Thus, the acceptable chi-square must result in a probability between 0.9 and 0.1 for the diametral differences to be considered as measurement error and not real dimensional changes. Satisfaction of this criteria provides confidence that there are no diametral changes which could reflect a change in the cavity configuration.

References

1. Evans, Robley D., The Atomic Nucleus, McGraw-Hill Book Company, Inc., 1955.

2. Parratt, Lyman G., Probability and Experimental Errors in Science, Dover Publications, Inc., 1961.
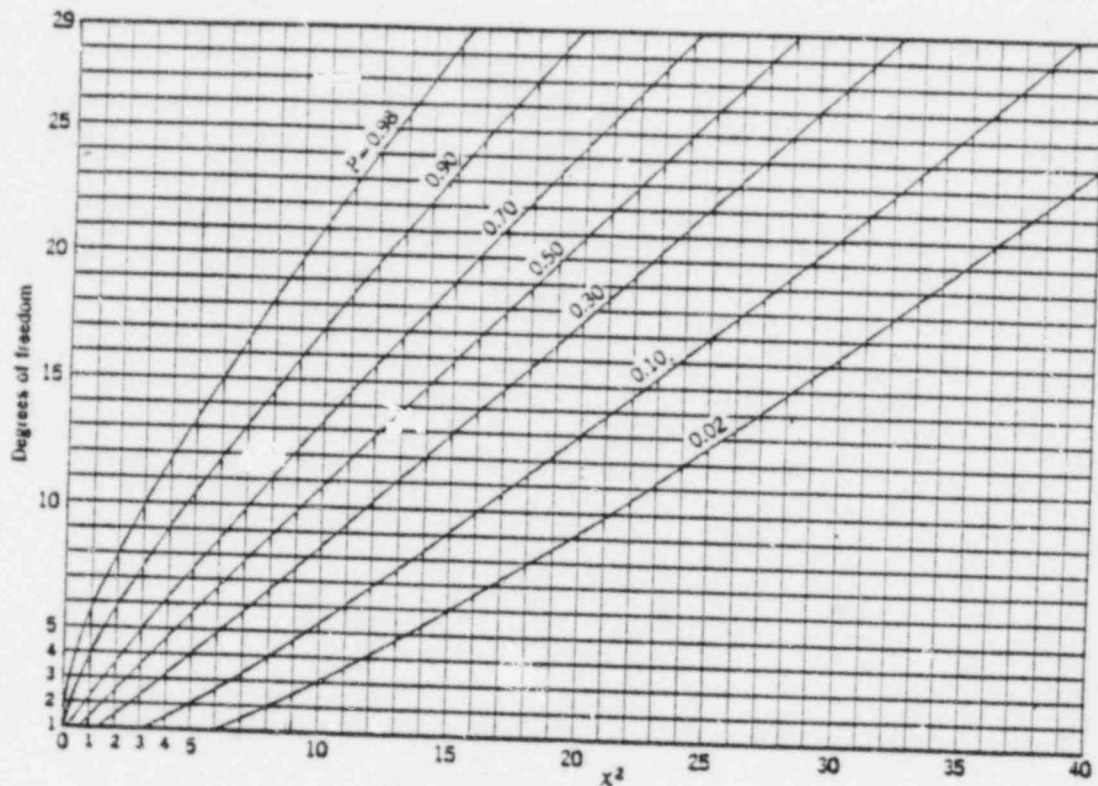
Fig. 2.1   The chi-square test.

CAVITY DIAMETER COMPARISON
FOR 1980AVG AND 1979

CAVITY DIAMETER COMPARISON

AT 4.5 TO 36.5 INCHES

MAXIMUM......................026
MINIMUM....................-.023
CHI-SQUARE............... 59.05
DEGREES OF FREEDOM..........48

CHI-SQUARE BOUNDS...... 36.70
                       60.40

CAVITY DIAMETER COMPARISON

AT 114.5 TO 144.5 INCHES

MAXIMUM......................006
MINIMUM....................-.016
CHI-SQUARE............... 15.61
DEGREES OF FREEDOM..........21

CHI-SQUARE BOUNDS...... 11.00
                       29.88

CAVITY DIAMETER COMPARISON

AT 42.5 TO 70.5 INCHES

MAXIMUM......................006
MINIMUM....................-.014
CHI-SQUARE............... 15.74
DEGREES OF FREEDOM..........20

CHI-SQUARE BOUNDS...... 10.20
                       28.70

CAVITY DIAMETER COMPARISON

AT 150.5 TO 174.5 INCHES

MAXIMUM......................021
MINIMUM....................-.023
CHI-SQUARE............... 51.11
DEGREES OF FREEDOM..........44

CHI-SQUARE BOUNDS...... 32.45
                       55.03

CAVITY DIAMETER COMPARISON

AT 78.5 TO 108.5 INCHES

MAXIMUM......................015
MINIMUM....................-.017
CHI-SQUARE............... 25.45
DEGREES OF FREEDOM..........30

CHI-SQUARE BOUNDS...... 20.55
                       39.97

17575