71-9022

COMBUSTION ENGINEERING

October 18, 1989
LD-89-114

Docket No. 71-9022
Certificate of Compliance No. 9022

Mr. Charles E. MacDonald, Chief
Transportation Branch
Division of Safeguards and Transportation
Office of Nuclear Material Safety
and Safeguards
Attn: Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Subject: CE-250-2 Shipping Container - Response to NRC Questions

Reference: Letter LD-89-064, A. E. Scherer (C-E) to C. E. MacDonald (NRC), dated June 15, 1989

Dear Mr. MacDonald:

In the Reference, Combustion Engineering provided the results of criticality analyses for the CE-250-2 shipping container under hypothetical accident conditions. This letter provides additional information requested by the Nuclear Regulatory Commission regarding assumptions made in performing that analysis.

On August 17, 1989, Ms. Nancy Osgood of your Staff contacted Combustion Engineering to request additional information in connection with your ongoing evaluation of our CE-250-2 shipping container. Ms. Osgood's questions are paraphrased below:

1. Since Combustion Engineering only provided a criticality evaluation for shipment of UO2 powder, should the Nuclear Regulatory Commission conclude that a Certificate of Compliance allowing the shipment of UO2 powder is all that is required?

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NT01

2. As part of the criticality analysis for UO2 powder, Combustion Engineering assumed that one (1) of the four (4) powder cans in the shipping container would be empty. It was not clear to the Nuclear Regulatory Commission that the empty powder can would retain its structural integrity during a 30 foot drop accident and, therefore, continue to provide the spacing function assumed for it. The Nuclear Regulatory Commission requests, therefore, that Combustion Engineering consider replacing the empty powder can with a more structurally rigid spacer.

In response to the first question, the answer is Yes. That is, Combustion Engineering only requires a Certificate of Compliance for the CE-250-2 shipping container which allows the shipment of UO2 powder. Shipment of UO2 pellets, as well as UO2 powder, will be transferred to our UNC-2901 shipping container once Nuclear Regulatory Commission approval is received on our pending Certificate of Compliance amendment request for that container. It remains our intent to discontinue use of the CE-250-2 shipping container once approval of the amended UNC-2901 Certificate of Compliance is received.

As regards the structural integrity of the empty powder can, Combustion Engineering has performed an evaluation of the load necessary to cause crushing. The results of the evaluation indicate that a dynamic load factor of approximately 262 would be required to cause crushing. It is our belief that such a force exceeds what could reasonably be applied to the powder can, within the CE-250-2 shipping container, from a 30 foot axial drop. As such, Combustion Engineering does not believe that replacement of the empty powder can with a more structurally rigid spacer is necessary. The details of our evaluation are contained in the Attachment.

If I can be of further assistance on this matter, please do not hesitate to contact me or Mr. C. M. Molnar of my staff at (203) 285-5205.

Very truly yours,

COMBUSTION ENGINEERING, INC.

A. E. Scherer
Director
Nuclear Licensing

AES:jeb
Attachment: As stated
cc: R. Chappell (NRC)
G. France (NRC - Region III)
D. McCaughey (NRC)
N. Osgood (NRC)
J. Roth (NRC - Region I)

Attachment to
LD-89-114

EVALUATION OF UO_2 POWDER CAN INTEGRITY

OCTOBER, 1989

Evaluation of UO_2 Powder Can Integrity

Introduction

The CE-250-2 Shipping Container is loaded with four powder containers, three full and one empty. These containers are stacked vertically within the inner retaining structure. The order of loading is either full, full, empty, full or full, empty, full, full. In the event of a drop accident, the full containers above the empty container will apply an impact load to the empty container. The criticality analysis for the CE-250-2 Shipping Container assumed that the empty container would remain intact during a postulated hypothetical accident. The possibility that the full containers could crush the empty container will be evaluated here.

Powder Container Data

The powder container material properties, dimensions, and weights are summarized below:

Material	304 Stainless Steel
Wall Thickness	18 Ga = 0.0478 in
Diameter	9.75 in
Cross Sectional Area	1.464 in^2
Height	11 in
Weight of Empty Container	6.5 lbs
Weight of Powder per Container	35 kg = 77.2 lbs

The following values for the yield stress and the modulus of elasticity of 304 Stainless Steel were taken from Reference 1.

These are minimum values over the range of temperatures required for consideration by 10 CFR 71.

$$\sigma y = 30{,}000 \text{ lbs/in}^2$$
$$E = 28.1 \times 10^6 \text{ lbs/in}^2$$

Analysis of Impact Loading

During an axial impact of the CE-250-2 container, the inner retaining structure will hold the powder containers in a stacked position. The load applied by the full containers on the empty container will be a uniform compressive load. The two possible failure modes for the empty container are buckling or crushing due to excessive compressive stress.

Timoshenko (Reference 2) gives the following formula for symmetrical buckling of a cylinder subjected to a uniform compressive loading:

$$\sigma_{CR} = \frac{Eh}{a\sqrt{3(1-v^2)}}$$

where: E = modulus of elasticity
h = wall thickness of cylinder
a = radius of cylinder
v = Poisson's ratio = 0.3

The values for these parameters given above were used to determine the critical buckling stress for the empty powder container. The following value was calculated:

$$\sigma_{CR} = 166{,}755 \text{ lbs/in}^2$$

This value is so large that failure of the container will be caused by the compressive stress exceeding the allowable stress, rather than by buckling.

Although the empty powder container will not crush when the compressive stress reaches the yield stress, the yield stress will conservatively be used as the allowable. An additional conservative factor is not increasing the yield stress to account for the high strain rate with which the load would be applied during impact.

In order for the axial compressive stress in the empty container to reach the yield stress during impact, the following load factor must be achieved:

$$DLF = \frac{\sigma y\ A}{\text{weight of 2 loaded containers}}$$

$$DLF = (30{,}000)(1.476)/(2)(77.2 + 6.5) = 262$$

The load factor which would actually be applied to the powder containers during a 30 foot axial drop has not been determined. However, the inner container is supported by springs and surrounded by vermiculite which effectively provide an energy absorber to cushion the inner container during impact. In addition, the outer container is constructed of 16 gage steel which will deform on impact dissipating a significant quantity of energy.

Reference 3, documents a series of 30 foot drop tests of shipping containers of the CE-250-2 type. In the 30 foot axial drop tests, damage to the outer container was extensive near the point of impact. The inner container, however, only suffered minor deformation. Essentially the shape of the inner container contents was imprinted on the bottom of the inner container. The inner container retained its structural integrity (i.e., did not crush). There was also slight damage to the contents of the inner container in the form of bending of sheetmetal.

It seems clear from Reference 3 that the "g" loading experienced by the contents of the inner container was significantly less than that felt by the outer container and of insufficient magnitude to result in damage of any consequence.

Conclusion

Based on the above evaluation, it has been concluded that the empty powder container will not be crushed during a hypothetical 30 foot drop accident. The material spacing assumed in the criticality analysis, therefore, will not be violated and a more structurally rigid spacer is unnecessary.

References

1. 1986 ASME Pressure Vessel and Piping Code, Appendix I

2. S. Timoshenko, Theory of Elastic Stability, Second Edition, McCraw-Hill Book Company, 1961

3. Advanced Nuclear Fuels Corporation Application for Use of the ANF-250 Shipping Container for Transport of Radioactive Materials, Revision 1, September, 1988.