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Via Regulations.gov

Ms. Brenda Edwards
U.S. Department of Energy
Building Technologies Program
1000 Independence Avenue, S.W.
Mailstop EE-2J
Washington, DC 20585

Re: Comments on *Supplemental Notice of Proposed Rulemaking for Alternative Efficiency Determination Methods and Test Procedures for Walk-In Coolers and Walk-In Freezers*; Docket No. EERE-2011-BT-TP-0024

Dear Ms. Edwards:

On behalf of our client, Bally Refrigerated Boxes, Inc. ("Bally" or "Company"), we are pleased to submit the enclosed comments on the February 20, 2014 supplemental notice of proposed rulemaking for walk-in cooler and walk-in freezer alternative efficiency determination methods and test procedures (79 Fed. Reg. 9818). Bally is committed to meeting the letter and spirit of energy efficiency testing, and appreciates the opportunity to provide comments on this rulemaking. Bally agrees with DOE's proposal to modify the current test procedure for measuring the insulation R-value of walk-in cooler and freezer ("WICF") panels to require that test samples be one inch in thickness and without non-foam facers, protective skins, internal non-foam members, or edge regions.

In this regard, the enclosed test results are being submitted to illustrate real-world testing inconsistencies in the manner in which WICF panels are tested under the *Uniform Test Method for the Measurement of Energy Consumption of Walk-in Coolers and Walk-in Freezers*, set out at 10 C.F.R. Part 431, Subpart R (hereinafter, "test procedure"). As the DOE recognized recently in tests of Bally's panels, testing WICF panels with the panels' steel skin or "facers" left on skews the results, as the samples exhibit significant inhomogeneity and thermal resistance. Under such testing conditions, R-value measurements simply have no correlation to the real world performance of the insulating foam in the panel.

The enclosed data also supports Bally's contention that differences in thickness and geometry also can present challenges to accurately measuring the R-value of a material with low thermal conductivity, such as polyurethane foam. As a result, it has long been standard practice in the WICF panel and polyurethane foam industries to measure the energy efficiency of a

representative, but relatively thin, foam sample (12" x 12" x 1"). In light of these results, Bally supports DOE's proposal that the energy efficiency testing of WICF pour-in-place panels should be conducted on one inch thick samples, with the facers off.

I. WICF Panels Should be Tested Without the Steel Facers

Pursuant to Section 6313(f)(1)(C) of the Energy Policy and Conservation Act ("EPCA"),[1] WICFs must "contain wall, ceiling, and door **insulation** of at least R-25 for coolers and R-32 for freezers." The test rule specifies that "the R value shall be the 1/k factor multiplied by the thickness of the **panel**."[2] In the final WICF test procedure, the Department confirmed that the 1/k factor was intended to apply solely to the foam:

> *In this final rule, **the terms "foam" and "insulation" are used synonymously**, but a panel is the fully manufactured product that contains, but is not limited to, the insulating material, metal skin, framing material, other structural members, or any combination thereof.*[3]

The Department went on to clarify that:

> *…**EPCA states that only the insulation material (that is, the foam) must meet the prescribed R-value**. (42 U.S.C. 6313(f)(1)(C))…For EPCA compliance, the R-value of the insulation must be separately determined in accordance with ASTM C518-04 as specified in EPCA. (42 U.S.C. 6313(f)(1)(C)).*[4]

Read together, the preceding language arguably mandates measuring the energy efficiency of the "foam" or "insulation" to determine the R-value of the WICF "panel."

There appears, however, to have been some confusion within the industry about whether or not to test the energy performance of WICF panel insulation with the facers on because of Section 431.304(b) of the test procedure, which states:

> *Foam produced inside of a panel ("foam-in-place") must be tested in its final foamed state and must not include any structural members or non-foam materials other than the panel's protective skins or facers. A test sample less than or equal to 4 inches thick must be taken from the center of the foam-in-place panels.*

According to the Department:

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[1] 42 U.S.C. §§ 6201-6422 (2012).

[2] 10 C.F.R. § 431.304(b)(1) (emphasis added).

[3] *Energy Conservation Program: Test Procedures for Walk-In Coolers and Walk-In Freezers*, 76 Fed. Reg. 21,580, 21,587 (April 15, 2011) (emphasis added).

[4] *Id.* (emphasis added).

> *DOE does not consider the facers to be "structural members." DOE believes that the measurement of the R-value of the foam with facers should be equal to a measurement of the R-value of the foam without the facers.*[5]

The Department's view of testing with the facers on appears to stem from various industry comments that it was feasible to measure the aging characteristics of foam panels with impermeable facers using ASTM C518.[6] Critically, the test data submitted in support of the comments was for one-inch thick panels with at least one facer removed, and arguably does not resolve the feasibility of testing with the facers on.[7] As you know, it has been Bally's view that metal facers create significant inhomogeneity and thermal resistance in the foam sample. As Section 4.4 of ASTM C518-04 indicates:

> *Special care shall be taken in the measurement procedure for specimens exhibiting appreciable inhomogeneities, anisotropies, rigidity, or especially high or low resistance to heat flow. The use of a heat flow meter apparatus when there are thermal bridges present in the specimen may yield unreliable results.*

Steel and polyurethane foam have significantly different thermal conductivity characteristics. The thermal conductivity for steel is 55 W/m K, while the thermal conductivity for new polyurethane foam (low end of range) is 0.0206 W/m K. This is a relative difference of over 2500:1.

In order to better understand and illustrate this principle, Bally commissioned ASTM C518 tests of its WICF panels by several independent, third-party laboratories that are certified under the National Voluntary Laboratory Accreditation Program ("NVLAP"). As the test reports included at **Appendix A** indicate, however, the test apparatus was unable to reach thermal equilibrium during the test of a four-inch thick foam sample with metal facers, and a validated result could not be obtained. Specifically, the Lasercomp 314 heat flow meter used by the third-party laboratory tracks two heat flow values, Q upper and Q lower. We understand that according to the apparatus manufacturer, if the difference between the two values exceeds five percent, this is an indication that unidirectional flow has not been achieved and the system is unable to reach equilibrium. As the enclosed data indicates, this is precisely what happened in tests of the four-inch panels with metal facers. The laboratory appears to have been unable to obtain any R-value results and had no option other than to abort the tests.[8]

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[5] *Energy Conservation Program: Compliance Date Regarding the Test Procedures for Walk-In Coolers and Freezers and the Certification for Metal Halide Lamp Ballasts and Fixtures*, 76 Fed. Reg. 65,362, 65,364 (October 21, 2011).

[6] *See e.g.*, Docket Number EERE-2008-BT-TP-0014, Docket Document Numbers 0062, 0067, and 0072.

[7] *See* Carpenter Co. Chemical Systems Division, *Thermal Resistance of Aged Walk-in Cooler Panels with Impermeable Facers*, Docket Document Number EERE-2008-BT-TP-0014-0025.

[8] *See* **Appendix A**, 2013092 Raw Data, pp. 1 – 4.

Curiously, DOE tests of Bally's WICF panels with the metal facers were not aborted, even though the Q upper and Q lower values diverged by significantly more than five percent. It is not clear whether the Netzsch HFM436/3/1 ER Heat Flow Meter Thermal Conductivity Instrument used in the DOE tests has a different tolerance, or whether the equipment is able to bypass the equilibrium state to provide results. What was clear to Bally, however, was that the failing R-values reported from the DOE tests, which ranged from 20.06 to 21.72, did not reflect the real world performance of its products. As a result, the Company commissioned additional laboratory testing in an effort to understand and replicate the DOE results for its panels. During this round of tests, Bally also tested the effects of various foam thicknesses, which are discussed in **Section II**.

As the test results enclosed at **Appendix B** indicate, the second laboratory used a different test apparatus, a Lasercomp Fox 300, and was able to measure R-values of 19.4 and 19.8, which are similar to the R-values reported by the DOE for Bally panels with facers. The laboratory noted, however, that tests with the metal facers on are not representative of the foam's thermal performance, because the metal skins caused excessive heat loss to the edges of the specimens. More importantly, the laboratory also tested four-inch samples without the facers. As the enclosed test report indicates, removing the metal facers appears to have provided an approximate 25% increase in the measured R-values of the foam panel.

Table 1: Comparison of Measured R-Values for 4" Walk-In Panels

Test	w/ Facers	w/o Facers	Difference
DOE (Intertek – Appendix C)	20.1	32.3	38%
Bally (NDS – Appendix B)	19.4	25.2	24%
Bally (NDS – Appendix B)	19.8	26.5	25%

As **Table 1** and the data enclosed as **Appendix C** indicate, the Department's retest of a Bally panel confirmed this disparity. The Bally panel (Specimen 4 in the report) initially failed the energy efficiency test with an R-value of 20.1 when tested with the facers on. Upon retest without the metal facers, the foam panel passed with a measured R-value of 32.3. Based on the foregoing, testing with the metal facers clearly results in artificially low thermal resistance values, likely due to the inhomogeneity of the sample and the increased thermal conductivity of the metal facers. What is less clear from the results provided in **Appendix B** is the extent to which foam thickness, multiple samples from the same panel, or variations in test equipment may have had on the test results, as discussed further in **Section II**.

II. Thermal Resistance May Skew Energy Efficiency Testing of Thicker Samples

It has been a longstanding practice in the WICF industry when testing a material such as polyurethane foam, to create a relatively broad, thin sample (12" x 12" x 1") to accurately measure the thermal conductivity or k factor of the foam. This practice is consistent with the intent of ASTM C518-04, as well as the DOE test procedure. Section 431.304(b) of the test procedure requires that the thermal resistance or R-value be calculated as the 1/k factor

multiplied by the thickness of the panel. The regulations also require that test samples be less than or equal to four inches thick, and must be taken from the center of the foam-in-place panels, but do not require measurement of the actual foam thickness. Similarly, ASTM C518-04, § 7.2.2 provides that R-value testing "shall either be of the actual thickness to be applied in use or of sufficient thickness to give a true average representation of the material to be tested." Read in combination with Section 7.6, it seems clear that ASTM C518-04 intends the critical parameter to be the accurate measurement of unidirectional heat flow.

Although the k factor of a material is constant and independent of thickness, *measured* values can change when products have varying thicknesses and geometries. In order to demonstrate this principle, the testing laboratory cut 12" x 12" samples of varying thicknesses. In order to minimize any variations, all samples were cut from the same panel. The test results are enclosed as **Appendix B** and summarized at **Table 2**.

Table 2: Comparison of R-Value Results by Sample Thickness

Sample	Measured Thickness	Density	Thermal Conductivity	Measured R-Value	Target R-Value	Difference
1" Thick Core	0.989	1.93	0.126	7.85	8	0.15
	0.999	1.88	0.125	7.99	8	0.01
2" Thick Core	1.992	1.96	0.126	15.8	16	0.2
	2.012	1.91	0.127	15.8	16	0.2
3" Thick Core	2.977	1.99	0.133	22.4	24	1.6
	2.859	1.89	0.135	21.2	24	2.8
4" Thick Core	3.529	1.93	0.140	25.2	32	6.8
	3.637	2.03	0.137	26.5	32	5.5

Beyond sample thickness, no clear factor stands out to explain the increasing divergence from the target R-value measured for the three- and four-inch samples. The data above suggests that the test apparatus may be experiencing some difficulty in achieving unidirectional heat flow for samples thicker than two inches. It may well be that the larger surface area of the three- and four-inch thick samples results in increased edge loss. We also understand from our client that certain laboratories using the Lasercomp system may be experiencing difficulties calibrating the equipment to handle samples thicker than two inches. This may explain why the DOE laboratory, using the Netzsch system, could obtain passing R-value measurements for the four-inch thick samples without facers, while the other two laboratories could not.

Bally also is unable to explain why the measured R-values for the one- and two-inch samples were below the target R-values of 8 and 16, respectively. Tests on one-inch thick Bally foam panels submitted previously to the Department,[9] as well as the results included in **Appendix B,** were consistently above 8.0. This is the first time Bally has worked with this laboratory, and it is not clear whether the lower R-values are the result of edge loss after cutting multiple samples from the same panel; differences in test apparatus or inter-laboratory

[9] Letter from Michael H. Coyle, President and CEO, Bally Refrigerated Boxes, Inc. to David Case, DOE Office of the General Counsel, May 18, 2012.

variability. Notwithstanding this discrepancy, the Company submits that the tests remain a useful indicator of the macro effects from testing with and without the facers, and the difference in test results for panels that are three and four inches thick.

Based on Bally's experience, although both the Netzsch and Lasercomp systems are available for testing the energy efficiency of foam panels, the Lasercomp appears to be more widely in use. Certainly, Bally is most familiar with the Lasercomp system, and expects others in the WICF industry to have similar experience. In addition, the Netzsch underlying data log is somewhat confusing, making it difficult to correlate the measurements to the results, particularly the equilibrium state. Given the variety of energy efficiency testing equipment available to the industry, and the apparent differences in performance at greater sample thicknesses, Bally submits that there remain issues with consistent testing of samples that are three to four inches thick. Accordingly, Bally agrees with DOE's proposal to reduce the allowable thickness of the sample to no more than one inch, and to require the sample be tested without non-foam facers, protective skins, internal non-foam members, or edge regions.

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Bally appreciates the opportunity to comment on the February 20, 2014 supplemental notice of proposed rulemaking. Please do not hesitate to contact me should you have any other questions or concerns.

Cordially,

Jean-Cyril Walker

cc: Michael H. Coyle, President, Bally Refrigerated Boxes, Inc.