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Impact of Variation in Environmental Conditions on the Thermal Performance of Dry Storage Casks

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General Comment

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Attachments

Comments on the proposed NRC NUREG docket id 2014 0273

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Add= Jorge Solis (JXS6)

The proposed US NRC NUREG; "Impact of Variation in Environmental Conditions on the Thermal Performance of Dry Storage Casks" comment deadline MAY 4th, 11.59 pm Eastern (US)
: http://www.regulations.gov/#!documentDetail;D=NRC-2014-0273-0001 ID: NRC-2014-0273-0001

This proposed NUREG needs to be withdrawn, thrown out, and totally redone because it is important. Currently, it is misleading for it does not live up to its title, nor to its scope. It also points to dangerously flawed environmental assumptions made by the NRC in some of its other rules.

This NUREG calculated max heat load as 34 kW, whereas Holtec, 2014, states that it is 47.05 kW, which is 13.05kW higher, leading to a peak fuel cladding temp approximately 255 F higher than they state. Failure to use the right kW and failure to consider sun makes the NUREG draft calculations of peak fuel cladding temp off by around 355 F or more. False assumptions regarding humidity cause further underestimations of peak fuel cladding temperature.

The only thing which the NUREG extensively evaluates is low level wind, and it doesn't do a proper job of that. The authors (Solis and Zigh) cheat on vent size in their model by pretending that they are all the way across (p. 27) whereas they are not, in reality. This would give some cross ventilation, which is sorely lacking in reality and is needed. The analysis of low level wind on underground casks fails to consider the impacts of ground type, container stacking or sun on the lid. Imagining that these casks will vent much to the air, unless it's cold, without forced ventilation is downright silly.

Holtec has requested exemptions which reduce space for circulation of helium; Holtec has requested packing of broken fuel; and other things which may reduce internal cooling. These impact cooling and temperature and have not been modeled.

Although these metal casks, with metal-concrete covers, remain outside, in direct sunlight, in often blistering environmental condition, the impact of sun is not taken into consideration. The impact of humidity is based on backwards-upside down assumptions. The impact of heat radiating off concrete into the lower vents which are supposed to be cooling does not seem to have been considered.

This NUREG draft assumes maximum kilowatts loaded in Holtec casks as significantly under what Holtec's 2014 document indicates. Holtec gives max decay heat values in kW as 47.05 kW and whereas this NUREG draft atrocity, written by Solis and Zigh, assumes max decay heat values in kW as 34 and 36.9 kW. Furthermore, in more than one location, the Holtec casks have been loaded with broken fuel and/or hotter fuel than allowed and given exemptions. Flimsy thin 1/2 inch Holtec inner casks have no safety margin for either routine material aging nor for accelerated aging due to neutron bombardment, hydrogen attack, internal and external corrosion. Once some of the errors in this NUREG draft are corrected, the temperature may be dangerously close to or exceed the service temperature of new steel, which could lead to a major nuclear disaster. You need to get competent people to work on this. There is no room for error and these are supposed to be professionals, but the NUREG looks like it was written by interns who don't know what in the hell they are doing.

The NUREG draft states that peak cladding temperature (PCT) increases 14.4F for every 10F ambient temperature. It can be estimated that at 80F the added external temperature to Holtec casks, in the sun, would be around 68F, thus the temperature would be like 148 F. The NRC insanely only evaluates for 100 F in the shade, even though this is frequently exceeded throughout most of America. At 100 F the temperature added to the cask from the outside would be at least 168F in the sun, probably higher. Thus the spent fuel would be around 100 F hotter than in the shade (divide 68 by 10 and multiply by 14.4). The US max temp. of 134 F should be used, plus a value added for the sun on the casks near summer solstice. If the number were 68 F (it will surely be higher), then this would be around 202F. Contingency should be added.

Table 4.17 has day 21 peak cladding temperature as 886.7 K. Plus the 143.55 K gives a total of 1030.25 K, which minus 273.15 is 757.1 degrees Celsius [C} and 1394.78 degrees F.
NUREG draft peak temperature day 21 of 886.7 K was 613.55 C or 1136.39 degrees F. This leaves a difference of around 258 F. Solar temperature eats even further into the margin, by perhaps 100 F or more.

The maximum service temperature for 316 steel is around 870 C or 1598 F. Were Holtec and the NUREG considering the hotter high burnup fuel?

Also they state that the PCT increases 14.4 F for every 10 F ambient temp. The max which they seem to have considered was 120 F, and due to faulty assumptions re humidity may be the equivalent of less hot. Based on their 14.4 to 10 formula, 100 more degrees of sun-ambient temperature would actually be equivalent to 144 F or more. The maximum service temperature of even new steel could be easily exceeded. The service temperature will decrease under the influence of neutron and other degradation.

This NUREG calculated max heat load as 34 kW, whereas Holtec, 2014, states that it is 47.05 kW, which is 13.05kW higher, leading to a peak fuel cladding temp approximately 255 F higher than they state. This makes the NUREG calculations off by around 355 F or more, if you add the est. 100 F for the sun. Their false assumptions regarding humidity cause a further underestimation of peak fuel cladding temperature.

Whereas Holtec's 2014 Tables 1.2.2, 1.2.3, 1.2.4, pp. I 51-53, say PWR max total heat load is 47.05 kW (MPC 37; 37 cells); and BWR (MPC 89; 89 cells) is 46.36 kW. (See: "FINAL SAFETY ANALYSIS REPORT ON THE HI-STORM FW MPC STORAGE SYSTEM, Holtec Project 5018 Holtec Report No. HI-2114830 Safety Category: Safety Significant, Revision 2", February 18, 2014 http://pbadupws.nrc.gov/docs/ML1405/ML14052A369.pdf)

This NUREG draft (NRC: Zigh and Solis) (p. 10) states:
Table 4-3 Decay Heat Values for Analyzed Casks Cask Type Decay Heat (kW):
HI-STORM 100 34 kW (Holtec)
HI-STORM 100U 36.9 kW (Holtec)

The only thing which the NUREG evaluates is low level wind, and it doesn't do a proper job of that. They cheat on vent size by pretending that they are all the way across, whereas they are not, in reality. This would give some cross ventilation, which is sorely lacking in reality and is needed. The analysis of low level wind on underground casks fails to consider the impacts of ground type, container stacking or sun on the lid. Imagining that these casks will vent much to the air, unless it's cold, without forced ventilation is downright silly.

The US NRC allows Holtec to assume a temperature of 100 F at Grand Gulf NPS, even though Vicksburg Mississippi, near Grand Gulf, has exceeded 100 F over 100 times in the shade, according to NOAA. In nearby Natchez, Mississippi, the temperature in the sun in 1799 - probably in March - was 120F. This NUREG says that peak cladding temperature (PCT) increases 14.4F for every 10F ambient temperature. Thus, these underestimations matter. Some states can actually be much hotter in the summer.

The Executive Summary says: "using average values may not be adequate, because more adverse ambient conditions could exist for prolonged periods of time, allowing a storage system to reach new steady-state conditions that could result in higher spent fuel cladding temperatures as compared to the steady-state conditions analyzed in the cask's safety analysis report (SAR) for normal conditions of storage. For cases with predicted small thermal margin, these adverse ambient conditions could result in peak cladding temperatures exceeding recommended limits for normal conditions of storage." Not only is there a risk of cladding rupture, but possibly of cask rupture, as they may also exceed the recommended service temperatures for the metal casks. This needs to be taken seriously.

Suspiciously, the NRC, and other nuclear researchers, seem to evaluate casks at the most ideal time of year of not too cold, not too hot, such as visiting casks at Diablo Canyon in California on the 25-26th of December when the sun is at its weakest.

The ambient temperature considered should be the maximum extremes ever at the location, with contingency, and not the average of the maximums, as the NRC uses. The temperature should be of the casks in the sun. However, since the dry casks may be moved, it is probably best to use the US extreme for hot air temperature of 134 F, with the heat of the sun added. The minimum would be minus 70 F.

In the midday sun, the temperature 0.4 centimeters below the soil surface was 71.5°C (160.7°F). The air temperature, measured four feet above the ground, was 42.5°C (108.5°F)." http://earthobservatory.nasa.gov/Features/HottestSpot/page1.php
Note that the above temperature is earth. Pavement or concrete would be hotter. This has not been considered for either the underground cask lids, nor for the lower vents of the above ground casks. 108.5F is not that unusual anymore.

According to NUREG 1536 cited by the current NUREG draft:
"(1) Normal Conditions [...]
The NRC accepts as the maximum and minimum "normal" temperatures the highest and lowest ambient temperatures recorded in each year, averaged over the years of record. For the SAR, the applicant may select any design-basis temperatures as long as the restrictions they impose are acceptable to both the applicant and the NRC." "NUREG-1536 Revision 1Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility Final Report Manuscript Completed: July 2010Date Published: July 2010 Office of Nuclear Material Safety and Safeguards " THIS IS NON-SENSE. THE TEMPERATURE MUST BE THE MAXIMUM EVER IN THE SUN, PLUS CONTINGENCY. IT'S NOT AN ANYTHING GOES AS THIS SAYS. IT'S NOT NEGOTIATING A CAR PRICE, IT'S ABOUT TEMPERATURE AND RISK TO PUBLIC HEALTH AND SAFETY.

THIS CURRENT NUREG ADDS NUTTIER TO NUTTY BY TRYING TO MAKE SOMETHING OF THE AVERAGES WITHIN THE YEAR, WHICH IS AN EVEN LOWER TEMPERATURE. WE NEED TO BE LOOKING AT MAXIMUM TEMPS POSSIBLE, EVER.

The transport rules discussed only consider -29°C (-20°F) and +38°C (+100°F), in the shade, which are not extreme conditions in North America, and are routine temperatures in parts of N. America. The record maximum in the US is 134 F and the record minimum is minus 70.

Here's what the NRC rule "Part 71, Subpart F–Package, Special Form, and LSA-III Tests2 § 71.71 Normal conditions of transport" (discussed by this NUREG draft) says: "...
(b) Initial conditions. With respect to the initial conditions for the tests in this section, the demonstration of compliance with the requirements of this part must be based on the ambient temperature preceding and following the tests remaining constant at that value between -29°C (-20°F) and +38°C (+100°F) which is most unfavorable for the feature under consideration. The initial internal pressure within the containment system must be considered to be the maximum normal operating pressure, unless a lower internal pressure consistent with the ambient temperature considered to precede and follow the tests is more unfavorable.
(c) Conditions and tests.
(1) Heat. An ambient temperature of 38°C (100°F) in still air, and insolation according to the following table:...
2) Cold. An ambient temperature of -40°C (-40°F) in still air and shade".

Transport temperatures are inappropriate, because they are only very short-term. What resists for the very short-term, may not for short, medium or long term. Apparently insulation, in this context, means concrete? What insulator would help keep dry casks cool on concrete or asphalt, without trees, in sunshine and sweltering heat? The dry casks need to put them under an open-sided shed or tent of some type to block the sun. Better, in an air conditioned building with solar panels and maybe back-up windows.

The 1970s are considered to have been exceptionally cold. Yet, the old USNRC Regulatory Guide from 1977 called for shipping casks designed for more extreme temperatures than the current one, even though weather was cooler: "REGULATORY GUIDE 7.8LOAD COMBINATIONS FOR THE STRUCTURAL ANALYSIS OF SHIPPING CASKS, May 1977":
"Regulatory Position C.1.a of this guide mentions environmental initial conditions. The external thermal environmental limits for which a shipping cask must be designed are stated in Appendix A of 10 CFR Part 71 as being 130°F (540 C) in direct sunlight and -40°F (-40'C) in shade." http://rampac.energy.gov/docs/nrcinfo/RegGuide_7-5.pdf NOAA says regarding the 1970s: "Comparing these decades using our best dataset for climate change analysis, the USHCN, we find that the decade of the 2000s was about 1.5°F warmer than the 1970s. For maximum, minimum, and mean temperature the difference, respectively, was 1.37°F, 1.55°F, and 1.46°F." http://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-

datasets/climate-normals/1981-2010-normals-data

Here is one of the most outrageous stupidities from this NUREG draft (p. 3):
"Currently, the dry storage cask thermal evaluation includes maximum and minimum ambient temperatures as defined in the SRP (NUREG-1536, 2010). The SRP states that the NRC accepts, as the maximum and minimum "normal" temperatures, the highest and lowest ambient temperatures recorded in each year, averaged over the years of record. However, this definition does not consider seasonal variations that may result in higher maximum and minimum values. In this case, a monthly averaged value may be more appropriate for the hottest months (summer season)." (This is false. It is unfathomable that a college graduate could come up with such a crazy statement, leading me to question if the authors really have the degrees which they claim. The averages of the maximum of each year, currently used by the NRC, would be the higher than what this proposes. Seasonal averages within one year might be higher, depending on which years are included, but overall the highest in any year will be the highest! The authors need to be fired, stripped of their degrees and sent to cleanup WIPP or Fukushima. The NUREG draft further states: "Measured monthly temperatures at some sites (ASHRAE, 1997) show that the annual average ambient temperature of 300 Kelvin (K) [80 degree (°) Fahrenheit (F)] could be easily exceeded for about 4 months." (This is the understatement of the millennia. Of course it will be exceeded. Firstly it is an average; apparently the mean or arithmetic average. An average will be exceeded, unless every temperature reading is the same. Secondly, because yearly average, the maximum and minimum, is largely irrelevant to the maximum temperature. And the average (high and low) given for June, July, August runs as high as 85 or more, in places with nuclear reactors. But, they should not be using the average, anyway, but rather the maximum temperature ever, plus contingency. Then they must add the impacts of sun and humidity and yes, wind and do it properly. Dew point should be examined for impacts on temperature and corrosion, as well.

In fact, where is discussion of corrosion in this NUREG draft document? It's supposed to be about the environment and thermal performance, and environmentally induced corrosion would have a negative impact on thermal performance.

In the 1950s, the US military came up with a more complex system called the Wet Bulb Globe Temperature. At least this level of complex analysis is needed. Instead the NRC delivers exemptions to Holtec and other stupidities too long to name or even recall.
"The WetBulb Globe Temperature (WBGT) is a measure of the heat stress in direct sunlight, which takes into account: temperature, humidity, wind speed, sun angle and cloud cover (solar radiation). This differs from the heat index, which takes into consideration temperature and humidity and is calculated for shady areas. If you work or exercise in direct sunlight, this is a good element to monitor. Military agencies, OSHA and many nations use the WBGT as a guide to managing workload in direct sunlight." http://www.srh.noaa.gov/tsa/?n=wbgt

The limitations of the WBGT are low air movement and high humidity which are most certainly problems with the dry casks: "WBGT's most serious limitation is that environments at a given level of the index are more stressful when the evaporation of sweat is restricted (by high humidity or low air movement) than when evaporation is free". "J Sci Med Sport. 2008 Jan;11(1):20-32. "Wet-bulb globe temperature (WBGT)–its history and its limitations." Budd GM. http://www.ncbi.nlm.nih.gov/pubmed/17765661

For dry casks this low air movement and high humidity would have a negative impact on heat removal, but also cause material sweating, corrosion, and degradation. Many, or even most, of the nuclear reactors are close enough to the ocean to have chloride induced corrosion-degradation issues too. Mold induced degradation is probably an issue at the sites, especially as mold is highly radiation resistant. Where in this NUREG is discussion of the impact (and causes) of degradation on structural-mechanical integrity of multi-purpose canisters and the overpack? Neutron embrittlement; possible hydrogen attack; corrosion, exacerbated by salt in the air, even some distance inland, will all impact the strength and integrity of the dry casks, over time. For these dry casks there would also be the issue of dampness, fog, condensate from high humidity levels and their impacts on corrosion and even mold. Mold could damage concrete and is radiation resistant. Dew Point seems important in this context.

According to the draft NUREG: "An ambient temperature of 300 K (80°F) is typically considered in the thermal evaluation for most of the dry casks certified by the NRC." THIS IS RIDICULOUS. YOU KNOW THIS IS FALSE. WHY ARE YOU TRYING TO KILL EVERYONE AND EVERYTHING?

Your NUREG draft states: "However, the measured ambient temperatures suggest that, to bound all sites, the SAR thermal evaluation should consider seasonal variations since, during the hot months, the dry cask reaches a new steady state that the SAR has not analyzed." While it may be true that the steady state has not been analyzed, the annual maximum temps is better and the maximum ever is better still and maximum ever in the USA with contingency and including sun is best. They state that "This study considered variations in the ambient temperature in the range of 300 to 322 K (80 to 120°F), which seems to envelope the natural variation of the ambient temperature during the hot season, according to measured data."

Furthermore, Solis-Zigh-NRC NUREG excludes the temperature impact of sun on metal, which as has been seen exceeds this amount. They excluded the full heat load. They put the humidity impacts upside down. And, they don't seem to have considered this except for low speed wind. This low speed wind issue seems to be a false debate. Put solar powered exhaust fans and open sided sheds to cover the casks from the sun or solar powered air conditioned sheds, would be better. Roof Vent Turbines would be a huge improvement over nothing, though may still be inadequate in some climates: http://wiki.smc.org.in/index.php?title=Roof_Vent_Turbines,_is_it_affordable_?]
NRC NEEDS TO GET OUT OF THE AIR CONDITIONING AND EXPERIENCE REAL WEATHER!

Solis-Zigh-NRC NUREG state:
"2.3 Humidity
Traditionally, the thermal evaluation for design certification assumes dry air, which is conservative, since humidity will increase the air thermal conductivity and heat capacity." (p. 3)
(Conservative? Conservative is less safe now? Whose stupid "tradition" is this? If humidity makes it hold more heat then it is important! The humidity decreases thermal conductivity but has heat capacity - it is already full of heat, which is why it is vapor!)
They continue: "Therefore, this study considers relative humidity in the range of 0 to 90 percent for ambient temperatures of 300 and 323 K (80 and 120°F)." (Where is 100% humidity? Sun impact? Plus they are only concerned with wind) They say: "However, high relative humidity values do not seem to persist for the prolonged periods of time necessary for the dry cask to reach a new steady state." (SOLIS-ZIGH-NRC ARE STARK RAVING MAD! IT IS HOT AND HIGHLY HUMID (often 100%) FOR MANY OF THESE SITES. They are on water and often in swampland and sub-tropical climates). "Therefore, this study assumes that dry air will continue to be an adequate approach, a slightly conservative assumption, as demonstrated in this evaluation." (p. 3) This means that their result could be right simply because they did it backwards. It is humid; they assume dry; they falsely assume that humidity is cooling rather than blocking cooling; they apparently believer that dry is hotter. So, by getting everything backwards that might be right. However, they have to put it going the right direction! It is humid and the humidity inhibits cooling.

The most silly assumption of all is that cool air will enter the vents at the bottom of the casks, when the casks are sitting on concrete or asphalt, uncovered. Where was the consideration of this point? Heat from the concrete-asphalt will radiate up, especially after sunset and as ambient temperature drops. While this will probably be cooler than the spent fuel, it won't be very cool. Plus, any serious ventilation needs to be cross ventilation. Common sense suggests a solar powered fan, as well.

Zigh and Solis, authors of this NUREG draft, cheat in their model: "The four vents in the bottom and top of the cask, respectively, were represented by one continuous inlet at the bottom and one continuous outlet at the top." (p. 27) They can't change the venting system like that in the model, without changing it in reality! Obviously this will increase air flow. A continuous inlet will let in more air! As we noted yesterday, the fuel temperature modeled is not the same as the newer Holtec specifications, either, but is much less.

A most important point remains that heat diffuses toward a new equilibrium and if it is hot outside, the spent fuel won't cool very much. "Heat transfer always occurs from a region of high temperature to another region of lower temperature." http://en.wikipedia.org/wiki/Heat_transfer

"As the second law of thermodynamics shows, in an isolated system internal portions at different temperatures will tend to adjust to a single uniform temperature and thus produce equilibrium." http://en.wikipedia.org/wiki/Entropy#Energy_dispersal
Ventilation or a fan could speed up air exchange and the fan cool the air to some extent, but there won't be much cooling in hot weather, period.

From the NUREG draft:
"3.0 GEOMETRY AND METHOD OF ANALYSIS
3.1 Vertical Aboveground Designs

In a vertical-ventilated aboveground spent fuel storage cask design, a spent fuel canister is typically stored in a concrete overpack, with the canister bottom resting on some type of base normal to the ground. Air vents are located in the bottom and top of the overpack, so air can flow freely through the gap between the canister and the overpack to cool the canister's outer surface, thus keeping the cladding temperature below Standard Review Plan (SRP)-recommended limits (NUREG-1536, 2010). Since the inlet and outlet air vents are separated by the cask's height, thermal mixing due to low-speed wind may not have an impact on the cask's thermal performance because of the physical separation of the air vents. This separation will prevent hot air coming from the outlet vents to mix with the cooler air at the bottom of the cask. Also, hot air coming out of the outlet vents will tend to flow up into the ambient air surrounding the cask. However, low-speed wind could block the air vents, which could have an impact on the cooling effect by reducing the mass flow rate through the annular gap. Therefore, this study includes this cask to determine the effect of other environmental factors and to conclusively determine how low-speed wind affects this design." (p.5) WHAT COOLER AIR? IT'S ON CONCRETE IN THE SUN!

Where is consideration of underground temperature? There won't be much cooling in hot weather by venting out the top!
"3.2 Vertical Underground Designs

In an underground design, the canister is stored inside some type of enclosure that is buried almost entirely, except for the overpack lid, which is located aboveground and includes the air vents. In this design, air needs to flow downwards into the enclosure container and then upwards in contact with the canister's outer shell. Decay heat from the spent fuel assemblies stored in the canister is thus dissipated through the canister's outer wall by a combination of convection, radiation, and conduction to flowing air. Finally, hot air exits through the outlet vent, which is located on top of the cask lid. For this design, the inlet and outlet vents are located in proximity to each other. These design features represent a challenge from the analysis point of view since, in addition to the typical environmental factors used in the thermal evaluation (e.g., ambient temperature, ambient pressure), the analysis must include other factors such as low wind speed. This increases both the complexity and the computational times, since usually three-dimensional (3-D) thermal models are needed to properly capture the heat transfer and flow characteristics of this design." (p.5)

"Heat transfer always occurs from a region of high temperature to another region of lower temperature". http://en.wikipedia.org/wiki/Heat_transfer
"As the second law of thermodynamics shows, in an isolated system internal portions at different temperatures will tend to adjust to a single uniform temperature and thus produce equilibrium." http://en.wikipedia.org/wiki/Entropy#Energy_dispersal
"the [thermal] conductivity of water vapour is actually much less than that of dry air. So, if humidity (i.e. water vapour) has any effect on the conductivity of air, it would make it less conductive, not more." http://www.weather.gov.hk/education/edu06nature/ele_air_e.htm
"steam does not transfer heat as well as liquid water,..." http://en.wikipedia.org/wiki/Boiling_water_reactor

Thus Solis-Zigh NUREG assumptions regarding humidity effects are false, as common sense also tells us. On p. 35, the falsely state that "water vapor has larger thermal conductivity" As just seen above, water vapor has less thermal conductivity. Then they say "and heat capacity than dry air, more heat is absorbed from the cask by humid air." Yes it has more heat capacity but it's already full of the heat! Thus they mix true and false in one sentence.

Solis-Zigh NUREG started off the sentence stating the obvious that "As the humidity increases, the ambient air contains more water vapor." (p. 35) And, while yes the water vapor has more heat capacity, it is already holding that heat-energy, which is why it is in vapor form. This is why it takes energy input to boil water. And, this, in fact, is what nuclear reactors are - deadly ways to get energy input to make water vapor!

By inverting their humidity assumptions, they have underestimated temperature to unknown degrees. Due to their faulty assumptions their worse case scenario might be worse than what they have presented: "As such, the PCT will decrease as the relative humidity is increased for both ambient temperatures considered in this study." [NOT!] "At an ambient temperature of 300 K (80°F), the PCT decreased by 0.6 K (1°F) for every 20 percent increase in the relative humidity (in the 50 to 90 percent range)." Since this was calculated upside down the opposite is probably true, meaning that at 80F and 100% humidity, would be about 3 degrees F higher.
They state that "At an ambient temperature of 323 K (120°F), the PCT decreased by 2.2 K (4°F) for every 20-percent increase in relative humidity (in the 50 to 90 percent range)." At higher temperatures the upside down nature of their assumptions becomes even more problematic. Though it is unlikely that there would be both 120F and 90% humidity for ambient air, due to the sun and absorption of heat by the concrete-metal, it could be even higher: "The rate of decrease in the predicted PCT is higher for the ambient temperature 323 K (120°F) case than for the ambient temperature 300 K (80°F) case because of the higher moisture content change for every 20 percent change in relative humidity in the latter, as shown in Tables 4-24 and 4-25". THIS GOES AGAINST COMMON SENSE PLUS THERMODYNAMICS. It should read "The rate of increase". They need to reevaluate all for both assumptions and kW inputs.

They should not be doing this in Kelvin, either.
[Temperature intervals: 22 Kelvin [K] is 22 Celsius [C} is 39.6 Fahrenheit [F] http://en.wikipedia.org/wiki/Kelvin%5D