August 4, 2009

MEMORANDUM TO: AFPB File

FROM: Alexander R. Klein, Chief ***/RA/***
Fire Protection Branch
Division of Risk Assessment
Office of Nuclear Reactor Regulation

SUBJECT: CLOSURE OF NATIONAL FIRE PROTECTION ASSOCIATION 805 FREQUENTLY ASKED QUESTION 08-0052 TRANSIENT FIRES - GROWTH RATES AND CONTROL ROOM NON-SUPPRESSION

The purpose of this memorandum is to close National Fire Protection Association (NFPA) Standard 805 Frequently Asked Question (FAQ) 08-0052. The enclosed position was previously sent for comment under the joint U. S. Nuclear Regulatory Commission's (NRC) Office of Nuclear Regulatory Research (RES) / Electric Power Research Institute (EPRI) Memorandum of Understanding (MOU) process. RES and the NRC's Office of Nuclear Reactor Regulation (NRR) collaborated on resolving the comments that were received from the MOU. It was later sent to the Nuclear Energy Institute's (NEI) NFPA 805 Task Force for industry and other stakeholder comment. No comments were received from the NEI Task Force. The enclosed position represents a joint resolution of this FAQ between RES and NRR.

Enclosure:
As Stated

CONTACT: Naeem Iqbal, NRR/DRA
Naeem.Iqbal@nrc.gov
(301) 415-3346

Charles Moulton, NRR/DRA
Charles.Moulton@nrc.gov
(301) 415-2751

MEMORANDUM TO: AFPB File

FROM: Alexander R. Klein, Chief
Fire Protection Branch
Division of Risk Assessment
Office of Nuclear Reactor Regulation

SUBJECT: CLOSURE OF NATIONAL FIRE PROTECTION ASSOCIATION 805 FREQUENTLY ASKED QUESTION 08-0052 TRANSIENT FIRES - GROWTH RATES AND CONTROL ROOM NON-SUPPRESSION

The purpose of this memorandum is to close National Fire Protection Association (NFPA) Standard 805 Frequently Asked Question (FAQ) 08-0052. The enclosed position was previously sent for comment under the joint U. S. Nuclear Regulatory Commission's (NRC) Office of Nuclear Regulatory Research (RES) / Electric Power Research Institute (EPRI) Memorandum of Understanding (MOU) process. RES and the NRC's Office of Nuclear Reactor Regulation (NRR) collaborated on resolving the comments that were received from the MOU. It was later sent to the Nuclear Energy Institute's (NEI) NFPA 805 Task Force for industry and other stakeholder comment. No comments were received from the NEI Task Force. The enclosed position represents a joint resolution of this FAQ between RES and NRR.

Enclosure:
As Stated

CONTACT: Naeem Iqbal, NRR/DRA
Naeem.Iqbal@nrc.gov
(301) 415-3346

Charles Moulton, NRR/DRA
Charles.Moulton@nrc.gov
(301) 415-2751

DISTRIBUTION:

DRA r/f	AKlein	HBarrett	PLain	SWeerakkody	CMoulton	RGallucci
JHyslop	DHarrison	MSalley	NSiu	MCunningham	GParry	NIqbal

ADAMS Accession No.: ML092120501

OFFICE	NRR/DRA/AFPB	NRR/DRA/AFPB	RES/DRA/FRB	NRR/DRA/APLA
NAME	NIqbal	AKlein	MSalley	DHarrison
DATE	08/ 03 /09	08/ 04 /09	08/ 03 /09	08/ 04 /09

OFFICIAL RECORD COPY

FAQ 08-0052: Transient Fires - Growth Rates and Control Room Non-Suppression

Guidance on the Use of Non-suppression Curves for Transient Fires in the Main Control Room and on Transient Fire Growth Rates, as per NUREG/CR-6850

Background:

Frequently Asked Question 9FAQ0 08-0052 was proposed by the Nuclear Energy Institute, through its National Fire Protection Association (NFPA) 805 Task Force, to clarify the guidance from Nuclear Energy Institute's (NEI) 04-02, "Guidance for Implementing a Risk-Informed, Performance-Based Fire Protection Program under Title 10 of the *Code of Federal Regulations* Part 50 (10 CFR 50).48(c)," which in turn cited guidance on the treatment of transient fuel fires provided in NUREG/CR-6850 (EPRI 1011989), "EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities." The guidance was not explicit in two regards. First, the guidance does not explicitly state which of the available manual fire suppression reliability curves (the non-suppression probability curves) should be applied to the case of transient fires in the main control room; the choices being the transient fire curve or the main control room (MCR) curve. Second, the guidance discusses fire modeling assumptions related to time-dependent fire growth profiles in general terms and in the specific case of electrical cabinet fires, but it does not discuss fire growth times for trash fires, one of the most commonly postulated transient combustible fires. The purpose of this FAQ is to clarify and update guidance provided in NUREG/CR-6850, Appendices G and P, for the treatment of transient fires in terms of both manual suppression and time-dependent fire growth modeling.

The NRC developed the interim position discussed below in order to achieve closure of this FAQ in a timely manner. This interim position was developed using currently existing information, databases, and experimental results, and should not be seen as prejudicing the NRC's view of future developments in this area. Final endorsement of this position will be addressed through the next revision of either Regulatory Guide 1.205 or NUREG/CR-6850.

Discussion:

Part 1: Non-suppression curves for transient fires in the MCR:

NUREG/CR-6850, Appendix P, provides fire non-suppression curves that characterize manual fire fighting effectiveness as a function of elapsed time since fire detection. Separate curves are provided for transient fires and for MCR fires. The guidance does not explicitly state which of these two fire non-suppression curves should be applied to the case of a transient fire in the MCR. The recommended practice is that all fires occurring in the MCR, including transient fires, should be treated using the MCR fire non-suppression curve.

This recommended guidance reflects (1) that application of the general transient fire non-suppression curve would not be accurate because the MCR is continuously occupied; (2) that in developing the non-suppression curves, the MCR curve included all reported MCR fires regardless of the fire source; and (3) the intent of the original authors of the RES/EPRI consensus methodology.

Part 2: Transient fire growth rates/times

NUREG/CR-6850, Appendix G, discusses in general terms the treatment of fires using a time-dependent fire growth profile. Specific fire growth time (i.e., time from ignition to peak fire heat release rate) recommendations are made for electrical cabinet fires. The guidance does not, however, address estimating the fire growth rate/time of transient fires.

The original intent of the authors of the RES/EPRI consensus method was that the use of a time-dependent fire growth profile is appropriate for any fire modeling case where a basis for such a profile can be established. It was not intended that this treatment be limited to cabinet fires. Hence, use of a time-dependent fire growth profile for transient fires, given adequate basis for the assumed growth time, is both appropriate and consistent with the intent of the original guidance.

Transient fires represent a wide range of potential fire sources from liquid fuels (e.g., solvents) to solid fuels of various sizes, types and configurations. It would be inappropriate to assume a single fire growth time for all transient fire sources. Rather, the fire growth time should reflect the nature of the transient fuel package that is assumed present in the fire scenario. Recommendations for appropriate fire growth times for three specific and common transient fire sources are detailed below. The following recommended fire growth times are the times from fire ignition to peak fire heat release rate. The fire growth profile is assumed to follow the classic “t-squared” curve as discussed in Appendix G. The three case recommendations are as follows:

- Common trash cans (i.e., plastic or metal receptacles up to 33 gallons in size intended for temporary trash collection) that contain routine types of refuse (paper, plastics, and other solid materials) may be assumed to grow from zero to peak heat release rate in 8 minutes. This guidance is based largely on two experimental programs that have tested transient fuel packages of this type. The details are provided in Attachment A.

- Common types of plant trash (paper, plastics, and other solid materials) that are contained in plastic trash bags but that are <u>not</u> contained within a plastic or metal receptacle may be assumed to grow from zero to peak heat release rate in 2 minutes. This guidance is based largely on one experimental program that has tested transient fuel packages of this type. The details are provided in Attachment B.

- Transients associated with spilled solvents or other combustible or flammable liquid fuels should be assumed to reach peak intensity immediately upon ignition. This guidance is the most conservative possible approach but also reflects the fact that fires associated with a spill of a liquid fuel would, in fact, grow to peak intensity in a very short period of time.

It may be appropriate to assume a fire growth period for other types of transient fuels and, as noted above, it is the intent of the original guidance to allow for use of a time-dependent fire growth profile wherever appropriate. If a time-dependent fire growth profile is assumed for other types of transient fuel packages (e.g., packing material, boxes, wooden pallets, etc.) then the analyst should provide a basis for the assumed growth behavior that includes consideration of applicable fire test data and reflects the nature of the transient fuel package being considered.

References:

1. Revision 0 to FAQ 08-0052, May 13, 2008, Accession No. ML081500500

2. NEI 04-02, Guidance for Implementing a Risk-Informed, Performance-Based Fire Protection Program Under 10 CFR 50.48(c), Revision 1, Accession No. ML052590476

3. NFPA 805, Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants, 2001 Edition (available through the Public Document Room or NFPA)

4. Regulatory Guide 1.205, Risk-Informed, Performance-Based Fire Protection for Existing Light-Water Nuclear Power Plants, Accession No. ML061100174

5. NRC Regulatory Information Summary 2007-19, Process for Communicating Clarifications of Staff Positions Provided in Regulatory Guide 1.205 Concerning Issues Identified During The Pilot Application of National Fire Protection Association Standard 805, Accession No. ML071590227

6. NUREG/CR-6850 (EPRI 1011989), Accession Nos. ML050940183 (Vol. 1) and ML050940189 (Vol. 2)

FAQ 08-0052, Attachment A: Summary of Experimental Insights for Trash Fires

There have been at least three studies that have experimentally evaluated fires involving trash receptacles (trash cans). The guidance in this FAQ resolution relies primarily on two of these three studies, the third being discounted as non-representative to nuclear plant (NPP) applications.

The first study was conducted at the University of California, Berkley, Lawrence-Berkley Laboratory (LBL) [A-1]. This report describes a series of fire tests involving unconfined bags of trash and trash in commercial plastic trash receptacles. The difficulty with this particular test set lies in the nature of the “trash” used. The plastic bags were filled with either “eucalyptus duff,” which is to say, leaves and twigs gathered from under local eucalyptus trees, or with polystyrene cups, paper cups, and “fluffed up paper towels”. The trash cans were filled using empty pint-size wax/paper milk cartons obtained from the campus cafeteria. Many of the milk cartons were opened at both ends and then stacked in several layers filling the receptacle. The open ends of the carton were placed facing up/down. These open cartons were then loosely filled with shredded pieces from additional milk cartons.

These fuel packages are clearly not typical of the types of general refuse one might expect to find in a NPP. They had a clear tendency to maximize both fire growth rates and peak fire intensity given both the rather flammable nature of the fuels and the fact that the fuel configuration maximized the fuel surface area. As a result, great care should be exercised when applying these tests to NPP situations. In the case of the trash can fires, two other quality data sets of more direct relevance are available, so the LBL tests are discounted as non-representative of NPP applications.

The second study was performed as a part of the early the Nuclear Regulatory Commission (NRC) Fire Protection Research Program and involved a series of tests designed to characterize a range of transient fuel fire source packages that might be found, in particular, in the control room of a NPP [A-2]. This included testing of both large (30 gallon) and small (typical office-size) plastic trash receptacles filled with crumpled paper. The results of particular interest are those for fuel package 4 (tests 7 and 8) and fuel package 5 (test 9). The most relevant results for these tests are re-produced in Figures A-1 through A-3 which illustrate the heat release rate profiles for tests 7-9.

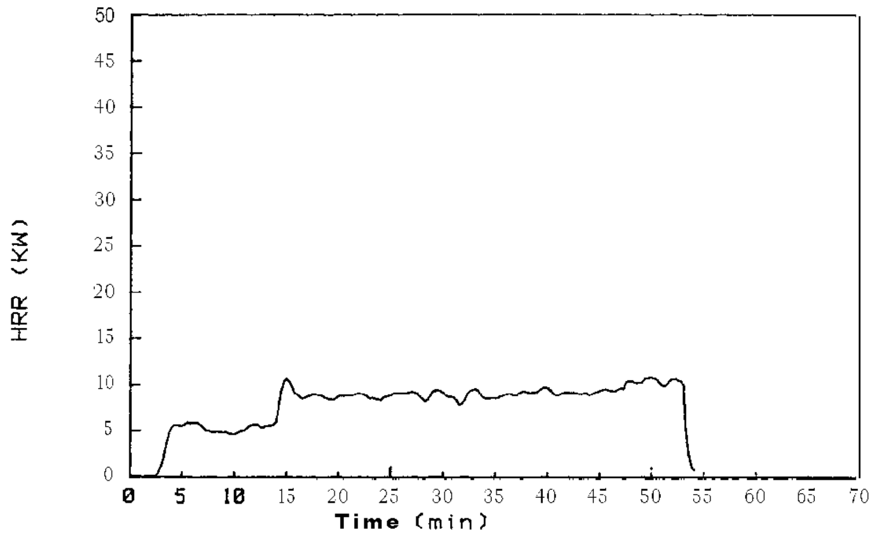

Figure A-1: Heat release rate for NUREG/CR-4680 test 7, small trash can fire.

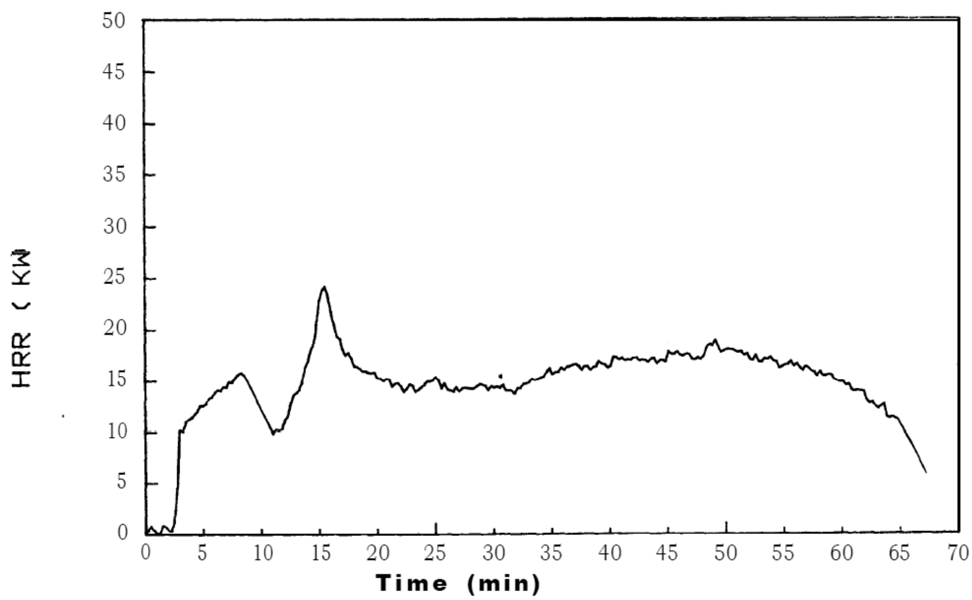

Figure A-2: Heat release rate for NUREG/CR-4680 test 8, small trash can fire.

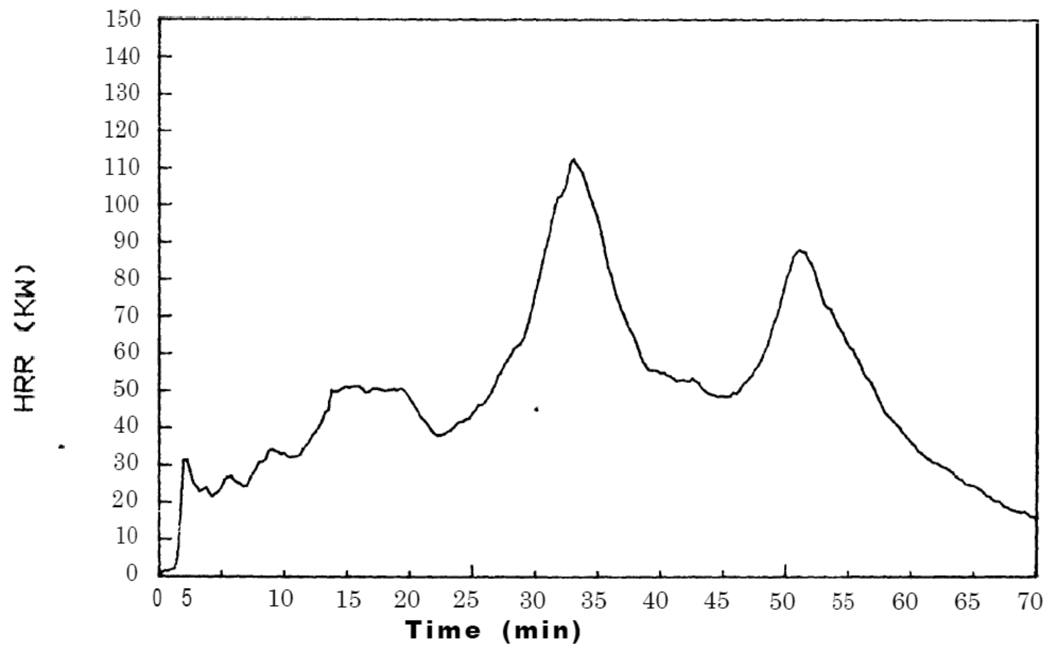

Figure A-3: Heat release rate for NUREG/CR-4680 test 9, large trash can fire.

Fire intensity in all three tests follows a similar general trend with respect to the HRR profile. In the case of test 7, the trend is observable but generally less pronounced because this fire remained at a relatively low intensity throughout. The behaviors of primary interest are those trends that occur on a time scale of minutes rather than the shorter-term variability that occurs on a time scale of seconds or 10's of seconds. Note that in each case, the fires show a rapid rise in fire intensity over the first 2-4 minutes reflecting fire spread across the top surface of the paper filling the trash can. The general trend of increasing fire intensity continues as the fire spreads deeper into the crumpled paper filling the trash can. This continuation of the initial growth stage lasts for several additional minutes (up to 7-15 minutes) at which time an initial peak in fire intensity is observed. After this initial peak intensity is reached, the fires subside somewhat. During this subsidence period the trash can itself was observed to begin melting and to collapse in upon itself. Once the trash container itself ignites, fire intensity grows relatively quickly reaching a second higher peak after 15-33 minutes. Overall, the behaviors of primary interest in each of the three tests are the initial peak reached in 7-15 minutes and the second larger peak reached in 15-33 minutes. In interpreting these test results, weight is given primarily to the observed time to reach the initial peak in fire intensity, which for these three tests were 7, 8 and 13 minutes respectively.

The third study of interest [A-3] was performed at NIST and involved two experiments "conducted to help characterize the potential hazard from ignition of nominal 136 L (30 gal) trash containers made from high density polyethylene (HDPE) and loaded with cellulosic debris." The trash containers tested are illustrated in Figure A-4, and are quite similar to fuel package 5 as tested in NUREG/CR-4680 with the exception of the trash loading.

Figure A-4: Photograph of the trash receptacle tested in NISTFR-4018.

In the case of the NIST tests “each trash container had 10 kg (22 lbs) of debris ’typical’ of a construction site. The debris consisted of cut pieces of 2" X 4" lumber, sawdust, cardboard, paper, and cups, food wrappers and paper bags from a fast food restaurant.” Again, the results of direct interest to this FAQ are the heat release rates. These results are reproduced in Figure A-5.

The NIST tests show a somewhat similar behavior to the SNL tests in terms of the initial fire growth. The first of the NIST tests (trash container 1) actually shows a steady climb in fire heat release throughout the test; the fire had not yet reached a true peak when it was suppressed at about 800 seconds (about 13 minutes). For the second test (trash container 2) a peak heat release rate is observed about 550 seconds (about 9 minutes) followed by a period of relatively steady burning at a somewhat reduced intensity.

Overall, the five available tests indicate fire growth times that range from about 7 to 13 minutes. Based on these test results, the recommended practice for this type of fuel source, general refuse in a plastic trash receptacle, is to assume a fire growth time of 8 minutes.

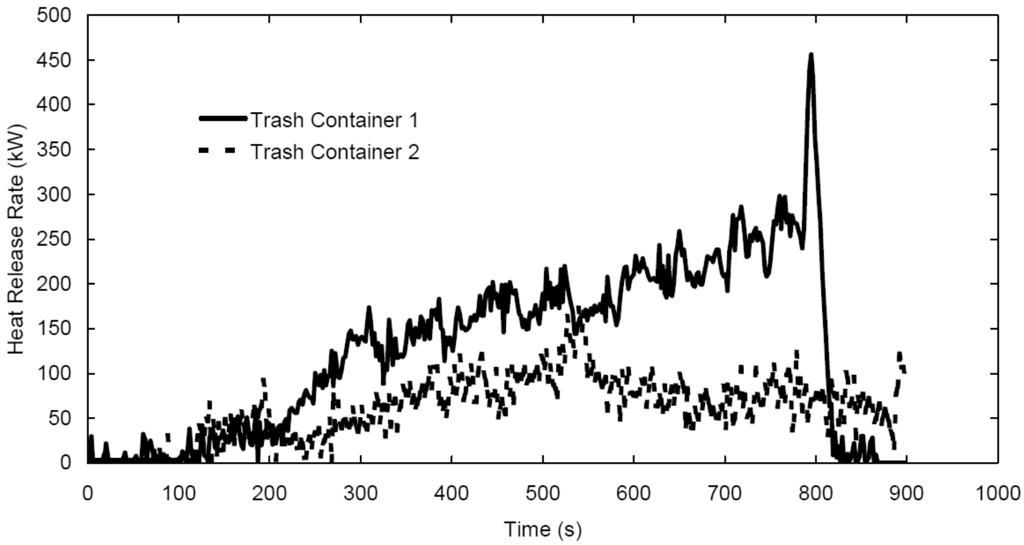

Figure A-5: Heat release rate test results for the two tests documented in NISTFR-4018.

It is also recommended that the same result be extrapolated to fires involving general refuse in a metal trash receptacle of similar size. This is because both of the cited studies noted that the initial fire growth behavior is actually associated with fire spread through the refuse and that the plastic trash receptacle became involved in the fire at a somewhat later time (i.e., after 8 or more minutes). Hence, similar initial growth behavior is likely to apply to metal trash receptacles, even though neither of the cited studies actually tested this type of receptacle.

It should be noted that a final study of potential interest is a National Bureau of Standards (NBS, now NIST) literature review completed in 1985 [A-4]. This review did not involve the conduct of any new tests, but did consider the results of prior test programs including both the LBL and SNL tests cited here. There is one figure in particular presented in this report that is worthy of some discussion; namely, Figure 11. This is a recommended heat release rate versus time profile that was developed to bound all of the observed trash fire curves. This particular figure shows an initial growth to peak of one minute. This initial growth rate is dominated by other types of trash fires and is not characteristic of the trash can fires. Hence, the application of this curve to a trash receptacle (trash can) fire would be conservative in comparison to the recommended practice developed here.

<u>References:</u>

A-1: Von Volkenburg, D. R., et al, “Towards a Standard Ignition Source,” Lawrence Berkeley Laboratory, LBL-8306, October 1978.

A-2: S. P. Nowlen, **Heat and Mass Release for Some Transient Fuel Source Fires: A Test Report**, NUREG/CR-4680, SAND86-0312, Sandia National Laboratories (SNL), October 1986.

A-3: D.W. Stroup and D. Madrzykowski, **Heat Release Rate Tests of Plastic Trash Container**, National Institute of Standards and Technology (NIST) , NISTFR-4018, April 24, 2003.

A-4: B.T. Lee, **Heat Release Rate Characteristics of Some Combustible Fuel Sources in Nuclear Power Plants**, National Bureau of Standards (NBS), NBSIR 85-3195, July 1985.

FAQ 08-0052, Attachment B: Summary of Experimental Insights for Trash Bag Fires

This attachment provides insights relative to the fire growth characteristics of trash bag fires as unique from the behavior of a fire involving trash confined to a trash receptacle (a trash can fire). The available tests potentially relevant to trash bag fires are documented in two reports [B-1, B-2].

The first report is the Lawrence Berkley Laboratory (LBL) report cited and discussed in Appendix A of this FAQ. The difficulties associated with the fuel loading in these tests have been described in Appendix A. Given the atypical nature of the fuel loading, care must be exercised in extrapolating these results to a more representative nuclear power plant (NPP) transient fuel load. Given that this is the only known study to report results for an actual trash bag fire, the results will be considered. The trash bag test results from the LBL study are summarized in Figures B-1 and B-2.

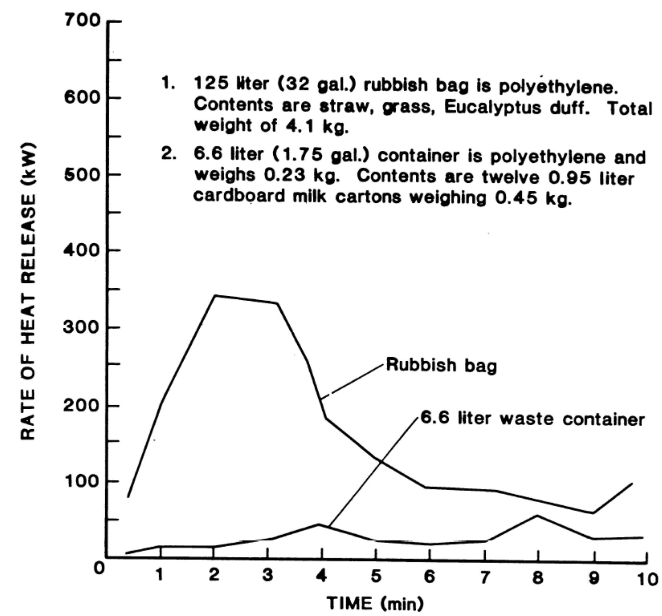

Figure B-1: Results of the LBL tests involving a trash bag filled with eucalyptus duff.

Figure B-1 compares the results of the first trash bag test to a test involving a small (6.6 liter or about 1.5 gallon) trash can. The trash bag fire grew to peak intensity in just 2 minutes. One interesting result here is that the trash bag fires grew in intensity more quickly than did nominally similar trash can fires. Figure B-2 illustrates the results of three tests involving one, two, and three trash bags respectively. Note that the fires reached peak intensity in 1-2 minutes, again emphasizing the relatively rapid rate of fire growth compared to trash can fires. The explanation for this difference is that the trash bags alter two key factors. First, in the trash bag fires there is a relatively larger exposed fuel surface area compared to the trash can fires. In the trash bag fires, the fire is free to spread over the entire surface of the trash bags whereas initial fire growth in the trash can was mainly associated with spread only over the upper surface of the trash within the trash can (e.g., rather than over the outer surface of the trash can itself). Second, the trash bag fires have freer access to oxygen in comparison to the trash can fires. For the trash can a two-way flow of oxygen into and then fire gasses out of the trash can must be established (again given initial fire spread through the trash rather than the trash can itself). The trash bags create a more classical fire plume development pattern with cold air and oxygen flowing in from the sides and fire gasses flowing upward above the fuel source. The trash bag configuration is more conducive to rapid fire development.

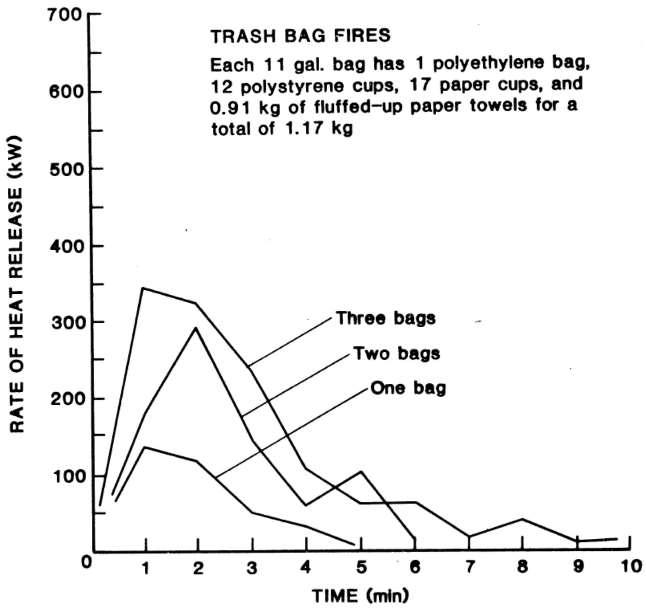

Figure B-2: Results of the LBL tests for trash bags filled with cups and paper towels.

The only other effort that has explored transient fuel sources other than trash receptacles (trash cans) is the previously cited NUREG/CR-4680 [B-2]. This test program did not involve trash bags, but did include testing of a transient fuel package made up of stacked computer paper (15 lbs or a 3" stack) and crumpled paper (1.5 lbs) in a 12"x16"x12" cardboard box (fuel package 3, fire test 5). Figure B-3 illustrates this fuel package. This particular fuel package is roughly similar in nature to a trash bag fire in that the cardboard became involved in the fire relatively quickly and the box did not appear to substantially inhibit air flow to the burning fuel. The heat release rate result for this test is illustrated in Figure B-4. For the SNL test, the time to peak fire intensity was approximately 4 minutes.

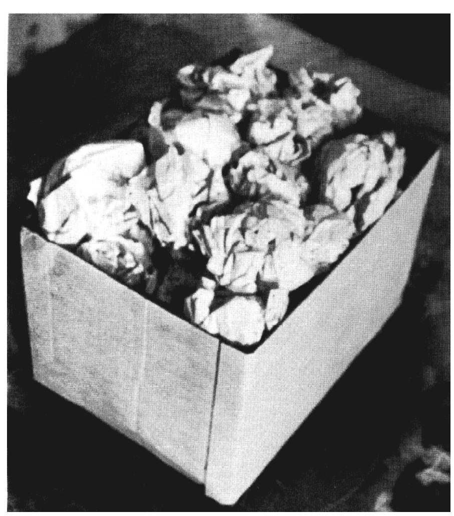

Figure B-3: SNL fuel package 3 - box with crumpled paper.

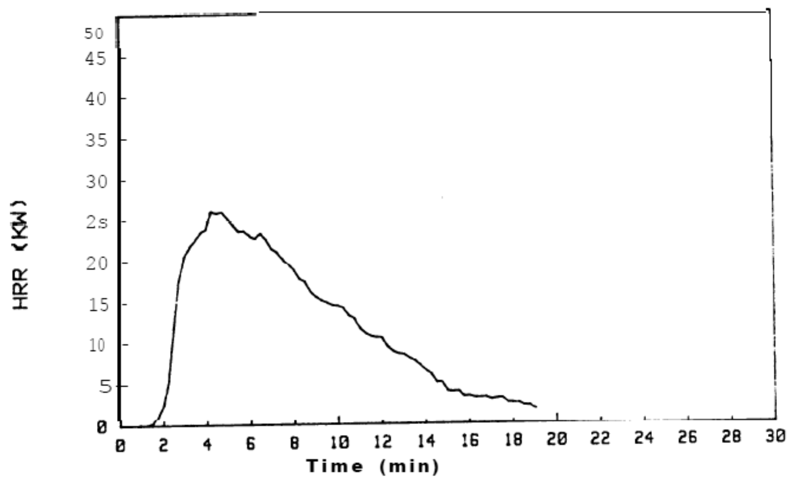

Figure B-4: The heat release rate profile from SNL test 5 involving fuel package 3.

Overall, it is concluded that the LBL test results showing peak heat release rates being reached within 1 minute in two cases and 2 minutes in the third likely exaggerate the early rate of fire growth as compared to more typical trash fire configurations. However, the SNL tests showed a fire growth time of 4 minutes for a roughly similar fuel package. Both test efforts illustrate that trash fires occurring outside of a trash receptacle (trash can) will grow more rapidly than will fires involving similar fuels that are confined within a trash can.

Given the available test results, the recommended general practice for the case of a trash bag fire (i.e., general refuse collected into a plastic bag but not contained within a trash receptacle) is based on a blending of the SNL and LBL test results. For NPP applications, recommended practice for trash bag fires is to assume a fire growth time of 2 minutes.

As a final note, the SNL tests did involve two other small transient fuel source packages (fuel packages 1 and 2). However, both of these packages involved use of a solvent (1 qt of acetone) as a part of the fuel loading. The ignition of this solvent dominated the early fire behavior for these tests. These fuel packages are not considered representative of typical solid refuse (trash) that would exclude flammable liquids. Hence, these tests have not been considered in developing the transient fuel fire growth times discussed here.

<u>References:</u>

B-1: Von Volkenburg, D. R., et al, “Towards a Standard Ignition Source,” Lawrence Berkeley Laboratory, LBL-8306, October 1978.

B-2: S. P. Nowlen, **Heat and Mass Release for Some Transient Fuel Source Fires: A Test Report**, NUREG/CR-4680, SAND86-0312, Sandia National Laboratories (SNL), October 1986.