FLAMMABILITY OF
PLASTICS & POLYMERS
USED AS
ALTERNATE DAILY COVERS

A SUMMARY OF TECHNICAL INFORMATION
FROM THE PUBLIC DOMAIN

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EXECUTIVE SUMMARY

The information contained in this report has been collected from documents previously presented in the public domain. The main sources include the National Fire Protection Association, American Society for Testing Materials, Underwriters Laboratories, and other references cited therein.

The main conclusions are:

RCRA Subtitle D alternate daily cover regulations require control of disease vectors, fires, odors, blowing litter, and scavenging.

The ASTM E1354 Cone Calorimeter evaluation procedure has shown all the common tarpaulins/geotextiles to be flammable and therefore they should be considered unacceptable for daily cover.

In order of increasing Time to Ignition, the results of the ASTM E1354 Cone Calorimeter evaluation are: Cormier RPVC, 24 seconds; Cardboard, 34 seconds; Sanicover, 42 seconds; Griffolyn, 43 seconds; Fabrisoil, 44 seconds; Typar, 52 seconds; Air Space Saver, 77 seconds; Plywood, 151 seconds; Plexiglass, 156 seconds; Red Oak, 266 seconds; and Dry Wall, infinite (non-combustible).

ASTM E1354 CONE CALORIMETER
TEST RESULTS

MATERIAL	IGN TIME (SECS)
CORMIER RPVC	24
CARDBOARD	34
SANICOVER	42
GRIFFOLYN	43
FABRISOIL	44
TYPAR	52
AIR SPACE SAVER	77
PLYWOOD	151
PLEXIGLASS	156
RED OAK	266
DRY WALL	INFINITE

The Heats of Combustion of the commonly used tarpaulins/geotextiles are equivalent to coal, coke, wood, and straw, and only slightly less than that of jet fuel, fuel oil, and gasoline.

HEATS OF COMBUSTION OF REPRESENTATIVE MATERIALS

COMMON PLASTICS (2,3,4,5)

Polyethylene	46.3 MJ/Kg
Polypropylene	46.4 MJ/Kg
Polystyrene	41.4 MJ/Kg
Polyvinyl Chloride	18.0 MJ/Kg
Urea Formaldehyde Foam	15.0 MJ/Kg
Unsaturated Polyester	26.0 MJ/Kg

COMMON TARPAULINS/GEOTEXTILES (8)

Cormier RPVC	14.6 MJ/Kg
Griffolyn	28.7 MJ/Kg
Sanicover	31.3 MJ/Kg
Air Space Saver	32.0 MJ/Kg
Fabrisoil	32.5 MJ/Kg
Typar	33.7 MJ/Kg

OTHER COMMON MATERIALS (2,3,4,5)

Charcoal	34.2 MJ/Kg
Coal, Anthracite	32.8 MJ/Kg
Coal, Bituminous	30.5 MJ/Kg
Coke	29.5 MJ/Kg
Fuel Oil, #1	46.1 MJ/Kg
Gasoline	46.8 MJ/Kg
Jet Fuel, JP-4	46.6 MJ/Kg
Lignite	28.0 MJ/Kg
Paper, Newsprint	19.7 MJ/Kg
Straw	15.6 MJ/Kg
Wood, Dry, Average	20.0 MJ/Kg

Organic materials, in general, are excellent fuels.

Plastics are classified as ordinary combustibles.

Hydrocarbons produce twice the heat per pound as do cellulosics.

Plastics are similar to most ordinary combustibles, such as wood, leather, wool, silk, etc. in that they are capable of thermal degradation into volatile and gaseous products of combustion.

According to the NFPA, the lack of stability of plastics under high temperature conditions and inherent combustibility, have eliminated the use of plastics for applications where a fire resistance rating is a requirement.

It is most convenient to think of hazard control in terms of controlling first the likelihood of ignition, second the control or containment of the fire spread, and third management of the fire impact.

It is important to recognize that claims for flame resistance have little meaning beyond the test method which was used to evaluate fire performance.

The most desirable tests, from the standpoint of fire protection, are those that are suitable for all products for a particular application and that treat all products equally. Separate tests for plastics, which do not allow comparison of the fire behavior under like test conditions, are undesirable. The measurement of the imposed radiant flux is important in predicting fire hazards. The desirable standardized testing procedure is the ASTM E1354, <u>Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products, Using an Oxygen Consumption Calorimeter.</u>

INTRODUCTION -
The RCRA Subtitle D regulations - Criteria For Municipal Solid Waste Landfills (1) become effective on October 9, 1993. Of specific interest is paragraph 258.21, Cover Material Requirements, which state:

> (a) Except as provided in paragraph (b) of this section, the owners or operators of all MSWLF units must cover disposed solid waste with six inches of earthen material at the end of each operating day, or at more frequent intervals, if necessary, to control disease vectors, fires, odors, blowing litter, and scavenging.

> (b) Alternative materials of an alternative thickness (other than

at least six inches of earthen material) may be approved by the Director of an approved State if the owner or operator demonstrates that the alternative material and thickness control disease vectors, fires, odors, blowing litter, and scavenging without presenting a threat to human health and the environment.

(c) The Director of an approved State may grant a temporary waiver from the requirement of paragraph (a) and (b) of this section if the owner or operator demonstrates that there are extreme seasonal climatic conditions that make meeting such requirements impractical.

In some segments of the solid waste disposal industry these pending rules are being overlooked in that polyethylene, polypropylene, and other "plastic" tarpaulins/geotextiles are being used as daily cover, even though it is clear that these materials are generally flammable. It is the object of this document to summarize information on the flammable characteristics of polyethylene, polypropylene, and similar "plastics".

FLAMMABILITY CONSIDERATIONS -
General
Any discussion of the fire hazards of materials must center upon those materials which are organically derived, i.e., those which are based on carbon. The simplest organic compounds are common fuels, as well as being building blocks for more complex materials. Organic liquids are fuels, solvents, and chemical intermediates. However, the largest variety of materials are organic solids. They include everything from specific compounds, such as aspirin, to common, but complex, everyday materials like wood, paper, textiles, and plastics. All of these materials have carbon as their principal constituent; almost all contain hydrogen; and many contain oxygen, nitrogen, and other elements in varying amounts.

Most organic materials are excellent fuels.

The common products of combustion are water and carbon dioxide (2,3).

Solid organic materials fall into two broad classes: hydrocarbon-based and cellulose-based. The former are derivatives of the unoxidized hydrocarbon building blocks, -

CH_2-, or -CH- (like polyethylene and polypropylene, for instance).The latter are based on a partly oxidized carbon unit: -CH(OH)- (like wood, paper, and cardboard, for instance). Cellulose-based material, as it occurs in its natural state, could be considered already partially burned (oxidized). When the two classes, hydrocarbons and cellulosics, are burned to carbon dioxide and water, they consume different amounts of oxygen and produce different amounts of heat. For each equivalent of combustion product generated, the hydrocarbon-based materials consume fifty percent more oxygen. On a weight basis, the difference is even greater.

Hydrocarbons produce twice the heat per pound as do cellulosics (2,3).

Until the middle 1950s this fact was almost unimportant with respect to safety. Most naturally occurring hydrocarbon materials were used only industrially, with the civilian population exposed to fire safety problems only rarely. However, the development of modern plastics changed all that. Most plastics are made from hydrocarbon, not cellulosic, material. Their wide use in building materials and consumer goods, such as furniture, home furnishings, clothing, automobiles, etc., has meant increasingly that the burning properties of hydrocarbons are of consequence to fire safety (2,3)

Rate of Burning
An important component of fire hazard is always the rate at which the combustion products are generated, whether the concern is for heat, smoke, or toxic gases. It is instructive to examine some of the general physical facts which contribute to the burning rate of a combustible material (2,3).

The burning material may be gaseous, liquid, or solid, but the oxygen (normally free oxygen from the air) is usually in the gaseous state. For the necessary chemical reactions to occur, the fuel and oxygen must be brought into contact at a molecular level, and this in turn means that burning is generally a vapor phase phenomenon (2,3).

The rate of burning is a function of how fast the chemical reaction of oxidation occurs, as well as the speed at which the vaporized fuel and oxygen are delivered to the combustion zone. In pre-mixed flames - those in which mixing has occurred before the chemical reaction is initiated - the

burning rate is controlled only by the inherent rate at which the substances chemically combine. This is generally quite fast; flames propagate under pre-mixed conditions at several feet per second. It is this reason that the contact of air and combustible vapors is so dangerous; the process, once started, is virtually impossible to interrupt (2,3).

A more common mode of burning is the diffusion flame. In this case, vaporized fuel mixes with oxygen in the combustion zone. The rate of burning is essentially controlled by the rate at which the two components arrive in the heated combustion zone. Once they arrive, combustion is essentially instantaneous (2,3).

Since gases mix with one another readily, the burning of a gaseous fuel, hydrogen or methane, for instance, is a rapid process. However, the burning of a liquid or solid requires first that the fuel be converted to the gaseous state (volatilization). This process requires the input of an appreciable amount of heat energy, often from the fire itself, and is almost always slow by comparison to the rate of burning (oxidation). As a practical matter therefore, the rate of volatilization of a material strongly affects its rate of burning. Liquids and solids are more concentrated fuels than are gases. Propane, for example, burns completely yielding carbon dioxide and water. At any given pressure, one volume of propane gas consumes five volumes of oxygen, or about 25 volumes of air. By contrast, liquified propane is some 300 times more dense than propane gas under normal conditions. This means that one volume of the liquid will produce 300 times as much heat, but it will also require 300 times as much air, Thus, the burning of highly volatile liquids and solids may also be affected by the rate of delivery of oxygen to the combustion zone, especially under poorly ventilated conditions (2,3).

Disregarding those materials that are self-igniting (hypergolic) the initiation of the combustion process requires some added heat. This heat must be sufficient to vaporize enough of the fuel to initiate oxidation and to accelerate the chemical combustion reaction to a rate where it can sustain itself. The heat required for ignition is greatly dependent upon the physical state of the materials and the heat transfer properties of its environment. Thus, combustible materials present in a dust - exhibiting a large surface area - may burn very readily or explode, while the same material in a solid block may be very difficult to

ignite at all (2,3).

MEASURING AND CONTROLLING HAZARDS -
General
In large measure the vastly different burning characteristics of gases, liquids, and solids pose different types of hazards. The methods for measuring and controlling them are also different.

It is most convenient to think of hazard control in terms of controlling <u>first</u> the likelihood of ignition, <u>second</u> the control or containment of the fire spread, and <u>third</u> management of the fire impact if ignition and spread cannot be prevented (2,3).

Liquids
Since burning actually occurs in the vapor phase, the most hazardous combustible liquids are those with a high vapor pressure or volatility. An empirical measure which combines volatility with the heat producing capabilities of the vapor is the flashpoint determination. The flashpoint is simply the temperature at which a liquid can be ignited under specified laboratory conditions. Flashpoint determinations yield hazard classifications, the most severe hazard being afforded by those liquids with the lowest flashpoints. As in the case of gases, however, the principal means of controlling the ignition of combustible liquids is in handling safeguards. In general, elaborate procedures exist to minimize the escape of combustible vapors in the handling of volatile liquids and to avoid sources of ignition (2,3).

If a fire involving such materials is initiated, means are also available to prevent the supply of additional combustible fuel to the fire. These include designs for the venting of storage tanks, in order to minimize explosions, and flame arresting, to guard against the travel of the flame into the storage area itself. Storage and separation criteria for bulk storage of organic liquids are also suggested to minimize the likelihood that additional supplies of flammable liquids will come in contact with the fire. However, the intensity of the fire, once begun, is a function both of the volatility and the amount of heat released when the fuel burns. Thus, heavy oils or tars may be difficult to ignite but can burn readily once combustion has started. A portion of the heat produced in the flame radiates back to the fuel surface and vaporizes more fuel. For most common organic liquids, the heat required to vaporize a given amount of material is a <u>few percent</u> of the heat of combustion (2,3).

Some firefighting techniques interfere with the passage of fuel from the liquid to the vapor phase. These include cooling the liquid to slow vaporization and the use of foam to cover the liquid surface (2,3).

Solids
In discussing MEASURING AND CONTROLLING HAZARDS of solids, the NFPA, Fire Protection Handbook (2,3) ignores industrial solids - "...the large group of chemicals (materials) which are solid but which are primarily to be found in industrial environments. Unless these materials are present as dusts, foams, or in other forms which present high surface areas, their fire hazards are similar to those of liquids" (2,3).

The solid materials are divided into two major classes: flexible materials, such as textiles and cushioning; and structural materials, which can include everything from steel and concrete to wood and synthetic plastic foams.

> For both of these classes of materials there is a variety of tests to determine their susceptibility to ignition. However, since ignition requires the volatilization of some of the solid fuel, ignition behavior is strongly dependent upon the amount of heat applied to the surface. Therefore, tests for ease of ignition often reflect considerably different results depending on the size of the source. The same applies to tests which purport to measure flame spread over small samples. Flame spread tests under which a small sample receives no more radiant heat load than that available from its own combustion are closer to ignition tests. There are a variety of such tests principally distinguished by the geometry necessary to support the sample in a configuration which approximates its real use (2,3).

FLAME RESISTANT TREATMENTS
Improvements in ignition control of materials have come about as a result of flame resistant treatments developed for both natural and synthetic polymeric materials. It is also possible to design polymeric systems in which a substantial fraction of the material is unavailable as fuel. Examples abound - filled polymers, halogenated monomers and polymers, and polymers based upon other chemistry than simple hydrocarbons.

> It is important to recognize that claims for flame resistance have little meaning beyond the test method which was used to

evaluate fire performance.

Therefore, materials which resist ignition or behave acceptably in small scale tests, may be wholly inappropriate for use when more severe, or substantially different, fire conditions are encountered. The present state of materials fire testing makes it important that materials be tested under conditions which simulate, as closely as possible, expected real fire scenarios (2,3).

Flame spread tests are probably the best known fire performance tests. The most widely used of these are the Steiner Tunnel Test (ASTM E84), and the Radiant Panel Test (ASTM E162). These tests attempt to simulate the spread of fire across a plane surface and may include the imposition of a known external radiant flux (2,3).

In 1981 it was recognized that the role of tests defining the heat release rates during combustion would likely become important in evaluating the combustion characteristics of potentially flammable substances. However, at that time no standard tests existed (2).

In 1991, the National Fire Protection Association reported that several tests had been developed for determining the heat release rates during combustion. Two standard tests now exist: ASTM E906 (NFPA 263), Method for Testing for Heat and Visible Smoke Release Rates for Materials and Products, and ASTM E1354, Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products, Using an Oxygen Consumption Calorimeter. These tests measure the rate at which heat is produced as a function of imposed radiant energy.

> **Because of the importance of an imposed radiant energy flux in real fire hazards, these measurements promise to be of increased importance in predicting fire hazards (2,3).**

In actual fact, this was an astute prediction, as shown by the fact that Underwriter's Laboratories retrofitted their Steiner Tunnel Test (ASTM E84) facility with instrumentation to allow heat and smoke release data to be obtained along with the normal Steiner Tunnel Test information (6).

Ideally, fire resistant treatments should be detectable as diminished heat release measurements. At present, this appears to be true only for a few materials, notably wood

impregnated with fire resistive compounds. Generally, decreased heat release is affected by the selection of materials which are inherently of low combustibility, such as concrete, metal, glass, and the like. Some success has been obtained in recent years with fire resistant coatings contributing to a material's lowered flame spread (2,3).

FIRE BEHAVIOR OF SOLIDS
While there is no special fire hazard for most accepted usages of plastics, some exhibit burning characteristics which are considerably different from those encountered with the more traditional cellulosic materials.

SPECIAL FIRE BEHAVIOR PROBLEMS
Test methods which in the past have been adequate to indicate the relative hazard of materials under actual use conditions have failed to predict the fire behavior of some plastics. In addition, different fire conditions cause significantly different burning characteristics. Of principal concern has been fire behavior which poses unusual hazards to life and property, including the following:

Ignitability and Rate of Burning
Although plastics tend to have a higher ignition temperature than wood and other cellulosic products, some are easily ignited with a small flame and burn vigorously. Very high surface flamespread rates have been reported - up to about 2 feet/sec, or 10 times the rate of flame spread across most wood surfaces (2,3,4,5).

Smoke Produced
The burning of some plastics is characterized by the rapid generation of large amounts of dense, sooty, black smoke. Chemicals added to inhibit flammability may increase smoke production (2,3,4,5). For plastic materials made mostly of polyethylene and polypropylene, smoke generation will not be as important as for plastic materials containing aromatic monomers - like styrene, for instance.

Toxic Gases
Any fire will generate lethal products of combustion, principally carbon monoxide. Depending on the plastic and the particular fire conditions, highly toxic gases, such as hydrogen cyanide, hydrogen chloride, and phosgene, may also be evolved (2,3,4,5). For plastic materials made mostly of polyethylene and polypropylene, where the combustion products are desirably carbon dioxide and water, the main toxic gas

problem will be carbon monoxide, produced when the hydrocarbon is burned with only a limited amount of oxygen. The other potential toxic gases, listed above, will only be produced from plastic materials containing nitrogen and/or chlorine. Polyvinylchloride (PVC) polymers are especially difficult with respect to hydrogen chloride production (2,3,4,5).

Flaming Drips

Thermoplastics tend to melt and flow when heated. In a fire situation, this characteristic may cause the material to melt away from the flame front and inhibit further burning, or it may produce flaming and tar-like dripping which is difficult to extinguish and which may start secondary fires (2,3,4,5).

Deviation from Test Results

Small-scale "bunsen burner" tests are used for product development and laboratory control purposes. In the past they were used to indicate that certain plastics are "self-extinguishing" or "non-burning" and, presumably, safe for use. Unfortunately, in real-life situations the same materials have shown flash-burning characteristics. Somewhat larger-scale tests, such as the NFPA 255, ASTM E84 "tunnel" test, also fail to adequately predict flash-burning characteristics under some end-use conditions (2,3,4,5).

The fire behavior problems summarized above can occur under every conceivable condition of burning, from complete to partial combustion or smoldering and destructive pyrolysis. When plastics and their constituent modifying agents, including flame retardant additives, burn, they can produce a wide variety of noxious and toxic by-products in varying concentrations.

> **In this respect, plastics are similar to most ordinary combustibles, such as wood, leather, wool, silk, etc. in that they are capable of thermal degradation into volatile and gaseous products of combustion able to cause harmful physiological effects when inhaled (2,3,4,5).**

In general, carbon monoxide is generated more rapidly than other toxic gases and tends to be the principal factor in fire fatalities. Nevertheless, unusually high burning rates, unusually heavy smoke production, and a higher heat content per unit weight are responsible for a greater concern about the fire behavior of certain plastics (2,3,4,5).

According to the latest information available from the NFPA, the lack of stability of plastics under high temperature and inherent combustibility so far have ruled out the use of plastics for applications when a fire resistance rating is a requirement (5).

FIRE TESTS FOR PLASTICS & POLYMERS

Combustibility characteristics and suitability for use should be determined for any material or assembly on the basis of tests which simulate the end-use condition as realistically as possible. The tests should be designed to show how the product will perform when it is subjected to the type of fire exposure which can be anticipated under the conditions of use.

The most desirable tests, from the standpoint of fire protection, engineering and codes, are those that are suitable for all products for a particular application and that treat all products equally. Separate tests for plastics or any other group of materials, which do not allow comparison of the fire behavior under like test conditions, are undesirable (2,3,4,5).

As explained previously, small-scale tests are now used mostly for product development and production control. Such tests are also suitable for determining the ignitability of such items as upholstery, where the ignition source is small and low intensity, but are unsuitable for evaluating the fire characteristics of materials under room fire or other "full-scale" fire conditions (2,3,4,5).

FIGHTING FIRES IN PLASTICS & POLYMERS

Plastics are classified as ordinary combustibles (2,3,4,5)

Consequently, extinguishing methods for fires involving wood and other ordinary combustibles (Class A fires) should be used to extinguish a burning plastic. Fire protection considerations should include automatic sprinklers, standpipe and hose systems, and water-type portable extinguishers. These should be supplemented by fire extinguishers or special automatic systems suitable for flammable liquids and electrical fires where these hazards exist (2,3,4,5).

The physical form of plastics will greatly influence their fire behavior. Molding pellets which are shipped in bags, drums, or large cartons provide little surface area for access to air. These same plastics in such shapes as

flashlight cases will have much more access to air and may burn vigorously until heat until heat causes the   shapes to melt, thereby reducing the surface area exposed to the air. Melting may be a hazard if burning drips carry flame to lower floors or spread fuel for later ignition. For this reason during fire fighting some hose streams should be used to cool exposed plastics to keep them from melting and dripping. (2,3,4,5).

HEATS OF COMBUSTION

The heat of combustion is, by definition, the enthalpy of reaction when fuel and oxidant at standard conditions are reacted and form products of combustion at standard conditions. A unique value for the heat of combustion is possible only if these conditions are fully specified (2,3,4,5). Examples of Heats of Combustion for a variety of materials are listed in Table I.

ASTM E1354 CONE CALORIMETER EVALUATIONS - STANDARDS AND TARPAULINS/GEOTEXTILES

Many of the commonly used tarpaulins/geotextiles have been subjected to an ASTM E1354 Cone Calorimeter evaluation (8). The original data were condensed into a verbal, and subsequently printed, presentation where individual graphical representation was restricted. In order to facilitate the evaluation and eliminate tedious comparisons, the original data included common materials (standards) as well as the tarpaulins/geotextiles, with all of the samples being evaluated by the same technique. The standard radiant flux in all cases was 25 kilowatts/square meter, equivalent to a "standard" waste basket fire.

The data presented here show the Heat Release Rate (Kilowatts/Square Meter) versus Time (seconds) as well as the Weight Loss (%) versus time. The subtitle indicates the material evaluated and its time to ignition.

The materials, both standards and tarpaulins/geotextiles, are listed Table II in order of increasing time to ignition.

CONCLUSIONS

(1) RCRA Subtitle D alternate daily cover regulations require control of disease vectors, fires, odors, blowing litter, and scavenging.

(2) The ASTM E1354 Cone Calorimeter evaluation procedure has

shown all the common tarpaulins/geotextiles to be flammable and therefore they should be considered unacceptable for daily cover.

(3) In order of increasing Time to Ignition, the results of the ASTM E1354 Cone Calorimeter evaluation are: Cormier RPVC, 24 seconds; Cardboard, 34 seconds; Sanicover, 42 seconds; Griffolyn, 43 seconds; Fabrisoil, 44 seconds; Typar, 52 seconds; Air Space Saver, 77 seconds; Plywood, 151 seconds; Plexiglass, 156 seconds; Red Oak, 266 seconds; and Dry Wall, infinite (non-combustible).

TABLE I

ASTM E1354 CONE CALORIMETER TEST RESULTS

MATERIAL	IGN TIME (SECS)
CORMIER RPVC	24
CARDBOARD	34
SANICOVER	42
GRIFFOLYN	43
FABRISOIL	44
TYPAR	52
AIR SPACE SAVER	77
PLYWOOD	151
PLEXIGLASS	156
RED OAK	266
DRY WALL	INFINITE

(4) The Heats of Combustion of the commonly used tarpaulins/geotextiles are equivalent to coal, coke, wood, and straw, and only slightly less than that of jet fuel, fuel oil, and gasoline.

TABLE II

HEATS OF COMBUSTION OF REPRESENTATIVE MATERIALS

COMMON PLASTICS (2,3,4,5)

Polyethylene	46.3 MJ/Kg
Polypropylene	46.4 MJ/Kg
Polystyrene	41.4 MJ/Kg
Polyvinyl Chloride	18.0 MJ/Kg
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COMMON TARPAULINS/GEOTEXTILES (8)

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OTHER COMMON MATERIALS (2,3,4,5)

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Coal, Anthracite	32.8 MJ/Kg
Coal, Bituminous	30.5 MJ/Kg
Coke	29.5 MJ/Kg
Fuel Oil, #1	46.1 MJ/Kg
Gasoline	46.8 MJ/Kg
Jet Fuel, JP-4	46.6 MJ/Kg
Lignite	28.0 MJ/Kg
Paper, Newsprint	19.7 MJ/Kg
Straw	15.6 MJ/Kg
Wood, Dry, Average	20.0 MJ/Kg

(5) Organic materials, in general, are excellent fuels.

(6) Plastics are classified as ordinary combustibles.

(7) Hydrocarbons produce twice the heat per pound as do cellulosics.

(8) Plastics are similar to most ordinary combustibles, such as wood, leather, wool, silk, etc. in that they are capable of thermal degradation into volatile and gaseous products of combustion.

(9) According to the NFPA, the lack of stability of plastics under high temperature conditions and inherent combustibility, have eliminated the use of plastics for applications where a fire resistance rating is a requirement.

(10) It is most convenient to think of hazard control in terms of controlling first the likelihood of ignition, second the control or containment of the fire spread, and third management of the fire impact.

(11) It is important to recognize that claims for flame resistance have little meaning beyond the test method which was used to evaluate fire performance.

(12) The most desirable tests, from the standpoint of fire protection, are those that are suitable for all products for a particular application and that treat all products equally. Separate tests for plastics, which do not allow comparison of the fire behavior under like test conditions, are undesirable. The measurement of the imposed radiant flux is important in predicting fire hazards. The desirable standardized testing procedure is the ASTM E1354, <u>Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products, Using an Oxygen Consumption Calorimeter.</u>
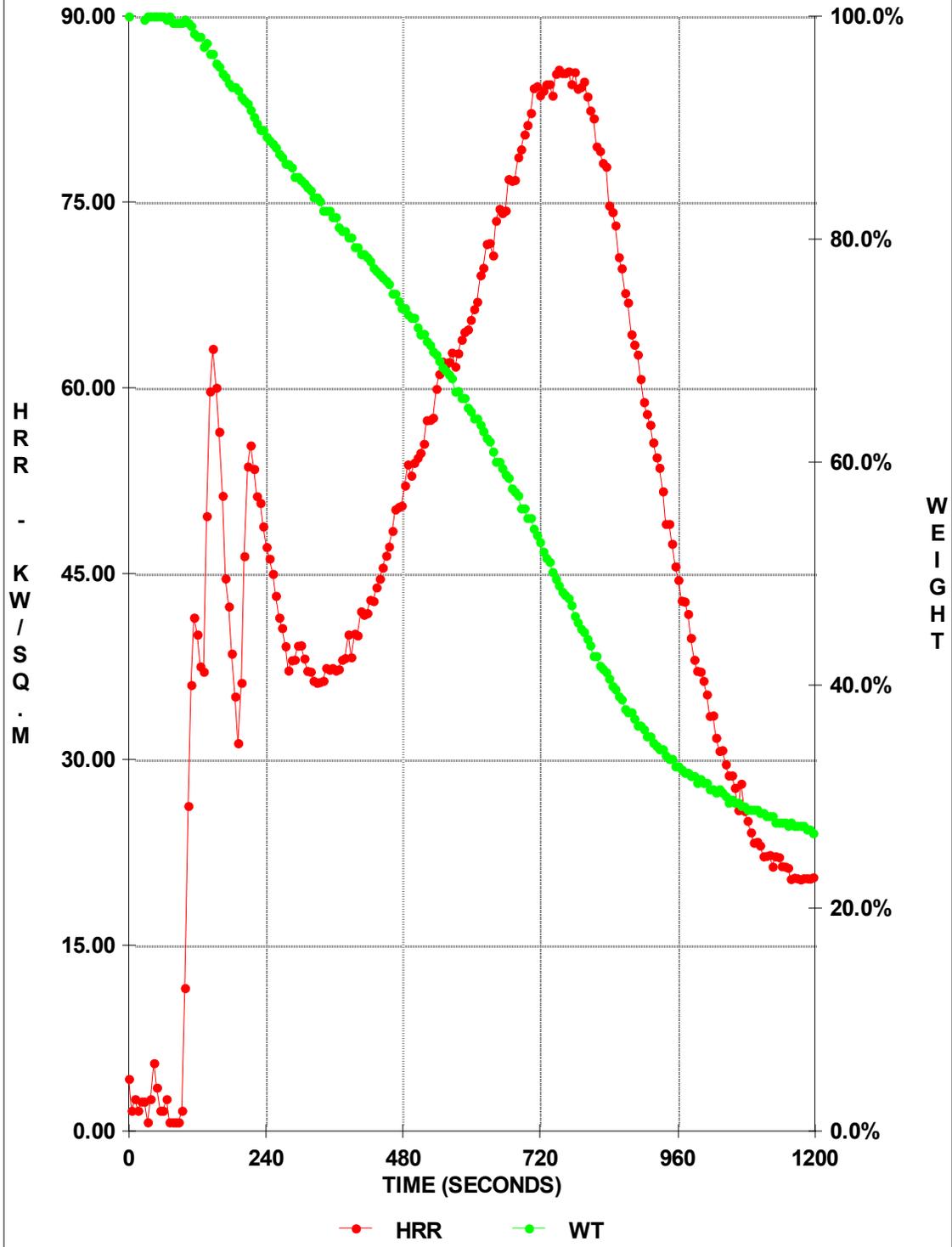
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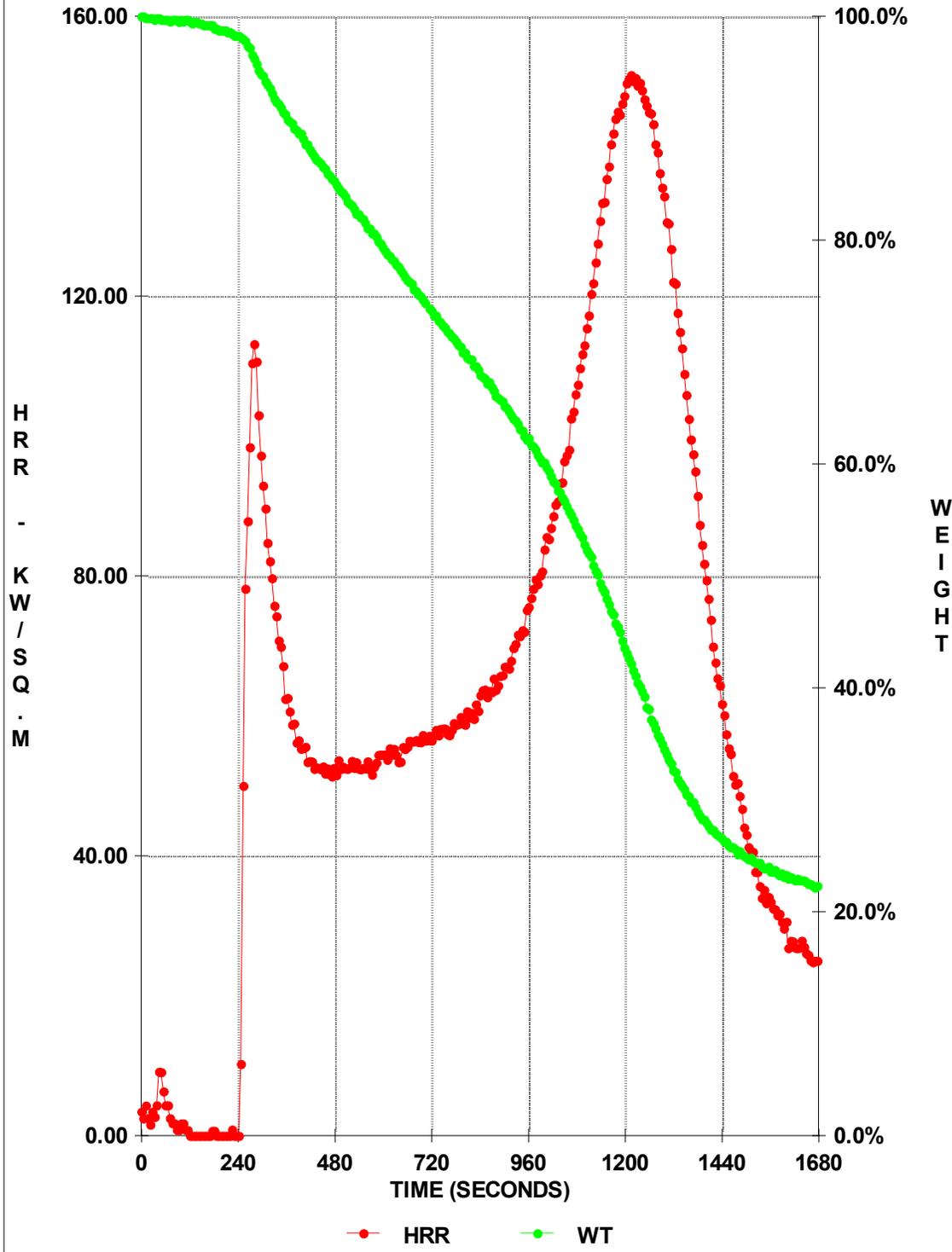
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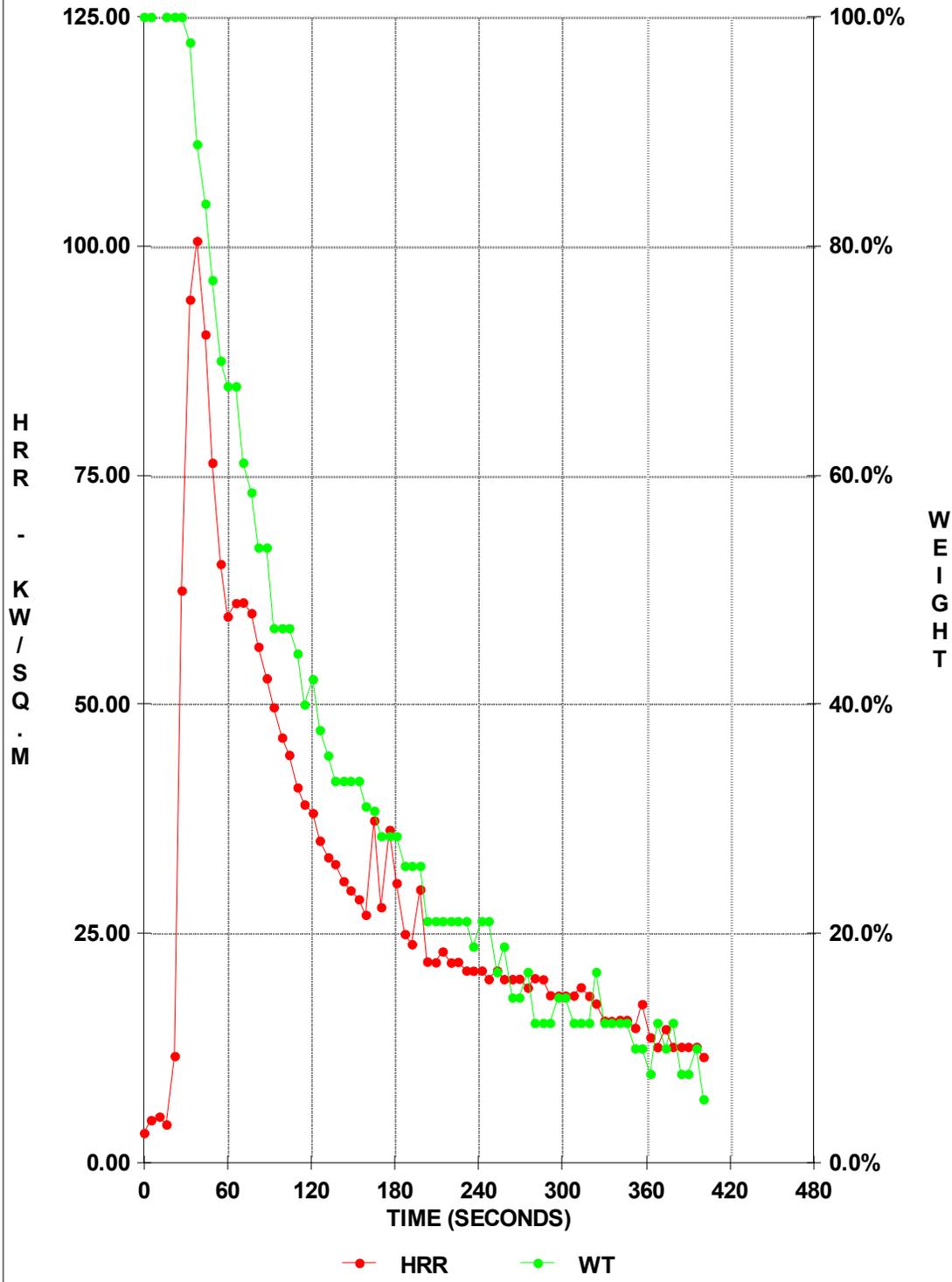
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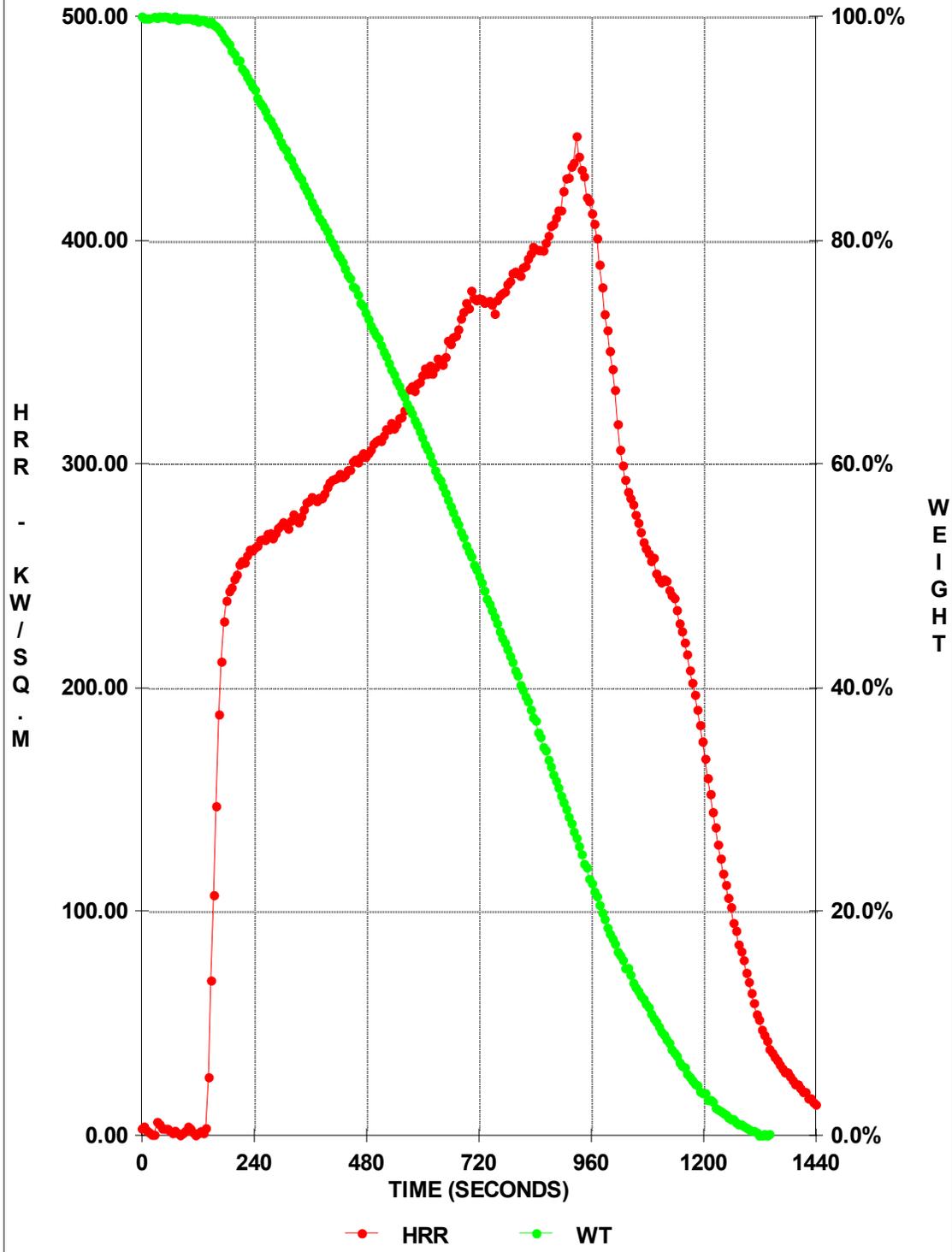
PLYWOOD; IGN TIME = 151 SECONDS

ASTM CONE CALORIMETER TEST
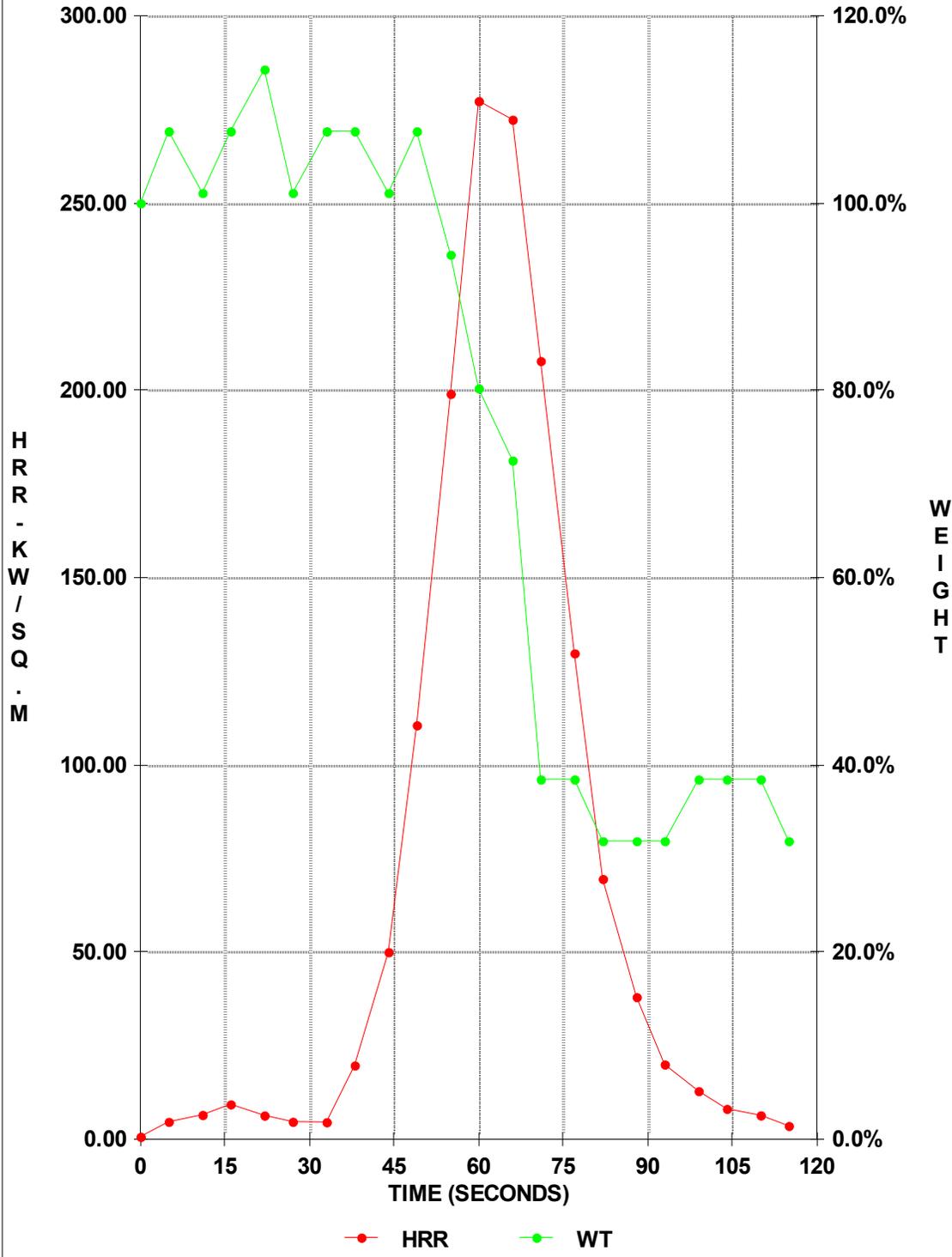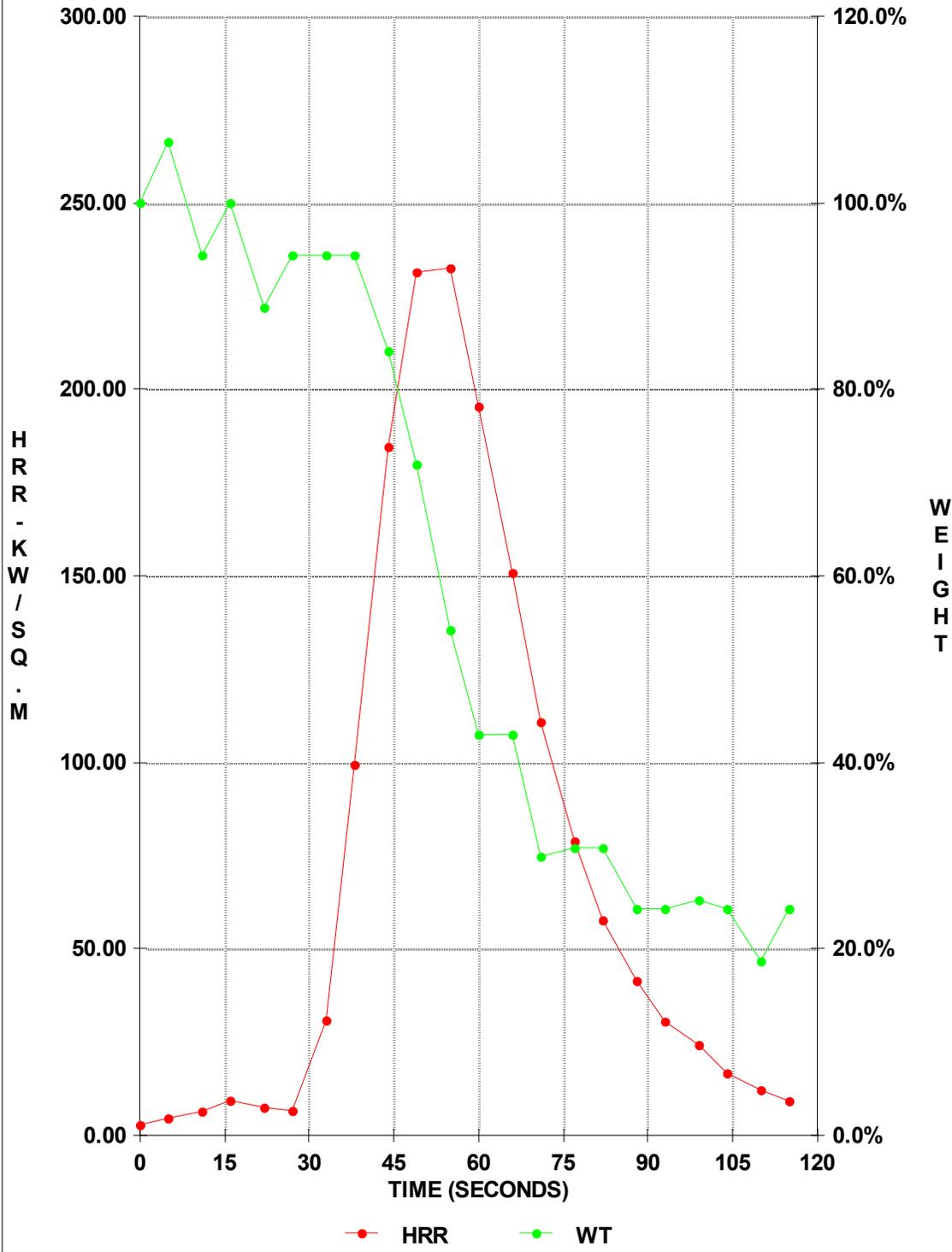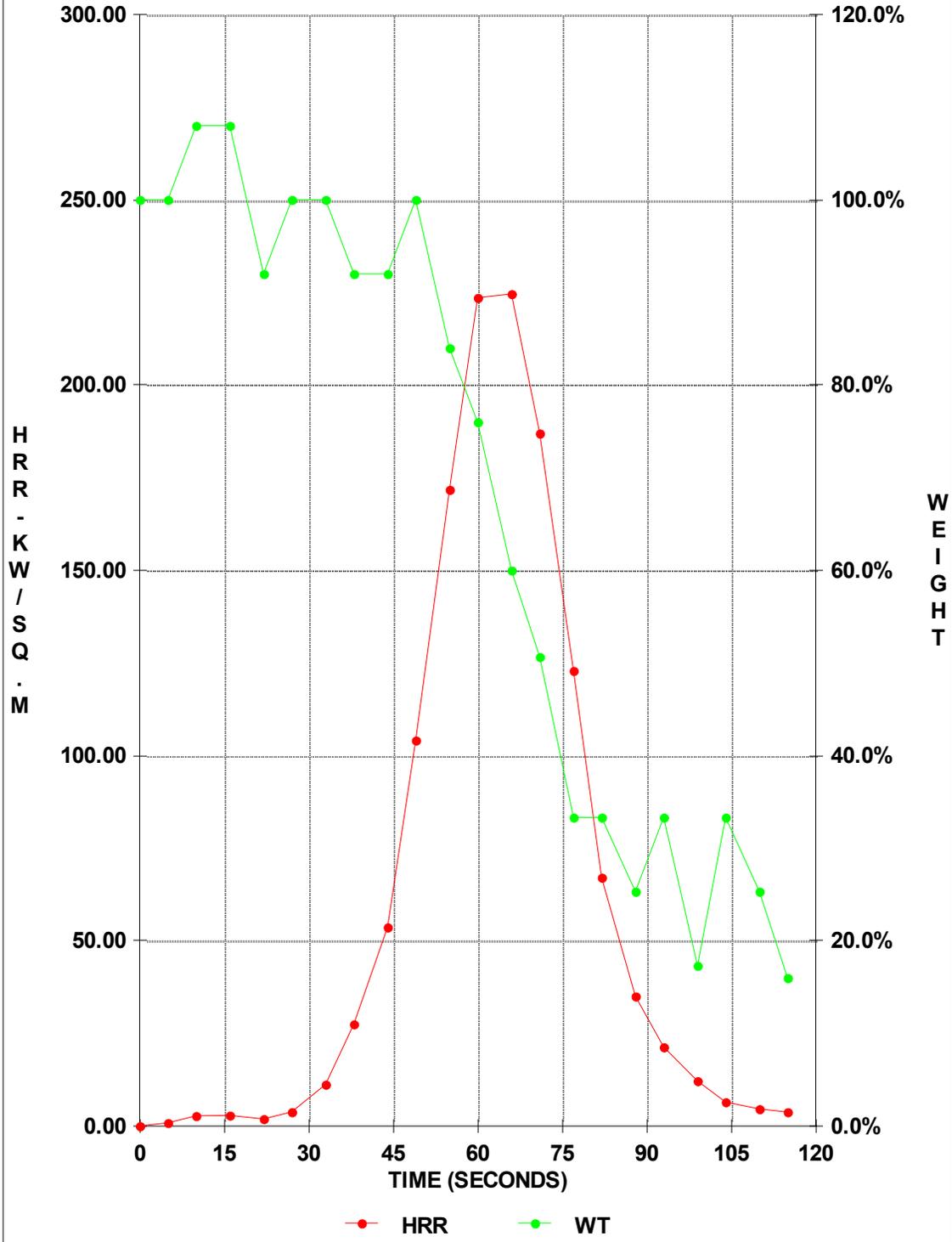
RED OAK; IGN TIME = 266 SECONDS

Legend: HRR (red), WT (green)

Y-axis (left): HRR - KW/SQ.M — 0.00, 40.00, 80.00, 120.00, 160.00

Y-axis (right): WEIGHT — 0.0%, 20.0%, 40.0%, 60.0%, 80.0%, 100.0%

X-axis: TIME (SECONDS) — 0, 240, 480, 720, 960, 1200, 1440, 1680

ASTM CONE CALORIMETER TEST

PMMA; IGN TIME = 156 SECONDS

ASTM CONE CALORIMETER TEST
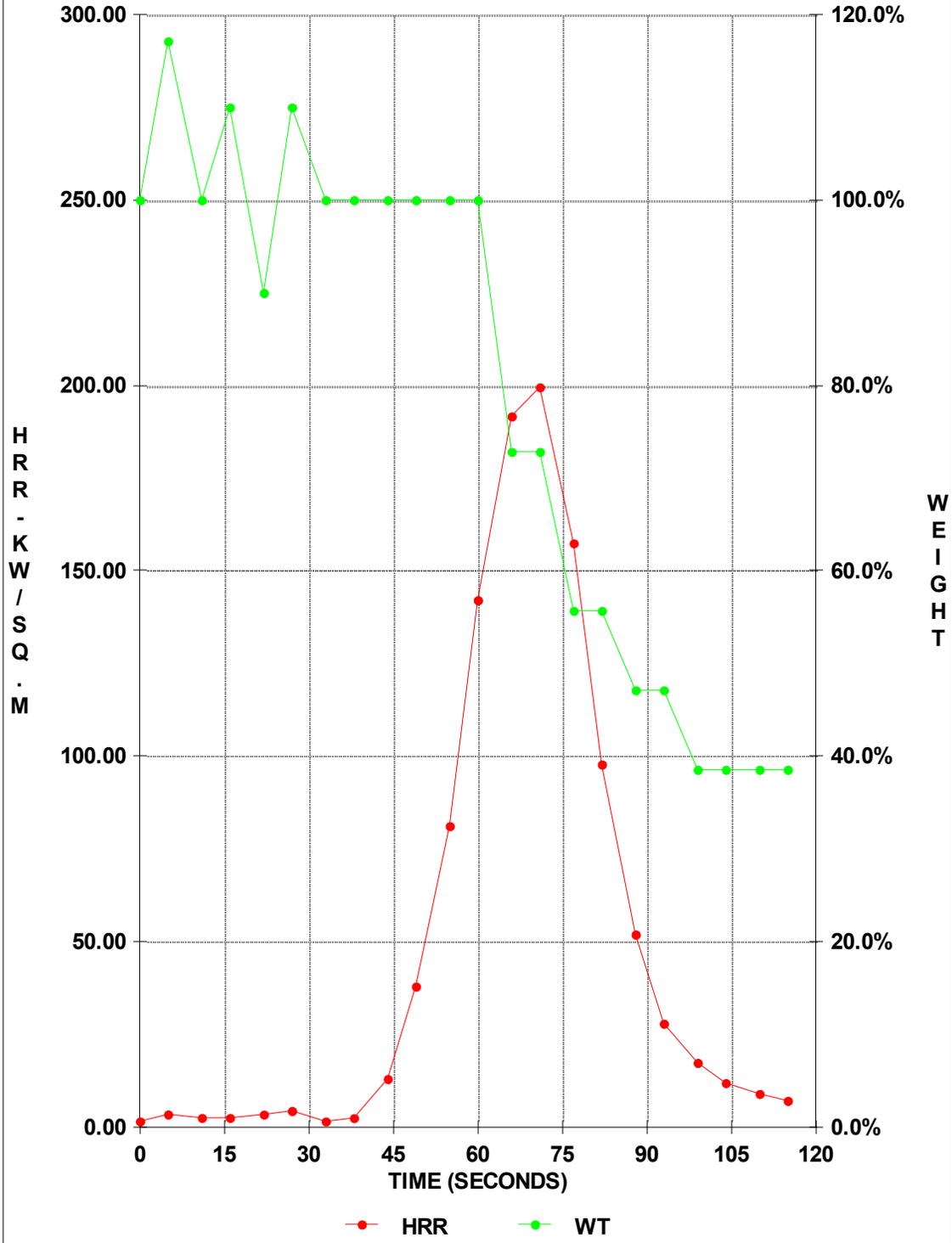
FABRISOIL; IGN TIME = 44 SECONDS

ASTM CONE CALORIMETER TEST
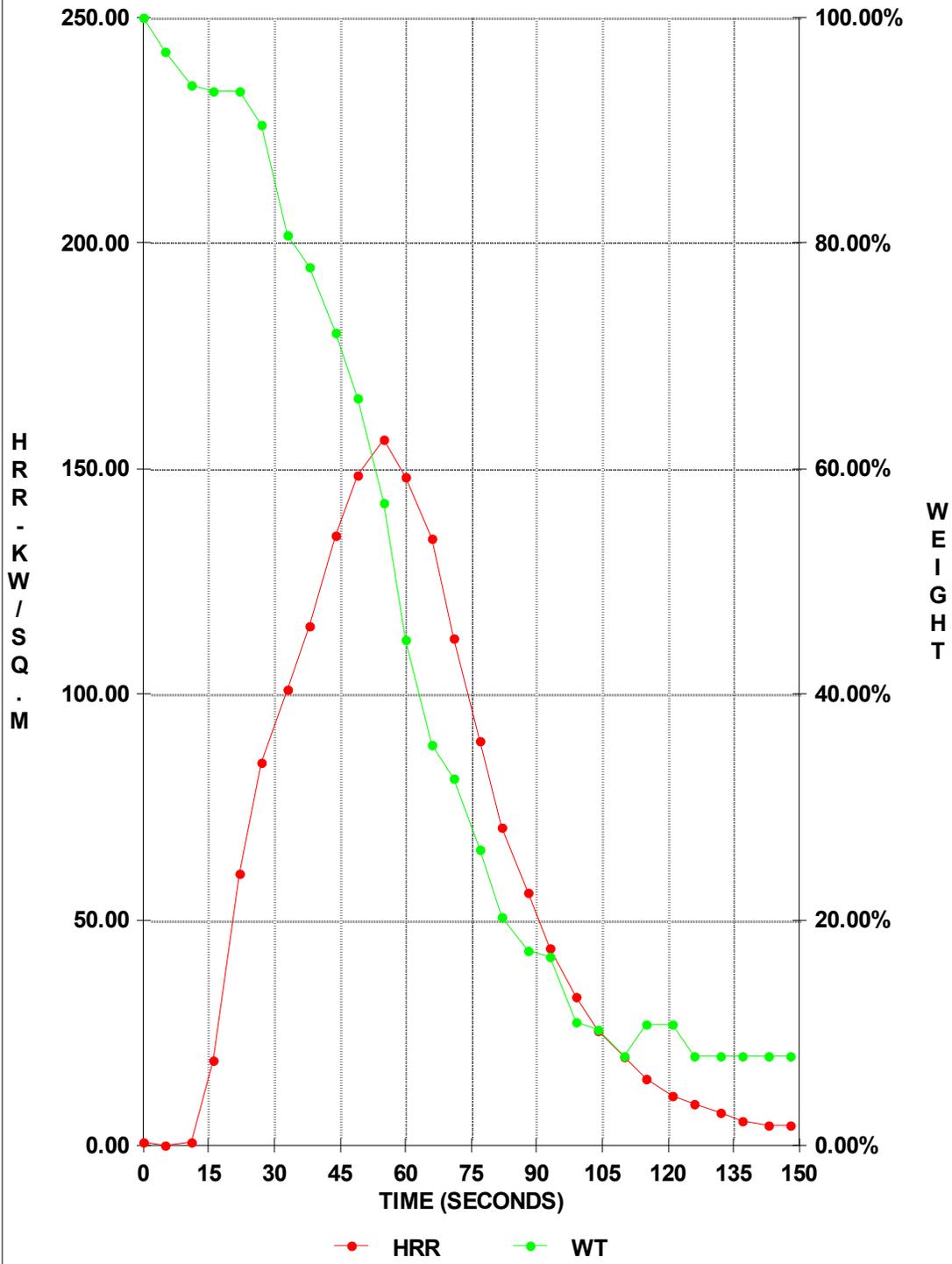
SANICOVER; IGN TIME = 42 SECONDS

ASTM CONE CALORIMETER TEST

TYPAR; IGN TIME = 52 SECONDS

ASTM CONE CALORIMETER TEST

CORMIER RPVC-22; IGN TIME = 24 SECONDS

REFERENCES -
(1) Code of Federal Regulations, Protection of Environment, 40, Part 258, Criteria For Municipal Solid Waste Landfills, Revised as of July 1, 1992.

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