

Explanation of Classification of Thermite Mixtures

SUMMARY: PHMSA is publishing this notice to inform interested parties of the process PHMSA has previously used and continues to use in the classification of thermite mixtures.

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I. Executive Summary

The Pipeline and Hazardous Materials Safety Administration (PHMSA) publishes this Explanation of Thermite Formulations Classification (Explanation) to inform the regulated community how PHMSA has previously reviewed and classified certain thermite formulations. This Explanation shows how PHMSA has temporarily reclassified certain thermite formulations as Division 4.1 flammable solids instead of Class 1 explosives while PHMSA completes its ongoing research project on thermite formulation classification. This notice also explains how PHMSA is instructing its approved test labs to evaluate thermite formulations submitted for classification testing.

Disclaimer: This notice does not have the force and effect of law and is not meant to bind the public in any way. This notice is intended only to provide information to the public regarding existing requirements under the Hazardous Materials Regulations (HMR).

II. Background

PHMSA's Hazardous Materials Regulations (HMR; 49 CFR parts 171-180) prescribe requirements for the transportation in commerce of explosives. 49 CFR § 173.51 states that, "unless otherwise provided in the HMR, no person may offer for transportation or transport an explosive, unless it has been tested and classed and approved by the Associate Administrator (173.56)." The HMR further explains in section 173.56 that anyone producing a new explosive must have that explosive first tested by a PHMSA-approved explosives test laboratory, where the lab would then provide a classification recommendation for the explosive. PHMSA then analyzes this information, considers the recommendation of the test laboratory, and issues the producer a classification and approval to transport that explosive in commerce.

In 2016, PHMSA received several questions from PHMSA-approved explosives testing labs about the proper classification of thermite formulations. Thermite formulations are pyrotechnic substances containing both a metal powder and a metal oxide, but they may also include additional ingredients to alter performance. When ignited by heat or chemical reaction, they are capable of undergoing a self-sustaining exothermic chemical reaction through decomposition by oxidation-reduction pathway¹, and therefore meet the definition of a Class 1 (explosive) material under § 173.50. Accordingly, all thermite formulations require examination and classification by a PHMSA-approved explosives test lab, as required in 49 CFR § 173.56.

¹ Whereas flammable solids are fuels capable of producing an exothermic reaction (releasing energy in the form of heat or light) through an oxidative reduction pathway (gaining or losing electrons), the reaction is not self-sustaining because an external oxidizer source is necessary. Thermite formulations contain both the fuel and oxidizer, and therefore the exothermic reaction produced is self-sustaining.

In response to the questions from PHMSA-approved explosives testing labs, PHMSA initiated a research project to assess the proper classification of thermites. Preliminary results of United Nations (UN) Manual of Test and Criteria (MTC) Test 6(c) (bonfire testing) indicated risk profiles consistent with classification criteria from Division 1.4 and Division 1.3 for various thermite formulations.²

To ensure thermite formulations are properly evaluated and classed, this notice serves to explain how the testing and classification scheme for explosive substances has been applied to thermite formulations. As a means of providing limited regulatory relief from HMR requirements applicable to thermite formulations as Class 1 explosive materials, this notice also serves to communicate how PHMSA has, pursuant to 49 CFR § 173.56(i), allowed certain thermite formulations to be classified as Division 4.1 (flammable solid) materials.

III. PHMSA's Thermite Research

PHMSA has been actively researching the proper classification of thermite and thermate formulations since 2016, when it received questions related to thermite classification from multiple PHMSA-approved explosives test labs. PHMSA reviewed how thermite formulations and articles were previously classified, noting the relatively small number of explosive approval (EX) applications received for these materials. The work included consultation with all DOT-authorized explosive testing laboratories, other US Federal agencies, and international explosives regulators,³ with the aim of identifying potential safety gaps inherent with thermite formulation transport classifications. PHMSA has previously determined that thermite formulations meet the definition of an explosive in the HMR, and that further oversight is necessary to properly manage the hazards they pose in transportation.⁴

Given that thermite formulations are used in a wide variety of applications, from metal welding to military munitions, PHMSA sought to mitigate the impact of its determination that thermite formulations are properly classified as Class 1 explosives while maintaining safety. Accordingly, PHMSA initiated additional research to evaluate the classification of thermite formulations and the range of their chemical characteristics.

Following initial inquiries into the formulation of thermites in 2016, PHMSA began the research phase of investigating the characteristics of thermite formulations in 2018 at Southwest Research Institute. This research indicated that thermite formulations exhibit pyrotechnic behavior that ranges from deflagration to detonation and identified important parameters including grain size, degree of mixing, morphology, and chemical composition. Additionally,

² https://unece.org/fileadmin/DAM/trans/danger/publi/manual/Rev7/Manual_Rev7_E.pdf

³ PHMSA has consulted with many other Federal agencies to share information about the various research PHMSA is conducting into thermite characteristics and potential classifications. Among the Federal and international agencies consulted are the US Bureau of Alcohol, Tobacco, Firearms and Explosives, the US Department of Defense, the US Department of Homeland Security, as well as transport regulators from Canada, the Netherlands, Sweden, and the United Kingdom.

⁴ 49 CFR 173.50(a) states that "For the purposes of this subchapter, an explosive means any substance or article, including a device, which is designed to function by explosion (i.e., an extremely rapid release of gas and heat) or which, by chemical reaction within itself, is able to function in a similar manner even if not designed to function by explosion, unless the substance or article is otherwise classed under the provisions of this subchapter. The term includes a pyrotechnic substance or article, unless the substance or article is otherwise classed under the provisions of this subchapter." See Interpretation Response # 18-0141 Onepoint4 Ltd. Clarification of HMR Requirements Applicable to Classification of Explosives ([Interpretation Response | PHMSA \(dot.gov\)](#)); and Interpretation Response # 20-0015 Onepoint4 Ltd. Follow Up to 18-0141 Clarification of Requirements for Classification of Explosives ([Interpretation Response | PHMSA \(dot.gov\)](#)).

researchers identified several potential inadequacies with the UN Classification tests for explosives and flammable solids. In particular, the N.1 Test method for readily combustible solids was not designed to account for mixtures that contain their own oxygen balance to support a self-sustained exothermic reaction. Specifically, the research noted concerns with the ignition source and dramatic performance changes with increased trough width. With these gaps identified, PHMSA sponsored additional research with Safety Management Services to explore classification testing and further characterization of commercial thermites of various compositions, including detonable and non-detonable formulations. The end goal of this research project is to develop an appropriate testing and classification scheme for these materials.

IV. Policy on Classification of Thermites as Division 4.1 (UN 3178) Flammable Solids

In order to provide clarity on how PHMSA has reviewed thermite formulations while its current research project is ongoing, PHMSA has decided to use its authority, in accordance with 49 CFR § 173.56(i), to issue this Explanation of how PHMSA has reviewed specific thermite formulations. PHMSA's past reviews of these thermite formulations has allowed for reclassification of thermite formulations from Class 1 explosives to Division 4.1 flammable solids. PHMSA's review of thermite formulations indicated that:

1. Thermite formulations meet the definition of an explosive, in accordance with 49 CFR § 173.50(a). Articles containing thermite formulations are therefore also provisional Class 1 explosive articles.
2. Manufacturers of thermite formulations must submit their products for testing at PHMSA-approved third party explosive laboratories in accordance with 49 CFR 173.56 before they are offered for transport.
3. On an interim basis, and concurrent with ongoing thermite characterization research, a thermite formulation that meets all UN MTC Test Series 2 criteria is eligible to be classified as a Division 4.1 (flammable solid) material (e.g., "UN3178, Flammable solid, inorganic, n.o.s., 4.1, Packing Group II"), upon the determination of the Associate Administrator for Hazardous Materials Safety at PHMSA.
4. Articles containing thermite formulations, regardless of whether the thermite formulation has a Class 1 or Division 4.1 designation, are not eligible for reclassification under this policy.
5. Articles containing thermite formulations are required to meet Class 1 exclusion criteria incorporated by reference from the UN Model Regulations Section 2.1.3.6 to be classified as not Class 1 explosives.

This Explanation is intended to provide the procedures and review that has previously led to PHMSA approving the reclassification of certain thermite formulations as Division 4.1 explosives until PHMSA has finished the research project it is currently undertaking to determine the proper testing and criteria required to address the transportation risk of thermite formulations more accurately. PHMSA encourages applicants seeking reclassification to Division 4.1 to employ this process if they believe such thermite formulations demonstrate similar criteria listed above. Lastly, the Explanation of prior reclassification processes described above is limited to thermite formulations. PHMSA emphasizes that articles containing thermite formulations require separate evaluation and approval under 49 CFR § 173.56, even if the thermite formulations contained within have been classified as "UN3178, Flammable solid, inorganic, n.o.s., 4.1, Packing Group II" pursuant to this policy.

V. Future Actions

PHMSA continues to conduct research on thermite formulations and their proper classification. Based on the findings of PHMSA's ongoing research, PHMSA may take action, including rulemaking, to better classify thermites for transportation.