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Review of Off-gassing from Wood Pellets A Canadian Perspective

The first time the off-gassing from pellets was observed was probably on May 9, 2002 when the ocean vessel MV Weaver Arrow loaded in Vancouver with wood pellets was discharging pellets in Rotterdam and one person was killed and two other people were severely injured as a result of exposure to carbon-monoxide when entering one of the cargo holds. Delta Research Corporation (DRC) in Canada immediately drafted the first warning and guideline (Shipper Cargo Information Sheet - SCIS) in accordance with the IMO regulations to inform on-board crews as well as dock workers in ocean ports about the nature of pellets and the potential risks involved. In June of 2002 the accident was announced by the Canadian delegation at the World Pellet Conference 2002 in Stockholm. Within another month a draft text for a classification of pellets as Material Hazardous in Bulk (MHB) was submitted by DRC to federal Department of Transport Canada and the International Maritime Organization (IMO) for introduction of wood pellets as a commodity in the IMO Bulk Code regulations for ocean transportation. Correspondence was also sent to the Swedish Maritime Safety Inspectorate in August 2002 to gain support for the introduction of the new code for pellets. IMO approved the introduction of pellets in the Bulk Code in 2004 and it became part of the updated version of the BC Code Handbook in December 2004 effective early 2005. From that time and onwards all ocean shipments of pellets from Canada were documented with reference to the new BC Code and the SCIS. It gradually became clear after studies by DRC that off-gassing in combination with oxygen depletion were not unique for pellets. In fact the general guidelines within the IMO regulations explicitly point to all wood products as oxygen depleting and a source of carbon-monoxide as well as carbon-dioxide. Casualties were subsequently reported onboard vessels carrying green lumber, chips and pulp logs. Transport Canada issued a Ship Safety Bulletin in December 2005 and subsequent bulletins from for example the UK P&I Club has warned the shipping industry about the danger with off-gassing from pellets. A further update of the BC Code was completed in close collaboration between Sweden and Canada in consideration of the importance of measuring both carbon-monoxide and oxygen depletion to secure safe entry. The new code is in effect from January 2009.

As a direct consequence of the risk realized with wood pellets in bulk the British Columbia Pellet Fuel Manufacturers Association (BCPFMA) was upgraded in early 2005

to the national Wood Pellet Association of Canada (WPAC) with the main objective to conduct research development of a Material Safety Data Sheet (MSDS) to better inform the industry partners in the supply chain as well as overseas clients about the danger with off-gassing from pellets. An agreement was reached between WPAC and University of British Columbia to develop a deeper understanding the quantitative aspect of off-gassing using reactors in the lab to simulate storage conditions for pellets. A number of papers listed in the bibliography were produced and published as a result of the research and a clear understanding emerged resulting in the embryo to the Canadian MSDS. This MSDS has since been upgraded numerous times and has become a repository for all information related to risk associated with wood pellets. The current comprehensive format for the Canadian MSDS was issued April 30, 2007 and introduced in the trade between Canada and Europe on all transoceanic voyages from there and onward in parallel with the SCIS.

On November 26, 2006 a repeat of the Rotterdam accident happened on-board MV Saga Spray in the Port of Helsingborg, Sweden despite clear instructions on-board the vessel and in the port. One person was killed and several other people were injured, one person very seriously. Immediately following the accident a decision was made by WPAC to conduct an on-board research project called “Emission from Wood Pellet During Ocean Transportation” (EWDOT) in an attempt to generate a model for the relation between off-gassing in a sealed cargo hold in relation to ambient air and water temperature, relative humidity and barometric pressure throughout a voyage from Vancouver to Helsingborg. The vessel MV Saga Horizon was fitted with an elaborate system of temperature sensors in the cargo as well as gas sampling tubes at various levels of the cargo hold. A close relation was developed with Dr Urban Svedberg in Sweden to process and interpret from the measurements taken on-board the vessel. This resulted in scientific papers and seminars for the industry in Canada and Sweden during October of 2007.

A DVD¹ with the title “the Lethal Dangers of Wood Products” has recently been produced by the Swedish Civil Contingencies Agency (MSB) and is dealing with the issues of off-gassing from wood products, including wood pellets, as well as oxygen depletion.

In June 2008 two people were killed in Finland when doing work related to silo storage of wood pellets. Dr Svedberg in Sweden continued the investigations of off-gassing and the risk of exposure during ocean transportation of pulp logs and chips from eastern Baltic to Swedish ports after 5 people were reported killed during a period of 24 months in Swedish ports. The main caused appears to be oxygen depletion and a to a lesser extent carbon-monoxide – a different pattern of emissions compared to what we see with wood pellets but still involving wood.

Accidents have also been reported in Germany. The most recent was a fatal accident within the last two month and another over a year ago which fortunately was not fatal. The risk exposure to off-gassing has also more recently been acknowledged in Austria and Germany due to an incident about 1 ½ years ago, luckily not fatal, and a recent fatal

¹ Order number MSB 0071-09, tel +46-(0)771-240-240, email rib@msb.se

accident also in Germany. Recent research in Austria by Dr Walter Haslinger et al has verified also the risk with residential storage of pellets.

Recent discussions between Austria and Canada, has resulted in agreed text to be included in the IEA Pellet Handbook to be published during the spring of 2010 recognizing the importance of the off-gassing as a health hazard which can be managed and over time probably also mitigated. Information about the hazard is the first step and should not be different from the warnings issued for other fuels such as fossil gas, fuels oil or coal.

The focus of the research at UBC shifted gradually and has become more oriented towards developing an understanding of the underlying causes of the off-gassing in combination with prevention. The study of self-heating is one of the focus areas and another has been conditioning the storage such that the off-gassing can be controlled by means of forced ventilation using temperature monitoring as the primary tool. In addition, WPAC has participated in the fire extinguishing research at the SP Technical Research Institute of Sweden in the development of the inertation technique using nitrogen injection.

The self-heating research has progressed to the point of modelling of the conductivity within pellets in bulk and the kinetics to the point of run-away temperature profiling. This work also includes investigation on the micro-calorimetric level. Additional research has been conducted to develop an understanding of parameters affecting the permeability within a column of pellets. A large research reactor (LRR) with a volume of approximately 3 m³ has been installed at UBC to study the off-gassing characteristics under controlled conditions, including different types of ventilation, implanted disturbances in terms of material stratification and asymmetric external heating (exposure of silo to radiation from the sun). The LRR is equipped with several hundred temperature sensors, humidity sensors and sampling ports for gas as well as extraction of materials. Exploration of the potential presence of trace gases to detect self-heating and the early stages of pyrolysis will be conducted as well as detection of other volatiles such as free hydrogen with the objective to explain strange phenomenon observed during explosive fires during bulk handling.

WPAC has conducted research to establish an understanding of the extreme explosibility of dust from wood pellets. This has resulted in guidelines introduced in the MSDS for handling pellets. Further work is planned in this area, including research to model the tribo-electric characteristics of wood dust as a complement to understanding the interaction with off-gassing and how fires are triggered in bulk storage of pellets.

Besides the remedial actions taken to secure the environment surrounding pellets the WPAC and UBC are doing research aiming at developing a better quality pellets with extremely low reactivity which would mean very low off-gassing and minimal propensity for self-heating. Similar work is conducted at the Bioenergy Technology Centre in Umeå, Sweden.

The WPAC is in the early stage of developing a “Best Engineering, Operating and Maintenance Practices Handbook for Safety in the Pellet Industry” in close cooperation with the insurance industry and occupational health agencies in Canada. The handbook will systematically bring together knowledge from North America and Europe as recommendations for design, operation and maintenance of the entire supply chain from feedstock handling and processing, through the production stage and the subsequent logistics to bring the product to the client.

Proposed actions going forward related to off-gassing

It is not clear if other accidents and less severe incidents have happened around the globe in the pellet business since the tendency is to put the lid on news, partly because the more severe accidents usually are subject to criminal investigations and partly because the industry is reluctant to generate more negative publicity than necessary. Also, the rate of accidents and incidents caused by fires and explosions in the pellet business is very high and there is a growing concern regarding the risk exposure from the insurance underwriters. In North America and probably also in Europe the industry has passed the point of comfort for the underwriters and the demand for better practices is on the forefront. It is time for the pellet industry to act rather than hide.

The problem with research in Safety and Health is the funding since it does not attract capital and politicians looking for sexy high-tech projects with short-term highly visible brownie-points. Only when fatalities occur do the issues get some attention. It is not clear how we will be able to change this. The off-gassing is as pointed out a critical issue since it is primarily an occupational health issue. The approach to consider with regards to off-gassing may consist of the following action items;

1. A standardized method for characterization of the off-gassing has been proposed as a work item for ISO Technical Committee 238 for Solid Biofuels. This proposal needs to be nominated and approved as a work item. The testing method should include a temperature controlled reactor unit and a suitable instrumentation system for sampling and gas analysis. The samples need to be selected according to standards and several of the parameters in the pellets needs to be characterized before the off-gassing is measured at different temperatures. This is typical work for a specialized group of experts to develop.
2. All pellet producers should have an MSDS available for their product. A template for a minimum MSDS needs to be developed. The Canadian MSDS can serve as a discussion point although it is likely a simpler version can be developed, particularly for the residential pellets market.
3. The current Shipper Cargo Information Sheet (SCIS) used by Canadian exporters should be reviewed and developed in to a template for bulk shipment. WPAC is currently communicating with the International Safety Panel (ISP) with jurisdiction focused on safety and health issues in the ports and is hoping to develop safety guidelines for port operations related to pellets.
4. Internationally standardized placards and pictograms warning for off-gassing should be developed and become mandatory for all packaging used for pellets. Instructions for ventilation should be developed and also applied on packages.

5. The same applies for storage spaces indoor and outdoor where pellets can be stored. Instructions for safe entry shall also be included and be based on generally accepted procedures for confined space entry.
6. More research needs to be done to develop a clear picture of;
 - a. Difference in off-gassing due to selection of feedstock material
 - b. Recommended manufacturing procedures which may help mitigate the off-gassing
 - c. Recommended practices for storing and handling pellets in a variety of ambient conditions such as;
 - i. Maximum allowed storage temperature
 - ii. Maximum acceptable relative humidity
 - iii. Methods for ventilation and cooling
7. Training programs should be developed for emergency personnel how to deal with incidents involving large storages for pellets to minimize the risk for exposure to off-gassing during rescue operations. This should probably also include instructions for inertation methods for fire fighting in pellet silos. Part of this effort should include;
 - a. development of standards for connecting fixtures
 - b. guidelines for injection geometry
 - c. guidelines for storing breathing equipment at larger storage sites
 - d. inventory of fire fighting equipment and nitrogen storage capacity as part of an emergency preparedness infrastructure

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