

## Monitoring of Self-Heating Coal Cargoes Prior to Loading

Coal cargoes can be particularly challenging to carry, with the possibility of methane production, oxygen depletion and the corrosion of metal structures. Coal from some parts of the world, particularly from the Indonesian province of Kalimantan, is also prone to self-heating due to its lower rank, sub-bituminous geological nature which can lead to spontaneous combustion. This Bulletin provides guidance on the factors that may trigger or promote self-heating and includes precautionary measures that should be taken to help identify and reject coal arriving by barge that has already begun to self-heat. If a vessel loads such a cargo without recognising the warning signs, it may experience significant delay while attempting to deal with the situation due to the remote location of coal ports in Indonesia.



Photo courtesy of: Ciriis Marine Surveyor

Coal cargoes may be liable to self-heating

### Mandatory Requirements

The International Maritime Solid Bulk Cargoes (IMSBC) Code states that coal with a temperature higher than 55°C should not be loaded. Above this temperature, the rate of self-heating in this type of coal can accelerate significantly in the presence of unlimited oxygen leading to fire without an external source of ignition.

### Factors Affecting Self-Heating

In general, self-heating does not take place homogeneously throughout an entire parcel of coal. Hot spots may occur if conditions conducive to self-heating exist.

As coal begins to self-heat, an increasing amount of carbon monoxide is produced. As the temperature of the coal rises the rate of reaction approximately doubles for every 10°C increase in an exponential manner until such time as the coal spontaneously combusts.

Self-heating takes place as a result of surface oxidation of reactive compounds in the coal. Some of the key factors which may influence self-heating include the size of the particles, their surface area, the air gap between the particles and the amount of air available.

The surface area of coal in the form of lumps and large particles is less than for the same volume of coal consisting of small particles and fines. Although it is easier for air to penetrate and oxidise lumps and bigger particles, the larger air gaps tend to dissipate any heat that may develop. Similarly, the reduced air gap between smaller particles and fines makes it more difficult for air to penetrate the cargo and trigger a reaction. Consequently, coal cargoes are more prone to develop hot spots if they do not contain significant quantities of large lumps or very fine particles. The air flow also needs to be sufficient to promote oxidation, but not strong enough to produce a cooling effect.

The presence of moisture due to rainfall can assist the oxidation process and may initiate or exacerbate a self-heating situation. Prolonged weathering or exposure to the effects of wind and rain while the coal is stockpiled or stowed in barges will therefore increase the self-heating risk. Conversely, covering the coal with tarpaulins may, in addition to protecting it from rainfall, restrict air circulation and reduce the possibility of self-heating.



Photo courtesy of: PT. Pancil Nusa Inspektor



Coal barge



Photo courtesy of: PT. Pancil Nusa Inspektor

Coal being loaded from a barge by a floating crane

If coal is loaded into a barge from a spout, the cargo may form a series of conical piles. Loading of coal in this manner causes the larger particles to migrate naturally towards the edges of the cone and for the finer particles to accumulate towards the centre. Depending on the available airflow and the size of the other particles, heat from the oxidation process may rise vertically through the cone so that it acts like a chimney, drawing in fresh air from around the base and causing the cone to self-heat. Ideally, coal barges should be trimmed level once loaded.

Barges loaded with coal being towed will be exposed to relative wind while underway. It has been found that hot spots may develop towards the bows of such barges because of the movement of air in this area, particularly lower down in the stow.

Coal that has been heavily compacted by bulldozers or loaders being driven over the surface is less likely to self-heat as the weight of such equipment tends to squeeze air from the cargo and reduce the gaps between particles.

### Assessing Coal for Self-Heating

Although cargo interests will almost certainly be aware of the propensity for many grades of Indonesian coal to self-heat due to its geological and chemical nature, cargo declarations often

fail to mention this. As a precaution, all Indonesian coal should be considered to be self-heating regardless of what is stated on the cargo declaration.

When a coal barge arrives alongside, the temperature of the cargo declared to the vessel, will usually be an average figure. However, even though the average figure may be less than 55°C, it is possible that the temperature of the cargo may be higher than this in places. If so, it cannot be loaded as to do so would contravene the requirements of the IMSBC Code.

The IMSBC Code recommends that vessels are provided with appropriate equipment to measure the temperature of the cargo when it arrives alongside for loading. All temperature measuring equipment should be regularly checked, serviced and calibrated as recommended by the manufacturer, and the vessel should carry a sufficient quantity of spare parts. Glass thermometers, either mercury or alcohol filled, are too fragile and thus unsuitable for this purpose. So called 'pocket-thermometers', in which the glass thermometer is held within a metal casing usually for mounting in tanks or pipes, are also unsuitable since the reaction time of the thermometer will be greatly increased due to the metal casing having to equilibrate with the temperature of the coal being measured.

Temperature readings provided by third parties should be viewed with caution, and every coal barge should be thoroughly checked by the vessel for signs of self-heating. It should also be remembered that the cargo may have been

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stockpiled or stowed on barges for many days or even weeks beforehand, exacerbating the possibility of self-heating.

If coal on board a barge is seen to be smouldering or emitting steam, the cargo in these areas should be checked very carefully. Smouldering coal indicates that it is burning. Steam signifies that the moisture within the coal has been heated to a point where it is vaporising, following which a rapid increase in temperature may be expected.

There are two methods for vessels to measure the temperature of the cargo on board barges. A temperature probe (thermocouple) may be inserted into the coal to measure the temperature at the end of the probe. Similarly, an infra-red thermometer may be pointed at coal to determine the surface temperature, however, the temperature of any hot



Coal temperature monitoring by infrared thermometer

Photo courtesy of: Critius Marine Surveyor

Temperature measurements should be carried out on board the barge before the cargo is loaded. Initial readings should be taken when the barge first arrives. Further temperature checks should be performed after one third of the cargo has been discharged, and again when two thirds of the cargo has been removed. On each occasion a number of pits should be dug below the surface of the coal, spaced equidistantly in the form of grid pattern over the entire surface area. The precise number of pits and their depths will depend on the size of the barge and the length of the temperature probe. Based on the average size of barges used to deliver coal to vessels in Indonesia, around 20 pits should normally be sufficient. Since coal is thermally insulating and given that the temperature readings are limited to the tip of the probe, several temperature measurements should be taken in each pit, varying the direction of the probe each time in order to identify any localised hot spots.

The probe should be left in place until the reading has stabilised, and the temperature should be recorded thereafter. All temperature records should be retained on board as they may be needed to defend any claims following the rejection of self-heating cargo or any loading delays associated with such action. Since the process of taking temperature measurements can be quite labour intensive, the appointment of a suitably experienced surveyor should be considered.

If just one of the temperature readings is found to exceed 55°C, the entire barge should be rejected even if all other readings are satisfactory.



Coal temperature monitoring by temperature probe

Photo courtesy of: Critius Marine Surveyor

areas so identified should be double-checked with a temperature probe due to the lower accuracy of infra-red thermometers compared to calibrated digital thermometers connected to a thermocouple probe. As exposed coal surfaces can rapidly cool, infra-red thermometer readings should be carried out on freshly-exposed surfaces, if possible.

A temperature probe provides a localised reading. In order to locate any hot spots, numerous temperature probe readings should be taken. Scanning the cargo with a handheld infra-red thermometer may identify hot spots near the surface.



Once the coal has been loaded and the holds have been sealed, the cargo should be monitored for signs of self-heating by checking the amount of carbon monoxide (CO) inside the holds at regular intervals in accordance with IMSBC Code requirements.

## Caution

If cargo interests become aware that cargo on board a barge has started to self-heat, it is possible that they may try to disguise such evidence by employing one or more of the following tactics in the hope of deceiving the vessel into thinking that the cargo is safe:

- Loading cooler coal on top of hot coal.
- Using bulldozers or loaders to turn over the surface of the cargo in the hope that it will be cooled by the wind and air.
- Cooling the surface of the coal by spraying it with water.

There have also been cases where barges rejected by one vessel following clear signs of self-heating have been towed to another vessel in the hope that the cargo will be accepted due to less vigilant controls.

Members requiring further guidance should contact the [Loss Prevention department](#).