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JOINT FIRE RESEARCH ORGANIZATION



# FIRE IN FISH MEAL IN M.V. "MOCAMEDES"

by

P. C. Bowes and K. N. Palmer

Summary

An account is given of a fire which occurred in fish meal carried by M.V. "Mocamedes". From observations made at the incident it is concluded that the probable cause of the fire was spontaneous heating of the fish meal. The conclusion conforms with the known behaviour of freshly prepared fish meal, and it is suggested that the meal was stowed too soon after preparation.

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Fire Research Station,
Boreham Wood,
Herts.

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## INTRODUCTION

A fire was discovered in fish meal in the lower No. 3 hold of M.V. "Mocamedes" on 29th July, 1953. The ship was berthed at Greenland Dock, Surrey Commercial Docks, London.

The incident was visited on 29th July by the authors by invitation of, and in company with, Assistant Divisional Officer Shepherd of the Fire Prevention Branch, London Fire Brigade Headquarters, and again on 30th July by one of us (P.C.B.) with Station Officer Box, also of the Fire Prevention Branch. An account of the early stages of the incident was obtained from Assistant Divisional Officer Selwood of "C" Division Staff, London Fire Brigade.

## HISTORY OF INCIDENT

M.V. "Mocamedes" was loaded with fish meal, in 100 lb gunny bags, by native labour at Walvis Bay, South West Africa. The loading of No. 3 hold was begun on or about 20th June, 1953, and was completed in three days. According to a Ship's Officer the weather at the time of loading was hot and very humid during the day and cold and foggy during the night, when considerable surface condensation occurred.

The ship sailed for England on 29th June, and berthed at Surrey Commercial Dock on 23rd July. Holds No. 1, 2 and 2a were unloaded first and no heating in the fish meal was reported. Unloading of Hold No. 3 was begun on 28th July and the main deck and part of the 'tween deck (Fig. 1) were cleared by the end of the day, but the hatch cover of the lower hold was not exposed.

Early on the morning of 29th July a member of the crew noticed that the starboard ventilator A (Fig. 1), communicating with the lower No. 3 hold, was warm and smoke was issuing from it. The Fire Brigade was called at 02·09 hours.

The Fire Brigade removed the after part of the hatch cover of the lower hold and found that the hold was hot and contained smoke. The topmost bags of fish meal in the lower hold were very damp and covered with white fungus. On removing bags a seat of fire was found in the position indicated by the shaded area "B" in Fig. 1. The fish meal and jute bags were charred and were smouldering slowly; no flame at all was encountered.

## AUTHORS' OBSERVATIONS

First visit (29th July). Removal of the affected fish meal was in progress and the seat of the fire had apparently been reached. The meal was charred to a dark chocolate brown and was smoking slightly and, since the bags had disintegrated, it was being removed by shovel and basket. In addition to a small amount of smoke in the hold there was a smell of ammonia.

Some bags of damaged fish meal were examined on the quayside. The meal was charred and caked and, when a lump was split open, it was found to be a uniform dark brown colour throughout and was hot in the centre. The bag fabric was generally charred brown but, in places, was more completely carbonized and disintegrated. It appeared that carbonization of the bag fabric occurred in places where the fabric would probably have been exposed to air, as in channels between bags in the hold. In other, less damaged, bags the meal showed varying degrees of darkening in colour.

The removal of undamaged bags in the lower hold hatchway had been carried only far enough to permit easy access to the affected area B. The bags still in position appeared to be clean and in good condition and were generally cool, but on thrusting the hand into channels between bags some warmth could be felt.

A narrow passage ran between the bags over the propeller-shaft tunnel. At two points on the port side of this passage hot spots had been found by the Fire Brigade. At these points there were channels between the bags which were large enough to admit the hand easily and which, a short distance in, felt very hot. In the entrance to one of the channels there were oily droplets adhering to the bags. The opinion was formed that these hot spots were flues communicating with a deep seated fire.

Second visit (30th July). Unloading was being carried out by stevedores with the Fire Brigade standing by. The lower hold had been cleared down to the level of the top of the propeller-shaft tunnel and the area affected by the main fire (B) had been cleared completely. It could be seen that the stowage was divided into sections by narrow transverse spaces indicated in the plan, Fig. 1, and dunnage was placed across the propeller-shaft tunnel as shown. This or similar dunnage was encountered in the passage, between the bags, explored on the first visit.

There was a hot spot in the position indicated by the shaded area C in Fig. 1. Faint wisps of smoke appeared from between the bags occasionally. As bags were removed from this area hot, darkened, bags were uncovered and an increasing area of damage was evident. Only a few layers of bags were removed from the heated region, however, as the stevedores tended to concentrate on the undamaged bags. It seemed probable that the hot spots in the passage between the bags (first visit) were flues communicating with the heated area C.

Further hot spots were reported, by the Fire Brigade Sub-Officer in charge, in the places indicated approximately by the areas D and E in Fig. 1. These were not uncovered in the presence of the author (P.C.B.).

It was noticed that a number of the bags being brought from the hold were frayed and holed, and the fish meal leaking out was darkened slightly.

## SPONTANEOUS HEATING TESTS ON FISH MEAL

On the first visit two samples of fish meal were taken from bags on the quayside. One consisted of undamaged meal, and the other was meal which had been heated to some degree and was darkened in colour.

A test of the Mackey type with controlled air flow [1] was carried out on each sample to detect any tendency of the meal to undergo spontaneous heating by oxidation. Specimens were packed at densities of 0·49 - 0·64 g/cm$^3$ in paper cylinders 3·5 cm diameter and with a packing length of 7 - 8 cm. The air flow was 300 cm$^3$/min. The first test carried out showed that self-heating either did not occur or it reached completion at a slow rate during the initial heating of the specimen to the temperature of the enclosure, 100°C. In further tests therefore the initial heating up to 94 - 96°C in three hours was carried out in an atmosphere of nitrogen; air was then passed through for a further four hours. In all cases the temperature continued to rise slowly to a steady value of 98 - 99°C and there was no sign of self-heating.

In order to test for the occurrence of heating due to microbiological activity in the meal, 140 g of the undamaged meal was moistened with the quantity of water necessary to increase the moisture content to 20 per cent (from the initial value of 8 per cent), and stored in a pint dewar flask in a constant-temperature room at 25.5°C. The temperature of the meal behaved in the manner shown in Fig. 2. Except for variations which were related to variations in the room temperature (due to unusually high day temperatures) the temperature remained virtually stationary for four days and then rose to 42.5°C in a period of twenty-four hours. It then fell slowly but remained above 40°C for two days before falling more rapidly to near room temperature by the tenth day. At the end of the test the fish meal was mouldy throughout and had an average moisture content of 19 per cent.

In moist vegetable matter it is possible for the temperature to rise to about 70°C as thermophilic bacteria become active, but the passage to this stage usually requires smaller heat losses or, what is in effect the same thing, larger masses of material than are possible in an experiment on the dewar flask scale. The present test could not therefore be expected to show whether temperatures as high as 70°C could be reached by biological activity in the fish meal.

## REVIEW

Fish meal is the dried and ground residue of whole fish or fish scrap that has been cooked and has had the oil extracted. The meal is recognized in the industry as being liable to heat spontaneously, and even ignite, if stored in bulk immediately after preparation. The heating is due to oxidation of the residue of oil, usually 5 - 12 per cent, present in the meal.

According to Harrison [2] it is normal practice for the unground material from the drier to be spread out on the floor for 24 to 48 hours before grinding; alternatively the dried material is ground and bagged immediately and the bags are allowed to stand 24 to 72 hours before stacking. The bags of meal prepared from material cured on the floor before grinding are allowed to stand loosely stacked for 24 to 48 hours before final close stacking. During the first six to twelve hours the temperatures in the centre of a bag may rise by 50 - 100°F (28 - 56°C). Harrison [2] has published curves showing a temperature rise of this order in Herring meal and Sardine meal in burlap bags. The degree of heating is less for less oily fish. It appears that spontaneous heating due to oxidation may be reduced, or even prevented, by packing the meal in multiwall paper bags [2, 3, 4].

Two sources [5, 6] give 6 and 12 per cent as the lower and upper limits respectively of moisture content for the safe storage of fish meal in jute bags; one [6] states explicitly that meal which has been over-dried or packaged above 100°F is dangerous. The reason for the existence of the lower limit is not clear, unless it is that material which has been over-dried is, at the same time, overheated and is therefore undergoing oxidation at a high rate.

Results of tests by Lewis [7] do not, so far, show any definite relationship between the self-heating due to oxidation and the moisture content of the meal. Observations of self-heating in bags of cured pilchard meals with moisture contents of 14 and 22 per cent have been reported [8]. Increases of temperature occurred in the bags within 12 hours and again after six days as follows:-

| Moisture content (%) | Temperature rise (°F) 12 hrs. | 6 days |
|---|---|---|
| 14 | 9 | 7 |
| 22 | 20 | 56 |

The initial temperatures are not stated. No explanation of these results is advanced but it is probable that the second temperature rise was due to microbiological activity.

## DISCUSSION

The occurrence of widely separated and, as far as could be seen, unconnected centres of heating in the fish meal, each well inside the separate "stacks" in the lower hold of M.V. "Mocamedes", strongly suggests that widespread spontaneous heating occured, and that the fire was due to this cause. The heating must have been in progress for a considerable period; the fact that it was not evident until after the ship berthed may be a mere coincidence or may be related to the change in ventilation conditions when the ship became stationary.

The damp and mouldy condition of the top bags found on opening the lower hold may have been due to the condensation of moisture, under the lower deck, driven from the centres of heating. It does not necessarily indicate that the fish meal in the lower No. 3 hold had a higher moisture content when stowed than the meal elsewhere in the ship. The authors obtained no information which indicated that the meal in the lower hold had been exposed to, for example, rain on the quayside before loading. The humid conditions prevailing at the time of loading should have affected the whole cargo equally. Thus, although it has been shown experimentally that the moistened meal is capable of self-heating it does not follow that an excessive moisture content was responsible for the heating that occurred in the lower No. 3 hold.

In the light of the known behaviour of fish meal the most probable explanation for the spontaneous heating that can be suggested is that the meal in the lower No. 3 hold was stowed too soon after preparation. If all the meal in No. 3 hold belonged to one consignment, that on the 'tween deck and main deck would have had a longer period in which to approach complete oxidation before stowage. A period of 24 hours or so could be expected to make a large difference to the state of oxidation of fresh meal and, it must be remembered, the loading of No. 3 hold took three days. Confirmation, or otherwise, of this explanation requires a detailed knowledge of the actual history of the meal involved, and this is not available.

The failure to observe any tendency to heat in the test for self-heating by oxidation was probably due to the fact that the oxidation was complete in the samples tested.

## CONCLUSIONS

1. The fire in the fish meal in the lower No. 3 hold of M.V. "Mocamedes" was probably caused by spontaneous heating of the fish meal.

2. The spontaneous heating may have been due to the meal being stowed in the hold too soon after preparation.

## ACKNOWLEDGEMENTS

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## REFERENCES

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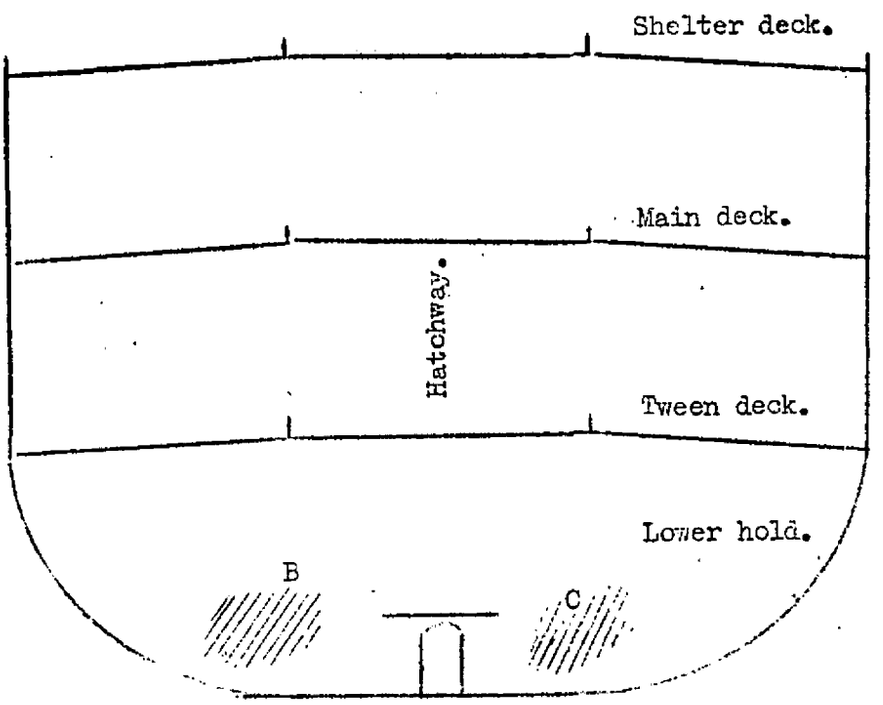


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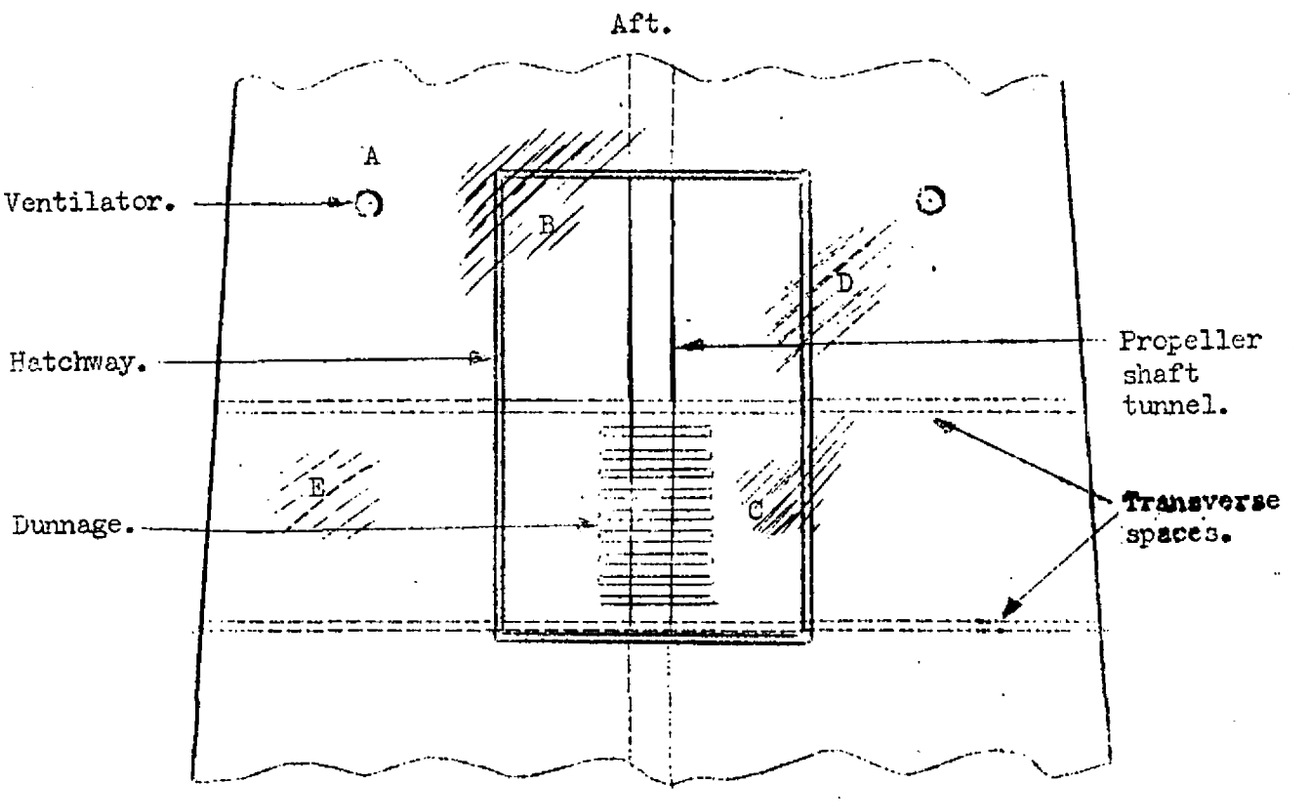


PLAN.

FIG. I. M.V. 'MOCAMEDES' SKETCH OF No. 3 HOLD

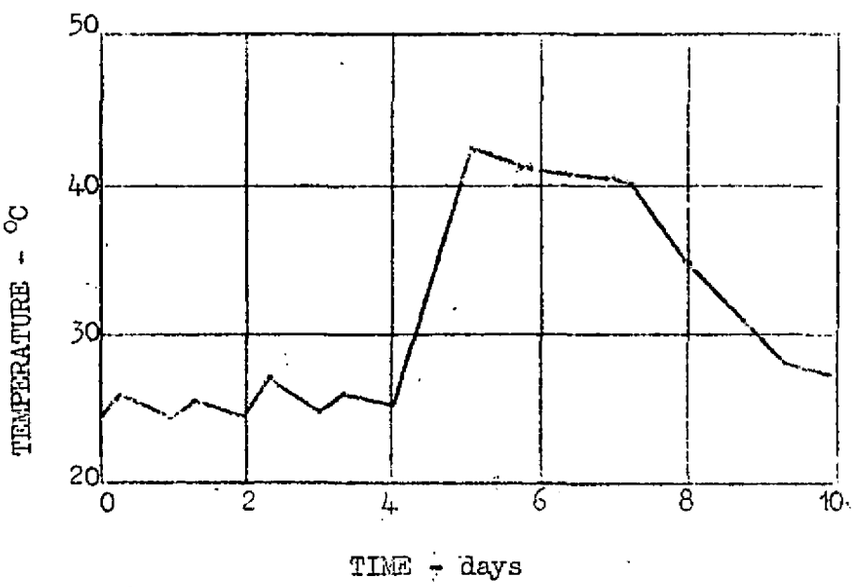


FIG.2 SELF-HEATING OF MOIST FISH MEAL