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Let It Flow! The Limitations of the Flow Table Test

When carrying cargoes that may liquefy, the vessel's owner and crew rely on the accurate testing for the cargo's flow characteristics. This raises the question: are all tests equal?

The problems associated with the liquefaction and dynamic separation of cargoes such as nickel ore, iron ore fines and bauxite are well documented. Too many vessels have been lost and the lives of seafarers taken away when these cargoes achieve a flow state and stability is lost.

These dangers are recognised by the IMSBC Code, which places an obligation on the shippers of Group A cargoes (those cargoes liable to liquefy) to provide the carrier with details of the laboratory analysis of the cargo – namely the 'transportable moisture limit (TML)' and the moisture content (MC).

The TML can either be measured directly (using one of the four Proctor Fagerberg methods), or by first testing for the flow moisture point (FMP) using the flow table or Penetration test methods, then calculating 90% of this value. These methods are detailed Appendix 2 of the IMSBC Code 2020 Edition.

The flow table method is widely used around the world. Its popularity is primarily because of its perceived simplicity and its ability to be used anywhere at any time, particularly in less-developed regions where there are limited laboratory resources.

Understanding the flow table test

The equipment required to determine the FMP is basic, comprising a standard flow table, frame and the flow table mounting, a mould, a tamper, scales and weights, a glass measuring cylinder, a mixing bowl and a drying oven.

The procedure is laid out clearly in Appendix 2 of the IMSBC Code, but in very basic terms the test is carried out by filling the mould with a cargo sample and tamping this into the mould (the tamping is alleged to simulate cargo compaction that may occur at the bottom of a ship's hold). The mould is then removed

carefully leaving the sample in the mould shape on the flow table. The flow table is then operated (turning the handle) which raises and lowers the table at a set rate and height.

If the sample is below its FMP, it will crumble on the table. Once this crumbling occurs, the sample is returned to the bowl and water added from the measuring cylinder. The process is repeated until a 'flow state' is reached and observed.

What is a flow state?

When the flow table operator notes the sides of the sample deforming (either convex or concave) by approximately 3mm without crumbling, this is considered to have deformed. The moisture content of the sample at this point is considered to be the FMP.

However, plastic flow state cannot be indicated by a generic measurement (3mm increase in base diameter for example). The IMSBC Code defines plastic flow state very precisely, referencing saturation, density and plastic deformation instead. The IMSBC Code also suggests that a template to gauge deformation/ size increase in any part of the sample is a useful aid and gives 3mm only as an example of an amount of deformation, not an absolute measurement.

Important limitations of the flow table test

The flow table test may not be appropriate for all cargoes. The IMSBC Code clearly outlines test parameters, in Appendix 2 subsection 1.1.1:

- The flow table is generally suitable for mineral concentrates or other fine material with **a maximum grain size** of 1 mm.
- It may also be applicable to materials with **a maximum grain size** up to 7 mm.
- It will not be suitable for materials coarser than this and may also not give satisfactory results for some materials with **high clay content**. It should be noted that only cargoes with mineralogical (silica) clay will impact the results.

Another key issue is that the test can be subjective. It relies on the personal interpretation of when a state of deformation has been reached. Relying on the tester's naked eye, two independent persons testing the same cargo could reach different opinions. This is the reason why testing houses write 3mm into their procedures to remove the requirement for interpretation and recognition of flow state. However, this is an incorrect approach as the IMSBC Code defines deformation very precisely, referencing saturation, density and plastic deformation.

Problems in practice

Due to the aforementioned limitations, experts say that use of the flow table test can be prone to over-inflating the FMP, which in turn overstates the TML value.

Inaccurate TML tests can have adverse effects on the carriage of the cargo. In regions where the flow table

test is regularly used, the moisture content can be as little as 0.5% to 1% below the declared TML, which presents little margin for error.

Equally, FMP can also be understated (typically in mineral concentrates) because the tester applies the absolute measure of 3mm before flow state has occurred, which is an incorrect approach.

We have observed that some shippers and mines often declare a relatively course cargo with a large percentage (50% or more) of the cargo being well over the limiting particle size of 7mm. However, the flow table has still been used despite the limitations outlined above, meaning the tested sample is either outside the boundaries for accuracy or not representative of the entire cargo to be loaded.

Some regions that use the flow table test to determine TML are exporting cargoes with very high clay content. A typical example is nickel ore from the Philippines. The IMSBC Code clearly states that clay content may affect the accuracy of the results.

Additionally, the misuse or erroneous application of the IMSBC Code subsection 1.1.4.4 (rapid plotting method) to determine the approximate FMP can lead to the overstating of the TML result, thus allowing the Shipper to potentially present cargo with a moisture content that is close to or in excess of the actual TML, again an issue that is more critical with cargoes such as nickel ore from the Philippines.

In Summary

The flow table test is a legitimate test method. However, due to its limitations, the owners and crews of carrying vessels should remain cautious when agreeing to load a cargo that has been tested using this method.

Always check the cargo declaration in detail, and if concerned about the accuracy of the test used for the specific cargo being delivered to the vessel, carry out a check test in accordance with Appendix 2 subsection 8.4 for approximately determining the possibility of flow and then, if this shows a potential issue, insist on additional laboratory testing before the cargo consignment is accepted for loading.

Source of Information: The NorthStandard P&I Club