TBS Shipping

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On a balmy Friday in April, Joe Cabrera arrived at his dock in La Place, Louisiana to oversee the final loading of the MV Hamburg Pearl, a bulk cargo ship soon headed across the Atlantic Ocean. This shipment marked the inaugural exchange of what he hoped would be a long and lucrative relationship between Joe's TBS Shipping and Lee Energy, a Crossville, Alabama firm that produced pressed wood pellets used as fuel for boilers and as a direct heat source. TBS had made many promises to Lee Energy, and it was his job to make sure that those promises were delivered on, and then some.

As he parked his car in his customary spot, Joe noticed with chagrin that the loading equipment, which should have been busy moving the last of the bulk cargo from the remaining barges onto the Hamburg Pearl, was still and silent. Joe was accosted on the way to investigate the matter by Ted Simmons, supervisor in charge of the dock. Ted was curt. "Joe, we're done loading the ship." "Great!" replied Joe. "Your crew finished sooner than I expected you…" "Thanks," Ted interjected, "but it's not great. Come have a look."

Joe allowed Ted to lead him to the waterfront where a crane scoop was poised over the open hatch coamings of the Hamburg Pearl, and next to a sizable barge. Joe darted his eyes back and forth between the ship and the barge. "Why is this barge half full of cargo?" Joe growled. Ted grimaced and explained. "The ship is full. To the brim. We can't get any more in her, and don't think we haven't tried."

Joe noticed a small headache developing behind his right eye.

"Ted, I courted this client. I built the relationship. I picked the ship personally and negotiated the delivery terms. I've committed to my client that we will get their cargo to them on this ship," groused Joe. "If I can't, then my client will have to pony up for cargo space on another ship for the overage, and no doubt at a premium. Do you have any idea what this could do to our relationship?"

"I can guess," replied Ted. "Look, I don't know what to tell you other than we loaded the ship like we always do, and there's about 1,600 metric tonnes of cargo left over. The captain is preparing to sail right now, and is currently running the numbers on the cargo weight and stow factor and so forth."

In a back office, Joe phoned his contacts at Lee Energy to explain the problem. His clients were not pleased, and in fact sounded like they blamed Joe for the mistake. "We told you how much cargo, and you picked the ship!" was their final judgment before signing off. Turning to Ted, Joe said, "get me the cargo numbers as soon as you have them, get the leftover cargo onto another ship as soon as possible, and for goodness' sake, get the Hamburg Pearl underway."

The next morning, Joe attended a teleconference with members of the TBS Shipping team, including then-COO and Executive VP Gregg McNelis and Shana McNerney, and the Hamburg Pearl was the first item discussed. Joe presented the facts of the case, including that the Hamburg Pearl's cargo volume was listed as larger than the expected volume of the pellets TBS Shipping had agreed to move. "How did you determine the expected volume of the pellets?" asked one of the executives. "Pretty standard, actually," replied Joe. "We took the weight of cargo we agreed to move and divided it by the known stow factor of the pellets." "That should do it," agreed the executive, since the "stow factor" described how much weight of something would fit into a given volume. The teleconference devolved into a brainstorming session about what could have caused the overage.

Many ideas were bounced around. Could there have been voids of space remaining in the ship's holds caused by the bulk cargo failing to properly settle? How that could be corrected, if it were true? Could the stated cargo hold volume of the MV Hamburg Pearl be wrong? Could the cargo itself have swelled up in the New Orleans humidity while waiting in barges for the ship to arrive? It was wood, after all. They were not even sure which the right questions to ask were. One thing was clear though: TBS Shipping needed an answer for why there was 1,600 metric tonnes of cargo still moored to a New Orleans dock long after the MV Hamburg Pearl set sail.

Background

Wood Pellet Energy

The biomass wood pellet industry competes with and supplements other forms of combustible energy, such as coal and petroleum products. Wood pellets are produced from natural wood sawdust, which is industrial waste resulting from the milling of yellow southern pine into boards for the home construction industry, among others. The waste sawdust is then "reduced to uniform size and dehydrated to the desired moisture level" (Lee Energy Solutions, 2011).

Historically, Lee Energy had sold their pellets to the agricultural industry, where they were burned in furnaces to heat poultry coops. The pellets were particularly well-suited for this purpose due to their ability to produce a consistent, dry heat that resulted in dramatically reduced moisture levels in chicken coops. Drier chicken coops in turn improved litter quality and reduced the chance of pneumonia in the poultry stock. Thus, the control of the moisture levels within the wood pellets was vital to the success of the customer and, therefore, of Lee Energy itself.

Moisture levels, in general, varied between 10% and 20% by weight, with the goal being 10% and with US EPA method 28 dictating that moisture content shall not be above 20%. While wood pellets may be produced from a variety of hard and soft woods, the process of wood pelletization was such that all end products had the same density, calorific values and ash production (with the exception of West African Iroko wood, which will yield a higher ash content). The possibility of changes in moisture content is also made less likely due to the presence of large amounts of water-resistant lignin, the same natural glue-like polymer that served as a binder for the pellets themselves (Coed Cymru, 2011).

The primary wood used for biomass pelletization in the southeastern United States is southern yellow pine, of which there were three sub-species. Southern yellow pine works particularly well for the production of such a biomass, because the natural level of lignin in the wood served as an inherent binder that improved pellet durability and moisture resistance. Lignin content had been found to be the only variable in the production of wood pellets that was affected by tree species (Coed Cymru, 2011).

The year 2008 saw a dramatic rise in the export of wood pellets from the US to European buyers from approximately 50,000 tonnes of export in 2006 and 2007, up 500% to 250,000 tonnes in 2008. This was due to a rise in pellet consumption in Europe, where the pellets were beginning to increase in popularity as a primary source for power generation as well as residential and commercial heating. (Spelter & Toth, 2009)

In this new European market, specialized trucks delivered these wood pellets to customers in bulk, pneumatically unloading them into chutes that led to storage bins. Such a delivery system was analogous to fuel-oil delivery methods and simplified logistics for those customers involved in power generation, who had grown accustomed to such systems of measurement. For these customers, particularly the European utility companies, it was desirable to express the volume of bulk pellets in terms that could be compared to their energy value of 4.9 kWh/kg (Spelter & Toth, 2009).

TBS Shipping

TBS Shipping was a subsidiary of the Yonkers, New York-based TBS International, which operated a fleet of several dozen ocean-going cargo vessels.

The bulk of TBS' efforts were geared toward meeting the needs of markets that could not be properly served by container and very large dry bulk vessel operators. TBS configured its fleet to enable service to ports that had greater restrictions on the size of vessels. Within this framework, TBS identified itself with the specialized hauling of large amounts of dry goods that were not containerized, and with attempts to build long-term relationships with customers whose needs met the specialized conditions of low-draft, highly-maneuverable vessels during at least one leg of the journey for which they were seeking charter (TBS, 2011).

As of 2011, the TBS fleet consisted of 52 vessels with a total capacity of 1.6 million deadweight tonnes. The fleet included 30 multi-purpose tween-deck ships and twenty-two handy-size/handy-max bulk carriers. The handy-size carrier was a dry bulk vessel with a deadweight of anywhere between 15,000 and 35,000 tonnes, while a handy-max bulker occupied the 35,000 to 59,000 DWT range. Such vessels were extremely flexible, with a typical fully-loaded, or “summer”, draft of only ten meters (33 feet). To date, there were approximately 2,000 registered handy-size/handy-max bulkers in service worldwide. Where appropriate, TBS could also arrange the hiring of larger vessels from other fleets. This was the case with the motor vessel Hamburg Pearl, a 200-foot ocean-going bulk carrier with retractable hatch combings that was hired to export the cargo in question to Tyne, United Kingdom (UK) (TBS, 2011).

Lee Energy contracted with TBS shipping to provide transport and customs services between its manufacturing facility in Alabama and its customer in Tyne, UK. The basic agreement called for shipping between 30,000 and 38,500 metric tonnes (MT) of material. The shipping charge was about $30 per metric tonne.

During the initial setup of this relationship, TBS representatives asked Lee Energy for a measure of the cargo stow factor, which, conveniently, Lee Energy had already painstakingly calculated as "max 53 cubic feet per metric ton."

The plan was for the pellets to leave the production facility in trucks, with the material weighed on site for conformance to the shipping contract. Trucks would move the cargo to the Tennessee river port where it was dumped into barges and barged to the shipping port in La Place, Louisiana, as shown in Figure 1.

Figure 1: Trucks dumping pellets into an open barge (McNerney)

Once in La Place, the barges would be "fleeted", meaning they would wait there until an entire load arrived and the ocean going ship was hired, and then floating cranes would transfer the pellets onto the hired ship, as depicted in Figure 2. The ship would then take the entire load across the Atlantic Ocean to Tyne, UK where the cargo would be weighed and measured on the ship, and then ownership transferred to the customer.

Figure 2: A crane loading pellets from a barge onto a ship (McNerney)

This trip, as planned, might take months from beginning to end. The longest part of this time was the wait time of the barges in La Place for the entire load to arrive, and for a ship to be hired and arrive in port. This means that the wood pellets would sit in unsealed barges on the water next to the Gulf of Mexico for three or four months, possibly.

The MV Hamburg Pearl

For the first shipment, TBS Shipping hired the MV Hamburg Pearl, which was a handy-max bulk vessel built in 1982 and sailing out of Liberia. The Hamburg Pearl had a total of seven cargo holds, each with its own hatch. See Figure 1 in the Appendix for the hold capacities.

The Hamburg Pearl had a combined 1,915,470 cubic feet of grain capacity, including hatch coamings. (SGS, 2011) Given the max stow factor of the material, TBS concluded that the Hamburg Pearl's pellet capacity was:

$$1{,}915{,}470\ ft^3 / 53\ ft^3/MT = 36{,}140\ MT$$

The total weight of the shipment turned out to be 36,110 MT, which was just under the expected capacity of the ship, with an expected volume of 36,110 MT x 53 ft^3/MT = 1,913,830 ft^3. However, with all cargo holds full to the hatches, the quantity loaded was only 34,505 MT, leaving 1,605 MT still sitting in barges. The leftover cargo was deemed dead freight, and dead freight charges amounted to just over $55,000 to Lee Energy, including $48,150 freight charges ($30/MT x 1,605 MT) plus almost $7,000 in additional costs due to the need for an additional trip with separate overhead expenses.

Investigation

It was clear to both companies that there was a serious discrepancy threatening their smooth relations going forward. The nature of this discrepancy was, however, opaque to the leadership of both TBS and Lee. While both companies shared ownership of this problem, the fact that TBS was a shipping company and the problem was a shipping problem meant that it was up to TBS to initiate an investigation into the problem. Stated briefly the problem was, "Why does a ship with cargo volume of 1,915,470 cubic feet fail to load cargo of volume 1,913,830 cubic feet?" Just as properly, one could have phrased the problem as, "Why does cargo with a volume of 1,913,830 cubic feet fail to fit into a ship with cargo capacity of 1,915,470 cubic feet?”

To approach this problem, TBS representatives gathered as much data and information as possible about the nature of the ship, the cargo, the calculations made, why decisions were made, and how decisions like these were generally made in the shipping and energy production industries.

These relevant data and this information were gathered and analyzed by the investigation team to discover which questions could be asked that could fill in gaps of understanding and point to the best areas of investigation.

Some of these questions could be answered quickly and painlessly, while others would require long studies. The team decided to focus initially on the questions that could be answered one way or the other quickly. If none of these questions yielded fruit, then additional plans could be made to spend time and money on the more difficult ones.

The initial question list looked as follows.

Question List with Answers

1. Is there a record of the volume of material received in Tyne, UK?

   The cargo arrived in Tyne and was measured having a weight of 34,505 MT.

2. What are the manufacturing tolerances of the wood pellets?

   Manufacturing tolerances are very small, and should not contribute to any significant difference in stow factor between lots.

3. Does the raw material source of the wood pellets vary in a manner that could affect the weight and/or volume of the final product?

   Not noticeably.

4. What (and how effective) is the process used to impart dimensional stability in the face of temperature and/or humidity changes?

   Pellets, though made of wood, are subjected to very effective moisture rejection measures, since moisture content is one of the key measures of quality for this product. The product may vary between 10% and 20% moisture content, with little impact on dimension.

5. What method was used to determine the stow factor?

   Citing ASTM standard E 873-82 Standard Test Method for Bulk Density of Densified Particulate Biomass Fuels:

   Bulk density is the measure of density of a bulk item under conditions important to its buyers, sellers, or users. For wood pellets, bulk density represents a packed volume of pellets that compares well with other types of energy products, such as coal or fuel oil.

6. Was there a significant change in the weight of the ship that could have affected the captain's estimate of stow factor, such as changes in fuel or fresh water levels?

   The fuel and freshwater levels are fairly constant during loading, and any small changes due to minor fuel and water consumption do not significantly impact the baseline weight of the ship.

7. Was there a significant foreign matter mixed into the pellets that contributed to volume?

   Although wood biomass is a type of agricultural product, the presence of foreign matter in it is very close to zero due to its highly-processed and quality-controlled production requirements. Foreign matter is not expected to be a significant contributor to volume.

Of these seven questions, only one lent itself to serious investigation: that of stow factor calculation. As such, the investigation team concentrated on understanding this issue. The team found that there were at least three different methods of stow factor calculation for these pellets, and the differences between them were important to the cargo discrepancy found.

Captain's Method

The most straightforward stow factor calculation was the one made by the ship's crew upon the completion of the loading of the ship. The method requires accurate knowledge of the cargo volume of the ship in question, the specific gravity of the water in which the ship rests, and how far into that water the loaded ship settles. By knowing the specific gravity of the surrounding water and measuring the draft depth of the ship, the crew can calculate the weight of the cargo. There are four draft survey steps:

1. Reading the draft marks of the ship, which consist of six (6) points of draft marks; fore, amidships, and aft on both sides of the ship. This is done before and after the loading.
2. Sampling and testing the sea water or dock water density at the place where the vessel floats.
3. Determining of deductible weights by measuring and sounding of ballast tanks, including fuel oil and freshwater, that exist on board the vessel at the time of survey. These amounts are adjusted to compensate for any changes in freshwater and fuel oil that occur during the loading process.
4. Using a hydrostatic table on board to calculate cargo weight, given the data from steps 1, 2 and 3.

In this case, the captain calculated a cargo weight of 34,505 MT. Then, using the known volume of the cargo holds, the stow factor was calculated using the following formula:

$$1{,}915{,}470 \text{ ft}^3 / 34{,}504 \text{ MT} = 55.5 \text{ ft}^3/\text{MT}$$

The report from the captain of the Hamburg Pearl of 55.5 ft^3/MT was significantly higher than the expected stow factor of (maximum) 53 ft^3/MT given by the manufacturer.

ASTM D 1895 Method B

ASTM International publishes testing standards for the bulk densities of items like the pellets in this case. In particular, ASTM D 1895 reads: “The test can provide a gross measure of particle size and dispersion which can affect material flow consistency and reflect packaging quantity”. This method ignores complicating factors like the excess waste materials often found in bulk agricultural products because pellet products, while agricultural in origin, are heavily processed and cleaned, removing essentially all foreign materials.

Method B of ASTM D 1895 applies specifically to "course powder or pellets" and states: "For coarse, granular materials that either can't be poured or that pour with difficulty through the funnel from Method A. The test is performed by pouring the material through a funnel into a cylinder of known volume. The apparent density is then calculated by dividing the weight of the material in the cylinder by the volume of the cylinder."

This method is presented here as a general method for determining the packaging density for pellets, as contrasted to the method actually used by Lee Energy.

Lee Energy's Method

Motivated by a good faith desire to accurately measure the bulk density of its wood energy pellets, Lee Energy used a methodology intended to determine the volume per unit of weight of their product by performing the following test:

"The pellets are dumped over a cylinder of 1 ft^3, and then the cylinder is raised 6 inches and dropped. The cargo settles a bit. The cylinder is then topped off with pellets and dropped again. This process is repeated three times. After the third drop, the cargo inside the cylinder is weighed."

This test was identified by the investigation team as ASTM standard E 873-82 “Standard Test Method for Bulk Density of Densified Particulate Biomass Fuels.” The resultant weight per cubic foot of product was then converted to cubic feet per metric tonne, and was ultimately calculated as 53 ft^3/MT.

The application of this standard was a quality control measure—rather than a shipping density measure—which lends support to the idea that the volume discrepancy resulted from two disparate—yet popular and applicable—understandings of the terms “bulk density” and “stow factor”. On the one hand, Lee Energy, as an energy industry member, desired to demonstrate mass per unit of volume of biomass energy pellets commensurable to those measurements used by the rest of the energy sector. On the other hand, the transportation industry desires a similar measurement that is representative of the way materials will behave as they are moved about from one mode of transportation to the next.

A Final Method

The team of investigators, upon discovering how different the intents behind the two bulk density testing methods were, nominated this difference as the prime suspect in the dead freight of April 15. Indeed, team members wondered aloud to one another how a ship full of pellets might be lifted and dropped three times to replicate the test method used by Lee Energy.

The team decided upon one final estimation of stow factor as a test of the discovery of the different stow factor calculation methods. The biomass wood pellets had a material safety data sheet (MSDS) that listed specific density (bulk density), and only needed conversion to units comparable to the ones used by Lee Energy and TBS Shipping. According the MSDS, the specific density of the wood pellets was 40 pounds per ft^3. This was converted to ft^3/MT using the following process:

1) 1 MT = 2,204.6 lb.
2) Therefore, 1 lb = .000453597 MT
3) Therefore, a density of 1 lb/ft^3 = .000453597 MT/1 ft^3
4) To get ft^3/MT, flip the numerator and denominator and divide the numbers. So, 1 ft^3/0.000453597 MT = 2,204.6 ft^3/MT

To follow this process using the MSDS bulk density value of 40 lb/ft^3, the team did the following:

1) 40 lb. = 0.01814388 MT
2) Therefore, the density according to the MSDS = 0.01814388 MT/1 ft^3.
3) 1 ft^3/ 0.01814388 MT = 55.12 ft^3/MT.

The stow factor of 55.12 cubic feet per metric ton found by this method is very close to the one calculated by the ship's captain—and is much closer than the stow factor provided by Lee Energy—but is, of course, dependent upon an accurate (and commensurate) MSDS.

Executive Dilemma

As noted above, the stow factor number that TBS Shipping needed for its contract with Lee Energy was one that helped them decide what size ship would be necessary to move a given weight of Lee Energy's pellets. As also noted above, the idea of "stow factor" is easily conflated with similar, but not identical notions of "bulk density", which has several standards for its calculation, none of which explicitly fulfilled the needs of TBS Shipping in this case.

Executives at TBS Shipping were left to decipher the information gathered by the investigation team and to make a determination of what caused the discrepancy about the Hamburg Pearl and how it could be prevented going forward.

Appendix

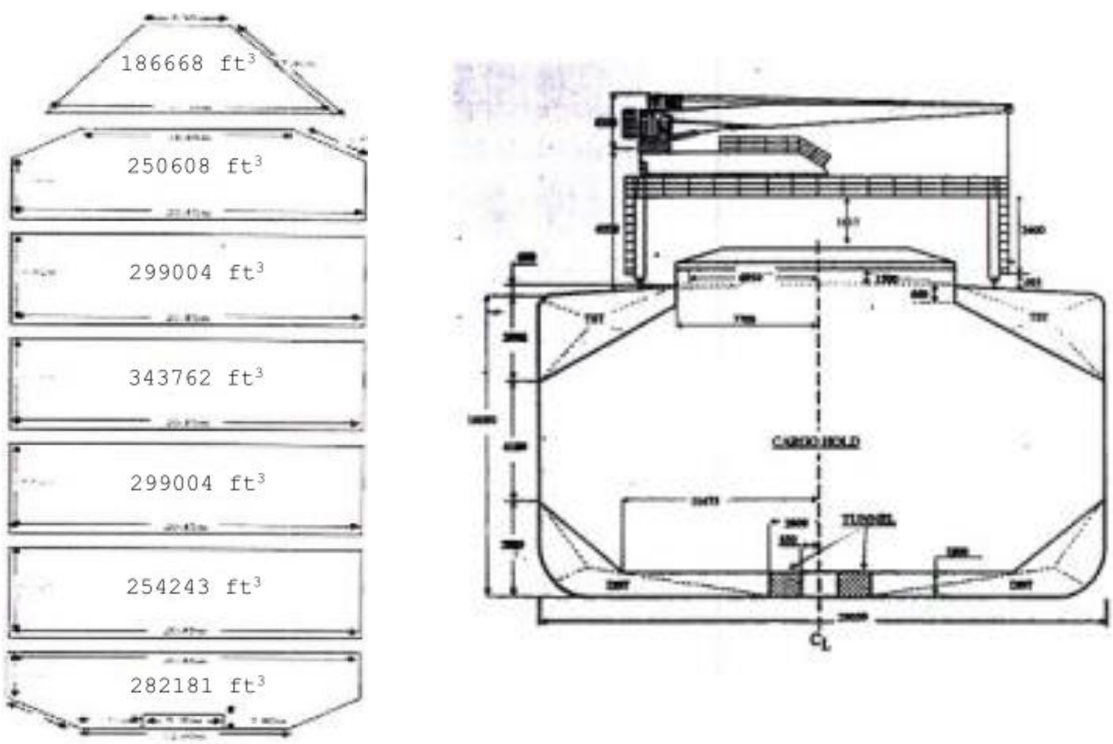

Figure 1: Hamburg Pearl cargo hold measurements (McNerney)

Endnotes

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