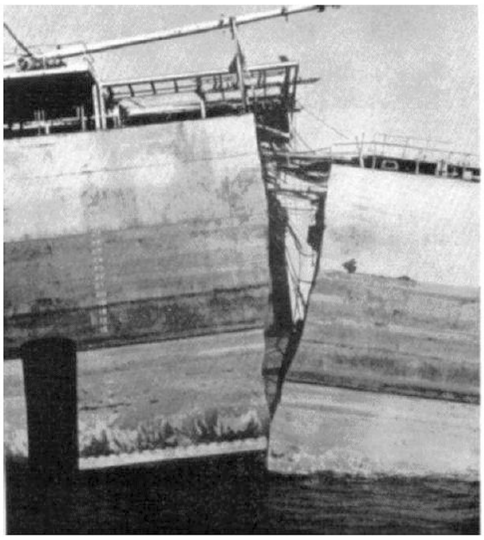
Illustration

The Liberty Ships

- Early in World War II, German U-Boats were sinking cargo ships destined to bring food and things to the people of Great Britain at three times the rate at which they could be replaced. Existing ship building methods still used **rivets** to clap the steel parts together, and that takes time.
  - The solution to the problem wasn't to let the British starve but to built ships faster than our U-boat guys could sink them. The "Liberty Ship" design, pioneered by the British, was just right for that because those ships were made from widely available cheap steel that was welded together and not riveted.
    One could built a ship like that in about 50 days, less than 20 % of the time needed for traditional techniques.
- Well, you can't beat the first law of economics. Liberty ships could be build very quickly and were cheap, indeed - but they had this unfortunate tendency to break apart without help from German submarines. Here are some pictures:

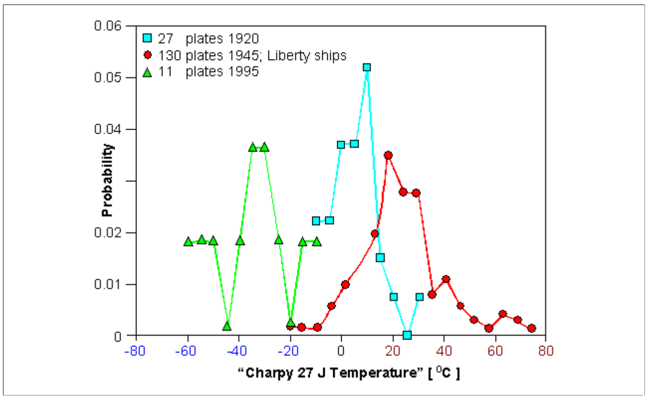


Fractured Liberty Ship
More pictures here.

Source: All over the Net.; see also [1)]

  - Here is a bit of statistics (from [1)]):
    - 4700 ships were built by 1946.
    - 1250 of these had suffered brittle fractures by 1953.
    - 230 of these fractures were classed as serious.
    - 12 of the ships broke in two.
- What has happened? Well, with any major new technology you are going to pay some dues. Some things, including things that are rather obvious in retrospect, are just not known or appreciated in the early phase and cause havoc. In retrospect, people never understand how one could have been that stupid; witness the various crises' around money and all this innovative money-related products since the first collapse of the Internet bubble.
  - Not all that much was known around that time about what we now call the "ductile to brittle transition" that happens at low temperature for all steels, the question is only at what temperatures. The fracture-initiating properties of cracks that are often produced, for example, at weld seams, weren't too clear either. The Liberty disaster actually started serious research into crack formation and propagation, and thus gave birth to what we now call "fracture mechanics".
    The links, by the way, will tell you far more about the topics than you ever wanted to know!
- In a nutshell, the fracture problems of the Liberty ships resulted from a mix of ingredients:
  1. All (simple) steels will become brittle at temperatures low enough. The steel for the Liberty ships had a relatively high ductile-to-brittle transformation temperature, and in the cold North Atlantic this temperature was easily reached. That was the main problem.
  2. The ships were often overloaded, increasing mechanical stress levels, and a big wave or whatever could start crack initiation at some weak spot. The square corner of a hatch that coincided with a welded seam, for example, was found to be such a place.
  3. Cracks, after initiation, could run large distances, right through a weld seam into the next plate. With rivets, cracks would have been arrested at the end of a plate.
  4. The steel used for the Liberty ships was worse than what was available around that time. This is neatly

demonstrated by the figure below.



Charpy test data from ship steel including plate from Liberty ships

Source: The paper of J.D.G. Sumpter, J.S. Kent [1)]

Shown is the probability that a specimen can be fractured with a low energy of only 27 Joule (i.e. the steel is quite brittle) vs. temperature for steel samples as indicated.
Several things become clear:

- "Liberty" steel was rather bad with respect to the temperature where it becomes brittle. Chances were that brittleness occurred at temperatures well above the freezing point of water.
- Better steel was already available. The results from some old 1920 ship steel plate are better than those for the Liberty ships.
- Modern 1995 ship steel is not brittle above 0 ^{o}C. Since water never gets colder than that, one needn't worry much any more.
- There is a large spread in the data - the steel properties vary considerably from lot to lot. The "Liberty" steel shows the largest variation, indicating that whatever steel happened to be available was used.

Time changed, but problems remained. No matter if your sword or your ship breaks apart in cold weather, you are not going to enjoy it.

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1) J.D.G. Sumpter, J.S. Kent / Marine Structures 17 (2004) 575–589