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APPENDIX F. THE MARKETS, COST AND BENEFITS OF SHIP BREAKING/RECYCLING IN THE UNITED STATES

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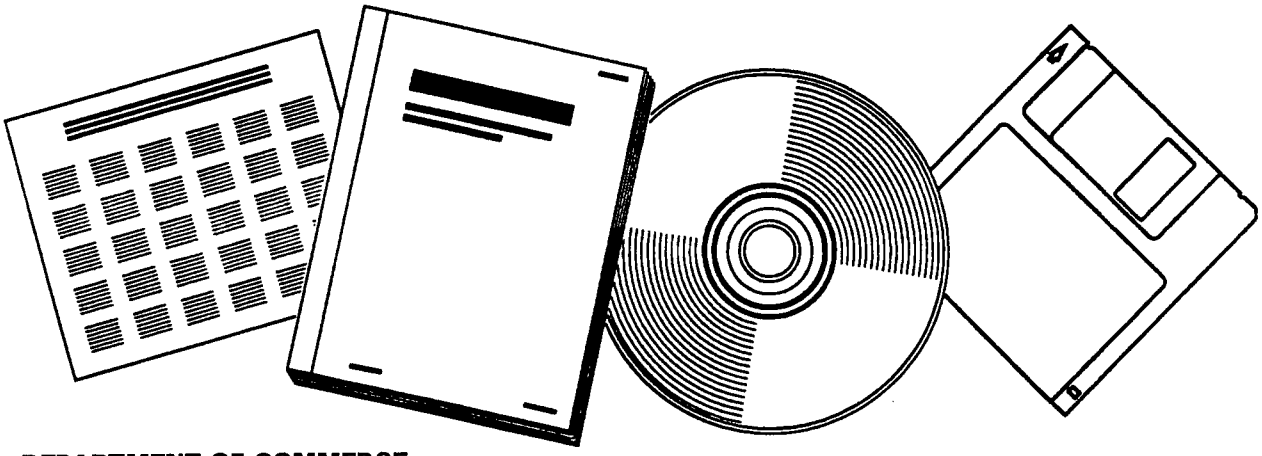

U.S. DEPARTMENT OF COMMERCE
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APPENDIX F

THE MARKETS, COST AND BENEFITS OF SHIP BREAKING/RECYCLING IN THE UNITED STATES

Report No. MA-ENV-820-96003-F

Contract No. DTMA91-93-C-00004

U.S. Department of Transportation

Maritime Administration

JULY 1997

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The state of the private ship breaking/recycling industry in the United States is discussed in terms of the costs associated with ship breaking/recycling, the costs and benefits of breaking and recycling ships, and the conditions necessary for a viable ship-scrapping industry in the United States. The markets for scrap materials from ship breaking fluctuate in accordance with materials availability and the regulatory environment. The scrap materials resulting from ship breaking operations include ferrous scrap, including steel alloys, nonferrous scrap, including copper materials, and nonmetallic scrap or fluff. Expected scrap yields and revenues by vessel species and types are discussed.

The various costs associated with ship breaking/recycling are discussed. For direct costs, such as towing, personnel, waste disposal, etc., the estimates range from $113.84 per LSW ton to $136.19 per LSW ton. For indirect costs, such as overhead, and bid and proposal costs, an additional $6.40 per ton should be added to the direct costs. A cost-benefit assessment shows that the environmental and societal impact costs of ship breaking/recycling are of some importance but are neither minimal nor overbearing.

An analysis of the viability of the ship breaking/recycling industry in the United States shows that these activities can be accomplished in an environmentally compliant manner and make a slight profit.

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Report No. MA-ENV-820-96003-F

Contract No. DTMA91-93-C-00004

U.S. Department of Transportation

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1.0 THE RECYCLING INDUSTRY AND RESOURCE RECOVERY

Chapter 1 of this report describes the state of the private ship breaking/recycling industry in the United States. Government sites and activities are discussed elsewhere.[1] Chapter 2 describes costs associated with ship breaking/recycling. Chapter 3 discusses the costs and benefits of breaking and recycling ships. Chapter 4 discusses conditions necessary for a viable ship-scrapping industry in the United States.

1.1 STATE OF THE INDUSTRY IN THE UNITED STATES

1.1.1 Description of the Industry

Shipbreaking can be defined as "any breaking of a vessel's structure for the purpose of scrapping the vessel, including the removal of gear, equipment, or any component of a vessel."[2] The private ship breaking/recycling industry in the United States can be divided into two sectors. The first embraces those companies which are in the regular business of converting discarded industrial and consumer products into salable recyclable components. These discarded products come from many sources, ships being only one of them. They range from home appliances (so-called "white goods") and automobiles to industrial scrap (such as tailings or ashes) and construction or destruction scrap. Companies in this sort of business will undertake ship breaking/recycling opportunities if the economic and regulatory situation makes it profitable to do so. In the United States, over 400 companies publicly list themselves as buyers and sellers of scrap species.[3]

Several dozen large companies are present in the generally localized scrap markets. Typically, the larger the population, the greater the number of scrap dealers present.

Further, the more specialized a location is for specific scrap streams, the more specialized are the dealers in that locale.[4] These generalized scrap companies tend to be reasonably well capitalized[5] and are quite competitive in a mature and well-established marketplace. Currently, these companies tend not to break and recycle ships.[6]

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[1] Maritime Administration, Report No. MA-ENV-820-96003-D, *Sampling and Analysis,* July 1997.

[2] 29 CFR 1910.15 (b) (1), 1915.4(1), et seq.

[3] *International Scrap Directory.* Worcester Park, Surrey, England: Metal Bulletin Books, Ltd., 1993.

[4] Ibid.

[5] Ibid.

[6] Maritime Administration, Report No. MA-ENV-820-96003-C, *Current and Advanced Technologies for the Ship Breaking/Recycling Industry*, July 1997.

The second industrial sector comprises those U.S. companies, currently eight in number,[7] which have been established to deal only with ship breaking/recycling opportunities as they arise. These companies are concentrated in low-cost areas near the Reserve Fleets owned by the U.S. Government. They rise and fall with the regulatory environment[8] and availability of ship feedstock for their operations. These companies tend to be thinly capitalized and nimble at seizing opportunities.[9]

1.1.2 Shipyards

Shipyards have not been a meaningful part of the breaking/recycling industry in the recent past, and ventures to recycle by shipyards have generally been unsuccessful.[10] This suggests that the shipyard management and labor culture is neither trained nor inclined to do the dirty work of breaking and recycling, and that the yards are tooled for the cleaner work of building and repair. Further, the capital investments for scrapping differ from those for building and repair. Lastly, recent experience has indicated that, without substantial regulatory changes and the availability of a large and reasonably steady flow of vessels available for scrapping, the shipyard industry would not consider recycling opportunities attractive.[11] The government experience differs due to factors other than economics.[12]

1.2 SCRAP SPECIES MARKETS AND MEASUREMENTS

This report uses the concept of a ship as an aggregate of feedstock for a recycling operation. Such a concept allows the aggregate feedstock to be considered as a bundled unit which supplies several species of scrap.[13] In addition, this concept provides a simple conceptual bridge between the Maritime Administration's (MARAD's) need to dispose of ships and the recycler's need to segregate scrap material. Material removed from a ship is classified in this report as (1) recyclable material (transformable and reusable in new products),[14] (2) reusable material (reusable with little or no transformation)[15] and (3) disposable material (neither reusable nor

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[7] Ibid.

[8] This report assumes that each ship breaking/recycling company, whether well capitalized or not, operates in full compliance with all applicable statutes, laws, and regulations.

[9] D. Rushworth discussion with Wilmington Resources, Inc., et al.

[10] This discussion excludes (1) boatyards which on occasion may reduce a small hull and (2) small shipyards dealing principally in the inland and near shore industries which may recycle merely to get rid of a useless hull.

[11] J. Cartner and M. MacKinnon discussion with R. Bates of Southwest Marine, Inc.

[12] Puget Sound Naval Shipyard recycles nuclear submarines, for example.

[13] The concept is similar to that used in the timber industry, where a boom of logs in flotation serves the dual purpose of supplying a bundle of multipurpose feedstock and acting as its own transportation medium.

[14] Comprising principally metallic ferrous, cuprous, and zinc scrap.

[15] Some machinery, fittings, and outfitting items.

recyclable).[16] This subpart describes the scrap markets, how scrap is measured and sold, and how scrap species emanating from the ships available for recycling are regulated.[17] For purposes of this report, metallic scrap is revenue-generating scrap; nonmetallic scrap is cost-generating scrap.

1.2.1 The Base-Case Ship

A substantial similarity exists among the three sample candidate MARAD ships.[18] The assumptions of a mathematical model constructed to provide estimates of scrap species yield will be presented, followed by a discussion of each type of ship sampled and the extended information generated by the model for intermediate ships.

1.2.1.1 Ship Classification

A convenient variable relevant to the scrap value of a ship is its length at the [load] waterline (LWL).[19] Within the range and for the purposes of this report, the LWL and length overall (LOA)[20] covariants are quite close. MARAD's standard classification scheme[21] for vessels categorizes ships by LWL. For example, a "C-2" designation indicates a ship LWL between 400 and 449 feet, while "C-6" indicates an LWL between 600 and 649 feet. This report discusses vessels in the C-2 through C-6 length categories.[22]

1.2.1.2 Dry Cargo Ships

Dry cargo vessels of the types considered here (or "general cargo" vessels) are essentially large box girders having internal bulkheads with one compartment between transverse bulkheads laden heavier than the others because of the propulsion machinery. From this, two conclusions can be clearly drawn. The first is that, even though a ship's machinery weight increases with ship length, it does not (within the range of ship lengths under discussion) increase significantly as a

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[16] "Fluff," or nonrecyclable, nonreusable, nonmetallic and regulated hazardous materials.

[17] The scrap markets variously use short tons (2,000 pounds) and (principally outside the United States) metric tons (or tonnes of 2,204.6 pounds) as the unit of measurement. The ship business uses long tons (2,240 pounds). This difference will be clarified in context where necessary.

[18] Maritime Administration, *Draft Sampling Plan for the WAYNE VICTORY, EXPORT CHALLENGER, and SHIRLEY LYKES,* September 28, 1995.

[19] This is a useful measurement for estimating a number of things related to vessel capacity. Vessel capacity, principally a cargo and revenue measure, is not relevant to this report.

[20] LOA is the length from bow to stern.

[21] Maritime Administration, Office of Ship Construction, *Classification of Maritime Administration Ship Designs,* Maritime Administrative Order 620-3, March 12, 1976.

[22] Great Lakes, coastwise, and inland vessels are excluded from this report, as are vessels of the following types: passenger, refrigerated, dry and liquid bulk, ferries, tugs and barges. The Maritime Administration distinction between its own and "outside" designs was not deemed material to this report.

proportion of overall light ship weight (LSW).[23] That is, the ratio of machinery weight to LSW is almost constant. This makes things nearly linear for interpolative and extrapolative purposes. Second, because the ferrous components of the scrap species dominate a ship's weight, one can reasonably assume, and this is borne out by rudimentary calculation, that ferrous and nonferrous scrap are distributed in about the same way on each vessel and therefore are amenable to being scaled in accordance with the LWL scheme and LSW proportion. In other words, one should not expect to see great changes in proportion in scrap species by weight or distribution when compared to LSW over the range of LWL (C-2 through C-6) considered in this report. This is borne out in fact, as shown in Table 1.

Table 1. Scrap Species Weights (LT) by Vessel Classification

Species	Vessel Classification				
	C-2	C-3	C-4	C-5	C-6
Ferrous	4192	6465	7183	8045	8835
Cuprous	49	73	83	93	114
"Fluff"*	240	376	418	468	517
Total	4481	6914	7684	8606	9466

* Nonmetallic and non-economic metallic materials, including liquids.

1.2.1.3 Availability of Technical Data

MARAD records the design and as-built weight of ships under its original purview by its standard ship system taxonomic scheme.[24] An example for the C-4 MARINER class hull is shown in Table 2.[25] The weight of each ship's subsystems allows prediction of similar systems, whether intact or transformed to scrap. The MARINER hull is representative of the hulls which are current candidates for recycling and which were measured for this report, falling as it does midway between the C-2 VICTORY-class and the stretched-hull C-6 SHIRLEY LYKES (originally a non-MARINER-class C-4) in length. Accordingly, the revenue-cost-benefit model by scrap species was based on MARINER values and extended to each of the other hulls, then modified as necessary by empirical observations. The results will be discussed by ship type and applicable ship system and subsystem. Empirically observed data from the candidate ships will

[23] Light ship weight is defined for purposes of this report as the total weight of ship and outfit, fuel, internal fluids and stores (not including crew or cargo). Within the precision necessary, this simplified definition suffices.

[24] Maritime Administrative Order No. 620-3.

[25] The complete Maritime Administration design style, e.g., "C4-S-1a," was not deemed material for this report.

Table 2. C-4 MARINER-class Cargo Ship Light Ship Weights

Item	Weight (LT)
Forgings and Castings	73
Shell Plating	1097
Framing	729
Deck Plates and Beams	1084
Bulkheads	194
Pillars and Girders	210
Miscellaneous Hull Steel	335
Foundations	129
Superstructures	411
Outfit Structural Steel	685
Hull Attachments	133
Lights, Doors, Hatches	26
Deck Outfit	151
Steward's Outfit	43
Hull Engineering Items	425
Piping	161
Miscellaneous Machinery	376
Main Propulsion	257
Feed and Condensate System	36
Evaporator System	19
Shafting and Propeller	388
Lubrication Oil System	33
Air Systems	3
Boilers and Fuel Oil Systems	235
Steam and Drain Piping	66
Miscellaneous	275
Liquids	88
Total Light Ship Weight	7662

be related to the MARINER-class ship and then applied to the range of ships under consideration, as described below.

1.2.1.4 Corrections to Base-Case Ship

Because the MARINER is used as the basic[26] ship, corrections are necessary for weights of the various subsystems in other length ranges. This correction is done by proportionalizing the LSW of each class of ship to the MARINER LSW.[27] The proportionality factor for each class of ship under this method (proportionality factor = 1.00 [C-4 MARINER]) is shown in Table 3. This factor is multiplied by the MARINER weight value for each subsystem to produce the estimated weights for the other classes. It is upon these estimated weights of subsystems, always limited by the actual weight of the ship class, that the scrap species model is based. These are idealized weights and thus require correction to produce reasonable expected yields.[28] These corrections are discussed below as appropriate.

Table 3. Light Ship Weight Proportionality Factors

Class of Ship	Proportion
C-2	0.58
C-3	0.90
C-4	1.00
C-5	1.12
C-6	1.23

1.2.2 The Scrap Materials Market

A ship can supply several species of scrap but by no means every species in which there is an active market. In the United States, 29 species of scrap are actively bought and sold,[29] with numerous subspecies and grades of subspecies. The markets are broadly classified as those dealing in ferrous scrap and those dealing with nonferrous scrap. These species in turn frequently have standards which the buyer imposes on the seller.[30] The quality and dimensional constraints of ferrous scrap are shown in detail in Appendix 1. Such buyer specifications have

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[26] The terms "base-case" and "basic" and "base" when used with "ship" are equivalent in this report.

[27] Maritime Administration, Office of Ship Construction, *Light Ship Summary, C4-S-1a,* revised March 29, 1955.

[28] The recycling process is obviously not exact and produces more waste or "fluff" than an exact calculation would suggest.

[29] *International Scrap Directory*, Worcester Park, Surrey, England: Metal Bulletin Books, Ltd., 1993.

[30] For example, No. 1 heavy melting scrap, a ferrous scrap species, is dimensionally limited by the buyer to the size of the scrap receiver box for the smelting furnace.

clear cost implications for the reseller of scrap, who must reduce portions of any recycled vessel to the dimensions and quality[31] which his buyer will accept.

1.2.3 Ferrous Scrap

Ferrous scrap from ships[32] comprises forgings and castings,[33] shell plating,[34] framing,[35] deck plating and beams, bulkheads, pillars and girders, miscellaneous hull steel,[36] foundations[37] and steel superstructures.[38] In addition, some structural steel outfit,[39] hull attachments,[40] doors and hatches,[41] deck outfit,[42] steward's outfit,[43] hull engineering items,[44] piping[45] and miscellaneous machinery[46] are ferrous scrap, as is some of the machinery discussed below. Of the ferrous sources the largest proportion, and benchmark species, is so-called "carbon steel," described in the trade as No. 1 heavy melting scrap.[47] Figure 1 shows the detailed U.S. specification of No. 1

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[31] Both the presence of contaminants and their magnitude (as well as the chemistry of the scrap) are important to the buyer.

[32] *Light Ship Summary.*

[33] Stem casting, stern frame casting and rudder horn.

[34] Flat keel plate, shellplating, bulwarks and bilge keels.

[35] Centerline vertical keel; transverse and longitudinal framing in and outside the inner bottom; framing in peaks, transom and cants; web frames.

[36] Inner bottom plating, platform decks, cofferdam flats and floors.

[37] Auxiliary machinery foundations, shaft stool foundations and miscellaneous foundations.

[38] Deck houses, miscellaneous houses and stack enclosures.

[39] Steel masts and kingposts, booms, hatch covers, stairways, and some steel sheet metal.

[40] Deck castings and mooring fittings, mast and spar forgings, rails and stanchions, ladders, miscellaneous hull fittings, and rat-proofing attachments.

[41] Sliding and hinged watertight doors; manholes and scuttles; airports, windows and lights; hatches and ports and nonwatertight steel doors.

[42] Anchors, chains, boats and davits, rigging and blocks, and miscellaneous steel deck items.

[43] Miscellaneous steel from the steward's outfit and armor and steel protection, if any.

[44] Ferrous parts of fire extinguishment and fire detection systems; heating systems; natural and mechanical ventilation systems; refrigeration systems; plumbing fixtures and drains and deck scuppers.

[45] Bilge and ballast systems; cargo oil system; fire mains, sanitary and freshwater systems; fuel oil transfer system; vents and sounding tubes and overflows and related cross-connections.

[46] Deck machinery, steering gear and rudder, communications equipment, and ferrous parts of the electrical system and dumbwaiters. The electrical system is discussed in detail below for (1) its cuprous scrap value and (2) its contamination with polychlorinated biphenyl compounds (PCBs).

[47] *International Scrap Directory*, Worcester Park, Surrey, England: Metal Bulletin Books, Ltd., 1993.

heavy melting scrap.[48] Ships of the kind considered in this report contain approximately 93% ferrous metal,[49] or the maximum amount of ferrous metal that can be reduced by a perfectly efficient recycler to No. 1 heavy melting scrap.

Figure 1. U.S. Specification for No. 1 Heavy Melting Scrap

Code No.	
200	No. 1 heavy melting steel. Wrought iron and/or steel scrap 1/4 in. and over in thickness. Individual pieces not over 60 in. x 24 in. (charging box size) prepared in a manner to insure compact charging.

Source: *International Scrap Directory.*

1.2.3.1 Ferrous Scrap Markets

By far the largest volume U.S. market for scrap species is that in ferrous scrap. One estimate[50] placed total consumption of iron and steel scrap produced in the United States at more than 53 million tonnes (approximately 52 million LT) for 1994. This implies that if all the ships MARAD now plans to scrap were scrapped during 1 year, they would account for less than 2 percent of the scrap market domestically.

1.2.3.2 Market Prices for Ferrous Scrap

Market prices for No. 1 heavy melting scrap are quoted weekly, and occasionally daily, in the United States as F.O.B.[51] mill.[52] Accordingly, a recycler of ships can obtain a higher profit if he is located near the buying mill, because transportation costs will be lower. Prices of melting scrap vary substantially from month to month. Figure 2 shows the secular variance in price since the 1920s in Chicago and Pittsburgh.[53] Clear volatility in prices can be seen from 1975 on. At the end of 1995, No. 1 heavy melting scrap was being bought in those cities at between $130 and $150 per gross tonne ($132 and $152 per LT). Although Figure 2 shows the market lately to be

[48] European specifications differ slightly from U.S. specifications.

[49] Based on C-4 MARINER calculations.

[50] Knight-Ridder Financial/Commodity Research Bureau, *The CRB Commodity Yearbook.* New York: John Wiley & Sons, Inc., 1994, p. 145. This figure does not include imported scrap.

[51] Free On Board (rail car and insurance paid to the mill railhead).

[52] *Scrap Price Bulletin.* Carol Stream, IL: Chilton Co., Inc., Metals Publishing Group.

[53] Knight-Ridder Financial/Commodity Research Bureau, *The CRB Commodity Yearbook.* New York: John Wiley & Sons, Inc., 1994.

on the rise, the future is difficult to predict, given the highly variant market behavior since 1975. There is no organized futures contract market in No. 1 heavy melting scrap; such a contract was tried briefly in the Chicago futures markets, but it failed owing to lack of interest.[54]

This report uses ferrous scrap prices at three levels. These are $125, $135, and $145 per LT for low-price, mid-price, and high-price markets, respectively.

1.2.3.3 Steel Alloys

Although there is a lively market in steel alloys,[55] the markets tend to be localized near mills requiring such melting scrap. Appendix 1 describes these species in detail. For purposes of this report, such alloys are not meaningful contributors to the economic model of recycled commercial ships of the types considered here.[56]

1.2.4 Nonferrous Scrap

The nonferrous scrap of interest in this report is copper-yielding scrap. Cuprous scrap is a small proportion of the weight of a ship but has the highest intrinsic value per unit weight of any recoverable species.[57] Cuprous scrap has a number of subspecies, as shown in Figure 3. Cuprous scrap includes bronze, brass, and various other copper alloys.[58] Copper wires are the subspecies of greatest interest here, although in the case of propellers, manganese bronze solids represent a subspecies of interest. Specifications for all U.S. cuprous scrap are shown in Appendix 2.

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[54] B. Copeland, *History of the Commodities Markets.* Chicago, IL: Commodities Press, 1989.

[55] Steel alloys are ferrous species comprising nonaustenitic steels typically with chromium and nickel alloying agents. They are generally termed "stainless steels."

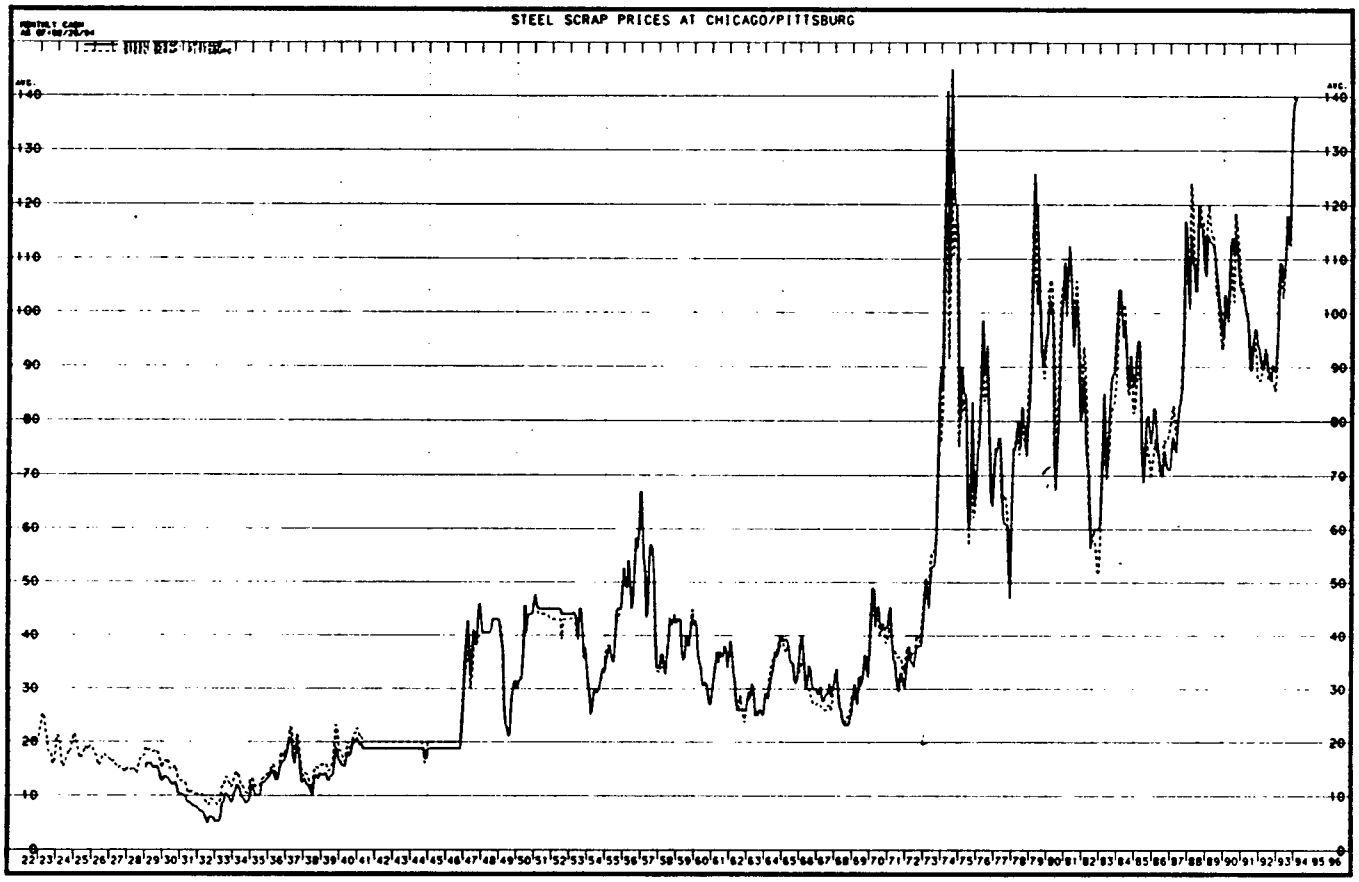
[56] Similarly, nonferrous aluminum scrap, not found in economic quantities on the candidate ships, is not discussed further here.

[57] Nolk, Bryn (ed.), *World Copper Databook.* Worcester Park, Surrey, England: Metal Bulletin Books, 1992.

[58] *International Scrap Directory*, Worcester Park, Surrey, England: Metal Bulletin Books, Ltd., 1993.

Figure 2

Price of Steel Scrap in Dollars per Gross Ton, Chicago and Pittsburgh



Source: *The CRB Commodity Yearbook.*

Figure 3

Cuprous Scrap Items Available in the U.S. Market

No. 1 Copper Wire
No. 2 Copper Wire
No. 1 Heavy Copper
No. 2 Copper
No. 1 Copper Wire Nodules
No. 2 Copper Wire Nodules
Copper Wire Nodules
Light Copper
Refinery Brass
Copper-Bearing Scrap
Insulated Copper Wire Scrap
Composition or Red Brass
Red Brass Composition Turnings
Genuine Babbitt-Lined Brass Bushings
High Grade–Low Lead Bronze Solids
High Lead Bronze Solids and Borings
Machinery or Hard Brass Solids
Machinery or Hard Brass Borings
Unlined Standard Red Car Boxes (Clean Journals)
Lined Standard Red Car Boxes (Lined Journals)
Cocks and Faucets
Yellow Brass Scrap
Yellow Brass Castings
New Brass Clippings
Brass Shell Cases without Primers
Brass Shell Cases with Primers
Brass Small Arms and Rifle Shells, Clean Fired
Brass Small Arms and Rifle Shells, Clean Muffled (Popped)
Yellow Brass Primer
Brass Pipe
Yellow Brass Rod Turnings
New Yellow Brass Rod Ends
Yellow Brass Turnings
Mixed Unsweated Auto Radiators
Admiralty Brass Condenser Tubes
Aluminum Brass Condenser Tubes
Muntz Metal Tubes
Manganese Bronze Solids
Mixed Low Copper Aluminum Clippings & Solids
Aluminum Copper Radiators
New Cupro Nickel Clips and Solids
Cupro Nickel Solids
Soldered Cupro Nickel Solids
Cupro Nickel Spinnings, Turnings, Borings
Miscellaneous Nickel-Copper and Nickel-Copper Iron

Source: *International Scrap Directory.*

1.2.4.1 Cuprous Scrap Market

The largest volume market for cuprous scrap subspecies in the United States is that in copper wire.[59] The price varies with the proportion and type of contaminants, the highest prices being paid for the least contaminated metal.[60] The 1993 consumption of copper in the United States was 4.78 billion pounds.[61] Some 2.88 billion pounds (1.29 million LT) of scrap were used to meet this demand.[62]

There is an active market in spot copper and in copper future delivery in New York, London and Chicago.[63] High-grade copper in Chicago has shown a secular decline in price since the late 1980s, as shown in Figure 4. High-grade copper is currently selling in the $1.00 per pound range; metallically contaminated[64] copper scrap[65] varies in price from $0.35 to $0.85.[66] This report uses prices of $0.90, $1.00 and $1.10 per pound for uncontaminated copper scrap and $0.10 per pound[67] for contaminated copper scrap. The $0.10 per pound price is a conservative estimate of what could potentially be recovered based on worst-case contamination concentrations. For initial revenue calculations, all cuprous scrap is deemed to be contaminated with environmentally hazardous substances. Corrections to revenues will be discussed below.

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[59] Ibid.

[60] Serjeantson, Richard (ed.), *Metal Bulletin's Prices & Data.* Worcester Park, Surrey, England: Metal Bulletin Books, 1994.

[61] Knight-Ridder Financial/Commodity Research Bureau, *The CRB Commodity Yearbook.* New York: John Wiley & Sons, Inc., 1994.

[62] Ibid.

[63] *World Copper Databook* and Knight-Ridder Financial/Commodity Research Bureau, *The CRB Commodity Yearbook.* New York: John Wiley & Sons, Inc., 1994.

[64] Typically wire scrap with tin solderings, lead sheathing contamination, broken circuit board phenyl-compound ends, etc.

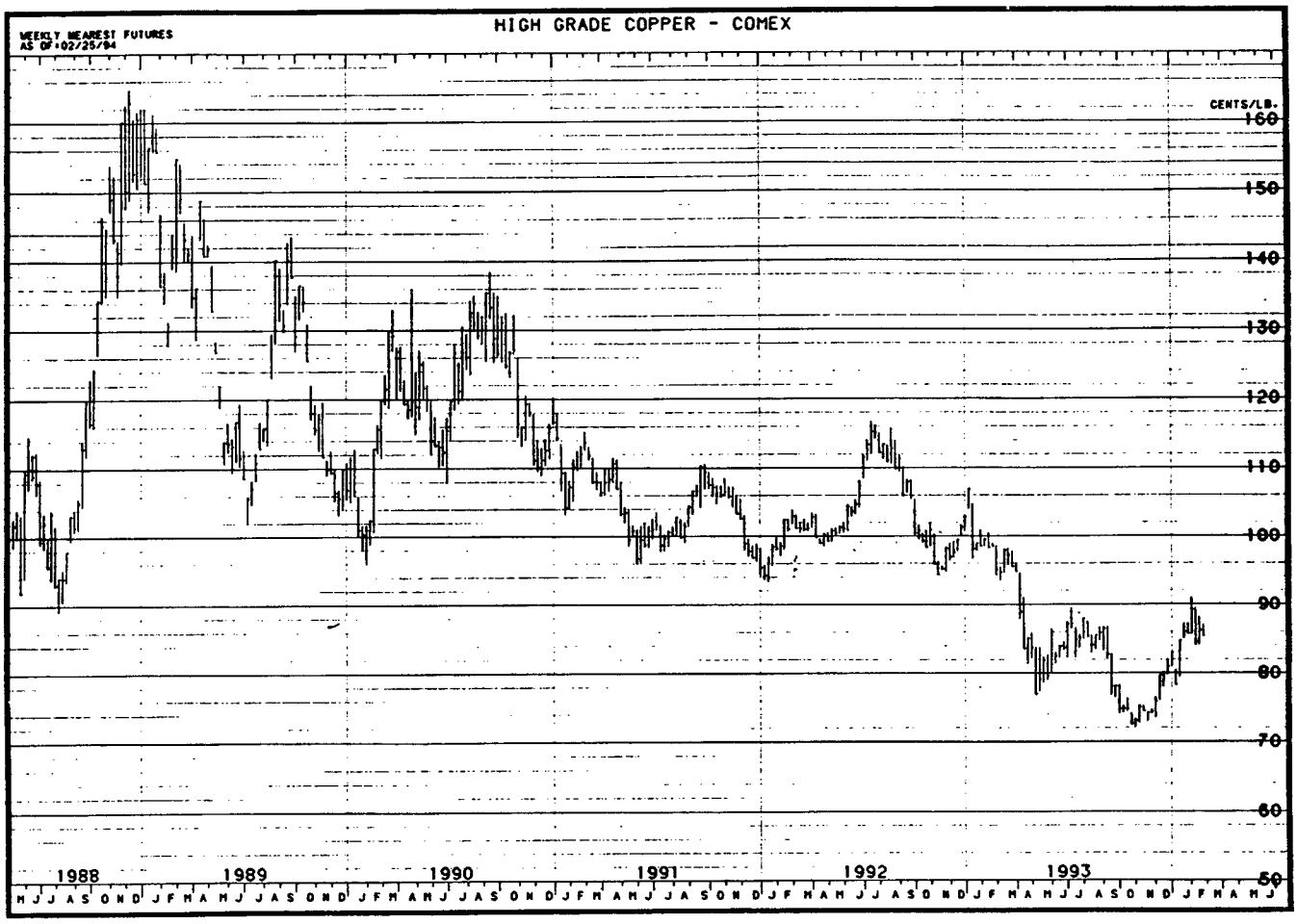
[65] See Appendix 2.

[66] *Journal of Commerce.* New York: Knight-Ridder, Inc., *passim.*

[67] Courtesy H.E.L.P.E.R., Inc.

Figure 4

Price of High Grade Copper in Cents per Pound



Source: *The CRB Commodity Yearbook.*

1.2.4.2 Expected Copper Yield

Ships of the kind considered in this report comprise approximately 1.3% cuprous metal by weight which can be reduced to the various subspecies of cuprous scrap.[68] It is the ready low-cost availability of the cuprous feedstock in the ship bundle combined with the accompanying ferrous scrap that makes the high-price per pound cuprous market attractive in ship scrapping. The high price and low shipping cost (compared to price) of cuprous scrap makes scrapping location less important than in ferrous scrap sales. The presence of an actively traded futures contract in copper might be useful to the high volume ship scrapper to hedge against price volatility, although such considerations are beyond the scope of this report.

1.2.4.3 Other Nonferrous Scrap

Other noncuprous and nonferrous scrap readily available from the ships at hand is limited, in economic terms, to zinc. The proportion of revenue obtainable from zinc anodes is trivial compared to other species and is not considered further here. Similarly, the extraction costs for the minute quantities of gold and silver in electronic gear—if on board—are substantially greater than the small revenues obtainable.[69]

1.2.5 Nonmetallic Scrap or "Fluff"

"Fluff" is the term used in the recycling trade to denote solid and liquid nonrecoverable nonmetallic materials obtained during the ship scrapping process.[70] Fluff is not salable. Moreover, fluff contains all the regulated hazardous solid wastes (including non-economic quantities of lead and cadmium) generated by a ship breaking/recycling operation. Fluff yield is the difference between total LSW and the combined weights of ferrous, nonferrous, and other recyclable or reusable scrap. This amounts to some 260 LT of solid fluff or 3.38% of LSW of the base C-4 MARINER ship. Some 70 tons comprise asbestos-bearing lagging and insulation. The remaining 190 tons are approximately 17.5% PCB-contaminated.[71] Some 156.75 tons contain other regulated materials such as lead and cadmium which are not as costly to dispose of

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[68] The electrical system of the C-4 base vessel weighs 106.8 LT. The entire electrical system is 1.3% of the LSW. Components of the ship's electrical system can be listed in detail but can be simplified to electrical wiring, controls, fixtures and ancillary items, and rotating equipment. Electric wiring comprises 0.25% of LSW or approximately 20 LT. Controls comprise 0.02% of LSW or approximately 1.6 LT. Fixtures and ancillary equipment comprise 0.034% or approximately 2.7 LT of LSW. Rotating equipment is 1% of LSW or 82.5 LT. Wiring and rotating machinery are thus the principal sources of copper. Controls, fixtures and ancillary equipment are PCB-laden "fluff" or non-metallic and regulated waste materials. Accordingly, for the base vessel, 102.5 LT of recyclable copper-bearing equipment are available of which approximately 75% by weight is copper and 25% is non-cuprous. This results in a copper availability of approximately 76.9 LT, or 172,200 pounds.

[69] The specifications of the species of actively traded noncuprous and nonferrous scrap are shown in Appendix 2. Should some of these species be found on a ship, entrepreneurial ingenuity might obtain a profitable market. For the purposes of this report, the likelihood of that occurrence is deemed to be low.

[70] Such items as insulation of various sorts, felts, gaskets, the nonmetallic portions of furniture and fittings, canvas work, glass, rubber, floor coverings, hold sparrings, miscellaneous joiner work, cement and tile coverings, interior joiner work, firebrick, electrical controls and fixtures, copper-bearing machinery casings, and electrical cable insulation are included in fluff.

[71] Maritime Administration, Report No. MA-ENV-820-96003-D, *Sampling and Analysis*, January 1997.

as PCBs. Fluff is a negative revenue item to the recycler since (1) it must be removed and (2) it generates a disposal cost. However, the removal cost is included in the direct labor cost of reduction, inasmuch as the reduction is necessary, anyway. A separate report in this series[72] has described in detail the types of hazardous materials regulated by the U.S. Environmental Protection Agency (EPA) which can reasonably be expected to be found on vessels that are candidates for recycling.[73] The principal cost-driving regulated materials found in recyclable ships, all contained in fluff, are, for purposes of this report, asbestos, polychlorinated biphenyl compounds (PCBs), and tankage hydrocarbons. Because each of these materials must be removed in the recycling process, the order of removal has economic impact.

1.2.6 Machinery

Machinery[74] falls into the categories of (1) reusable components and (2) recyclable components. There is a domestic market in used components such as compressors, electric motors, winches, lifting devices, windlasses, actuators, and accumulators. For the vessels considered here, however, the market is not lively. Most, if not all, of the components are obsolete by current standards, and can be obtained elsewhere either in better used condition or unused at a lower price than from the recycler. Spare parts usage is possible if there were a need—which there is not. Most of these items are ferrous. Some, such as main generators, motors, and other electrical components, are, however, high in copper content, which makes them intrinsically more valuable than merely ferrous materials. Other reusable items are discussed below.

1.2.7 Fittings and Outfit Items

There is a domestic market[75] in bitts, cleats, chocks, capstans, mooring winches, and the like. However, this market is thin and typically requires substantial inventory holding time before sale. Accordingly, fittings and outfitting items are not a determining factor in the revenue generated from a hull.

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[72] Maritime Administration, Report No. MA-ENV-820-96003-B, *Substantive Law on Environmentally Compliant Ship Breaking/Recycling in the United States*, July 1997.

[73] These are PCBs, asbestos, cadmium, ethylene glycol, loose lead- and chromium-containing paint chips, polycyclic aromatic hydrocarbons (PAHs), organo-tins and hydrocarbon sludge in tankage.

[74] Main propulsion, turbine drain and leakoff system, main reduction gears, main condenser, main air ejector, main circulating system, feed heaters, feed and condensate system, contaminated system, saltwater evaporator system, shafting , bearings and stern tubes, propellers, miscellaneous shafting parts, lubrication oil system, miscellaneous engine oil tanks, air systems, boilers including fuel oil burners and soot blowers, boiler draft system, automatic combustion system, stacks and uptakes, fuel oil service system, main steam piping, auxiliary stem piping, exhaust and escape piping, steam drain system, access systems, work shop, lifting and handling gear, machinery space ventilation, machinery space fixtures and miscellaneous instruments and gauges.

[75] I. Renton discussion with Martifacts, Inc. personnel.

1.2.8 Reworkable Scrap

In the ship breaking/recycling business, reworkable scrap is usually confined to large plate sections that can be rerolled. This market is small in the United States, although in India and Pakistan substantial demand is generated by reroll mills situated near scrapping yards. The reroll material typically comes from Very Large Crude Carrier (VLCC) tonnage, in which construction features large expanses of unreinforced plate that can be removed in mill-acceptable sections. In addition to the lack of U.S. demand for such plate, the ships under consideration for scrapping are neither constructed as tankers nor large enough to provide the needed unreinforced plate area. Accordingly, this market is not considered further in this report.

1.2.9 Artifacts

Artifacts are items of aesthetic value in the market[76] which are traded in retail stores.[77] Each vessel provides one or a very few of each item of interest. Price may be high compared to volume, but volume per vessel is low. Accordingly, artifacts are not a determining factor in the revenue generated from a hull.

1.2.10 Subsystems

Ventilation, powering, electrical generation, hull and other identifiable subsystems may be salable as complete subsystems, but the market is thin and prone to PCB prohibitions. One case is known of a mechanical ventilation system obtained from a scrapped naval vessel and used in a shoreside restaurant;[78] however, this appears to be a geographically local market and could be unlawful, depending on the PCB-lading of the components.

1.3 EXPECTED SCRAP YIELD AND REVENUE BY VESSEL TYPE AND SPECIES

Estimated yields for both cuprous[79] and ferrous scrap can be made for vessels ranging in length from the C-2 through the C-6. Where empirical data are available, a ship name is attached in the discussion that follows. A summary of these yields is shown in Table 4. The expected revenue per LSW ton is $125, $135 and $145 for low-price, mid-price and high-price base metal markets.

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[76] This market comprises such outfit items as chronometers, clocks, sextants, binnacles, running lights, magnetic compasses, steering wheels, and wooden hatch covers.

[77] J. Cartner discussion with M. Darcy of D'Arcinoff Investments, Ltd. The market in artifacts is substantial in older vessels with a great deal of wood or brass components and in passenger vessel crockery and linens. This is not the case in the ships considered here.

[78] D. Rushworth discussion with Wilmington Resources, Inc. personnel.

[79] The revenue model assumes complete recovery of ferrous scrap and incomplete recovery of cuprous scrap. In the case of ferrous scrap, this is feasible. In the case of cuprous scrap, substantial concern resulting from PCB presence inhibits full recovery of the resource for sale at the market price. This matter will be addressed in Chapter 4.

Table 4. Expected Revenues by Scrap Metal Weight (LT) by Market Condition (Low, Middle and High Price) for C-2, C-3, C-4, C-5 and C-6 Vessels

Ship Type	Scrap Species	Weight (LT) (from Table 1)	Metals Market Price (thousands of dollars)		
			Low	Middle	High
C-2	Ferrous	4192	524	566	608
	Cuprous	49	11	11	11
	Other*	---	29	29	29
Total for C-2		4241	564	606	648
C-3	Ferrous	6465	808	873	937
	Cuprous	73	16	16	16
	Other*	---	45	45	45
Total for C-3		6538	869	934	998
C-4	Ferrous	7183	897	970	1041
	Cuprous	83	19	19	19
	Other*	---	50	50	50
Total for C-4		7266	966	1039	1110
C-5	Ferrous	8054	1006	1086	1167
	Cuprous	93	21	21	21
	Other*	---	56	56	56
Total for C-5		8147	1083	1163	1244
C-6	Ferrous	8835	1104	1193	1281
	Cuprous	114	16	16	16
	Other*	---	56	56	56
Total for C-6		8949	1176	1265	1353

*Figures for "Other" Scrap Species are estimates.

1.3.1 C-2. VICTORY Ship (WAYNE VICTORY)

The LSW of a C-2 is assumed for this report to be 4481 LT and the proportionality factor is 0.58. At the three market conditions for ferrous and cuprous scrap, and with an included term for artifacts, fittings and machinery[80] ($29,000 for the VICTORY-class), VICTORY ship revenue ranges from $564,000 to $606,000 and $648,000. This appears a reasonable value for all C-2 hulls. Visual survey of the WAYNE VICTORY does not contradict these expected yield values.

1.3.2 C-3. Dry Cargo Ship

The C-3 LSW for this report is assumed to be 6914 LT and the proportionality factor is 0.90. The additional revenue term is $45,000. C-3 scrap yields are higher than C-2 yields because the C-3s are larger. The covariants dominating revenue are the same as for C-2 hulls and range between $869,000 and $998,000. These are reasonable in the low-price and high-price metals markets. The revenue mid-range is $934,000.

1.3.3 C-4. Cargo Ship

The selected base case vessel is MARAD's C-4 MARINER class ship, for which a great deal of information is available. The EXPORT CHALLENGER, while not a MARINER-class vessel, has characteristics related to scrapping purposes that make it useful as a source of empirical data applicable to the MARINER class. The LSW of the C-4 is taken to be 7,684 LT and the proportionality factor is 1.0. The additional revenue term is $50,000. The scrap is valued from $966,000 to $1.04 million and $1.11 million for the respective markets.

1.3.4 C-5. Dry Cargo Ship

The LSW of a C-5 vessel is assumed to be 8,606 LT and the proportionality factor is 1.12. The additional revenue term is $56,000. The revenue yield ranges from $1.08 million to $1.16 million to $1.24 million.

1.3.5 C-6. Dry Cargo Ship (SHIRLEY LYKES)

The LSW of a C-6 vessel is assumed to be 9,466 LT and the proportionality factor is 1.23. The additional revenue term is $56,160. Again, the value of the empirical data obtained from the SHIRLEY LYKES is more important to confirming base-ship matters than the C-6 classification, which was made only after the vessel was increased in length overall by the addition of a container-carrying midship section. The revenue yield ranges from $1.18 million to $1.27 million to $1.35 million.

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[80] This term is devised by assuming a maximum revenue of $50,000 for such items from the C-4 MARINER vessel and proportioning by MARINER LSW and candidate hull LSW. Manganese bronze propeller weights, if present, are included in this figure. The SHIRLEY LYKES, for example, has a stainless steel propeller; however, no decrement is made of the expected yield additional term. To do so would be falsely precise.

2.0 TYPICAL SCRAPPING MATERIAL AND LABOR COSTS

2.1 INTRODUCTION TO COSTS

The following discussion[1] will describe costs in several categories. Costs[2] are either direct costs, which are isomorphically applicable to a particular "job"[3] or "cost center," or "indirect costs" which cannot be applied isomorphically to a "job". These categories will be discussed as (1) direct labor costs,[4] (2) direct materials costs[5] and (3) indirect costs.[6] Indirect costs will be further subdivided into the categories of (1) indirect benefits to labor costs,[7] (2) general and administrative costs,[8] (3) overhead costs[9] and (4) bid and proposal costs.[10] The overall costs

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[1] The footnotes in this section give some background to how costs are measured. The use of costs as a measurement rather than revenue allows linear manipulations within the cost data set.

[2] The accounting business attempts to make mutually exhaustive and exclusive definitions for the categories into which costs are placed. However, this task is made difficult by the attempt to place one- or two-dimensional definitions in the multidimensional context of business measurement. As a result, a large number of rules and practices are prevalent in the field. These practices do not have the force of statute unless expressly cited therein. Often, however, accounting rules are influenced by statutory interpretation. Accounting practices and standards are construed by increasingly complex exceptions which give way to "prudent business judgment" when the rules become too complex to be practicable. In other words, accounting is neither completely accurate nor exactly precise and, as are all models of behavior, is assumption-driven.

[3] The accounting field has developed a matrix methodology of manipulating accounting data among various "jobs" in a manufacturing environment. The concept is simple. Direct costs are applied to each job as they arise; indirect costs are allocated across all jobs based on some convenient and reasonably predictable covariate. Either direct labor cost or direct labor hours of each job when compared to the sum of such costs in all similar jobs are typical covariates. The objective is to allocate all non-isomorphic costs reasonably across all jobs. The jobs are assigned costs, or "absorb" them in accounting jargon.

[4]These are labor costs dealing with the "direct" work of ship breaking and ship-materials handling and disposal. Direct labor is distinguishable from "indirect labor" in that the latter cannot be fully charged in accounting to one and only one job at hand. Similarly, "Other Direct Costs" are those non-labor costs directly chargeable to a specific job, whereas indirect costs must be distributed to a number of jobs by some established method.

[5] Non-labor costs directly chargeable to a specific job..

[6] Costs that are not direct costs.

[7] So-called "fringe benefits" comprising Federal and State Unemployment Tax Assessment (F.U.T.A. and S.U.T.A.), Federal Income and Compensation Act (F.I.C.A. or "Social Security") contribution, annual vacation, "sick" leave, personal leave, administrative leave, parking, personal protective clothing and items, various insurances, etc. These items are often divided into "mandatory" or legally compelled items and "non-mandatory" or negotiated items.

[8] Defined as indirect labor and non-labor costs which are necessary and sufficient for the opening and operating of the business, without "jobs" present.

[9] Non-general and administrative costs which are necessary to the ongoing operation of the business if contracts which are directly chargeable are present. For example, facilities rent, insurance on personalty, most utilities, facilities maintenance, and, for our purposes, interest on capital used to purchase or lease equipment. The decision whether to lease or buy is beyond the scope of this report.

[10] So-called marketing labor and costs which can be conveniently categorized as dealing with obtaining business.

discussed here assume a "job cost"[11] approach in which each job is a single ship. The covariant for distributing indirect costs to each job or ship in the ship breaking/recycling model is direct labor person-hours.[12] For purposes of this report, revenue less cost equals net profit or net income. Gross profit is calculated by subtracting direct labor cost and other direct costs from gross revenue. Operating revenue is obtained by subtracting indirect benefits cost from gross profit. The model used here employs the concept of complete revenue fulfillment as described in Section 1.1, with cost items lessening revenue to yield net income. This methodology allows for the efficient identification of costs which might be reduced by, for example, technology application, regulatory change or political action. These will be discussed as they appear.

2.1.1 Labor Productivity and Cost

Labor productivity is directly related to direct labor cost.[13] The best estimate for ship breaking/recycling using current conventional technologies, heavily directed toward manual labor, is approximately 0.375 LT per person-hour.[14] This method of ship breaking/recycling has been described in detail elsewhere.[15] This means that one person-hour is directly attributable to the removal, handling, repositioning and delivery to the rail car for disposal for each 0.375 LT of LSW (or 2.67 hours per ton).[16] Increase in productivity will be reflected in this report as decrease in cost, making separate calculations for increases in productivity unnecessary.

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[11] "Job-cost" accounting in mathematical terms is merely a measurement summation of particular similar business units reassembled with permissible intra-matrix transfers of cost values. This is all designed to make a reasonably coherent model of company performance. It frequently fails on assumptive grounds in complex operations but is useful as a simple model here.

[12] The calculation of so-called indirect rates is performed for aggregations of similar costs where it would be too time-consuming or rationally impossible to charge these costs as direct costs. For example, if two ships require 10,000 and 8,000 direct labor hours respectively to recycle and if both ships are being recycled in the same accounting period, each ship will "absorb" its fair share of the total indirect costs accrued by the ship recycler during the accounting period. The first ship will absorb 10,000/18,000 or 55% of the two ships' indirect costs. The second ship will absorb 45% of the cost. Separate indirect cost "rates" can be calculated for indirect benefits, general and administrative, overhead, and bid and proposal burden. The "full burden rate" is the sum of these four percentages of burden. The percentage can then be applied to the requisite direct costs to determine an additive term. Typically only general and administrative and selected overhead costs are applied to "other direct costs" such as materials. Indirect labor costs are usually burdened with indirect benefits costs in order to derive a reasonably accurate cost of indirect labor for management purposes.

[13] There is an inverse relationship between labor hours and labor cost and productivity, within limits, with lower productivity producing higher costs. At the extreme ends, infinite productivity produces no cost while no productivity produces no cost.

[14] Courtesy Wilmington Resources, Inc.

[15] Maritime Administration, Report No. MA-ENV-820-96003-C, *Current and Advanced Technologies for the Ship Breaking/Recycling Industry*, July 1997.

[16] This becomes important to later discussion, in that the separation of PCB-laden materials from fluff is included in the productivity measurement used in the model.

2.1.2 Direct Costs

Direct costs are those costs which can be isomorphically and directly charged to the task of ship breaking/recycling. Direct labor cost and other direct costs will be considered in turn.

2.1.2.1 Direct Labor Costs

"Ship recycler" is not a standard labor category of the U.S. Department of Labor. However, the level of skill used for the ship breaking/recycling operation is reasonably ascertainable.[17] Persons having skills in the cutting of metals and in heavy mechanical work and in crane and lifting operations can be employed in vessel scrapping. The work is neither delicately precise nor clean. A good number for a mix of direct labor is $9.37 per hour.[18] A rounded and low-end average rate is $10.00 per hour. For purposes of this report, three hourly rates—$10.00, $11.00, and $12.00—are used in various scenarios. These are the so-called low-, mid- and high-cost labor rates. This rounded rate does not include any extraordinary expenses or regional factors or any indirect benefits costs (see Section 2.1). Reducing these three direct labor costs to LSW tonnage terms, direct labor cost (using the standard productivity rate described above) is $26.67 (low-rate), $29.33 (mid-rate) and $32.00 (high-rate) per LSW ton. The impact of increase in labor cost resulting from new technologies applied to ship breaking/recycling is discussed below.

2.1.2.2 Feedstock or Ship Cost

The strategy of recyclers in the current uncertain regulatory environment is to bid low in the high bid process in order to obtain the lowest cost possible for feedstock vessels. This is because of (1) the extreme influence feedstock cost has on net profit and (2) the visibility of feedstock cost in management reporting.[19] Empirical bid prices vary across the board from a few dollars to the low millions of dollars for naval vessels.[20] The best-judgment realistic cost to the recycler varies between $50,000 to $150,000 for a MARAD vessel. The lowest expected cost to the recycler then is $6.50 per LSW ton; the middle value is $13.02 per LSW ton; and the high value is $19.53 per LSW ton. The impact on cost to recyclers as a result of changing the bid process is discussed below.

2.1.2.3 Other Direct Costs

The other direct costs attributable to reduction of a ship are the costs associated with certain consumables and expendables, environmental control costs, towing, personnel protection, rigging and subcontracted costs. Each will be discussed.

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[17] Courtesy of Wilmington Resources, Inc.

[18] U.S. Department of Labor national composite for semiskilled labor, 1994.

[19] Frequently, cost accounting reports and methods are used for management accounting purposes, which may result in interpretative distortions.

[20] Analysis of Defense Reutilization and Marketing Service bids as well as Maritime Administration bids.

2.1.2.4 Towing

For the purposes of this report, towing is assumed to cost $30,000 for removal to the recycling facility from a Reserve Fleet. This assumes contract towing by one tug for 5 days at $6,000/day, paid by the recycler.[21] Accordingly, a fixed cost of $3.90 per LSW ton is used in the cost model.

2.1.2.5 Personnel Protection

The cost of personnel protection is deemed to be a direct cost for the purposes of this report, although it usually is included as an indirect benefit cost. Personnel protection includes items such as protective clothing, respiration protection devices, hard hats and ear protectors to comply with Occupational Safety and Health Administration regulations.[22] Some $35,000 is estimated per C-4 vessel (64 persons for 40 work-days), or $4.56 per ton. Steel-toed shoes and gloves are expected to be provided by working persons.

2.1.2.6 Direct Cost Consumables and Expendables

These costs include gases for cutting, expendable items used in ship reduction, sheeting and tenting and netting, filters, marking and handling items for hazardous materials, etc. It is outside the scope of this report to estimate exactly the costs of such items; however, a recycling source[23] indicates $3.00 per ton is a reasonable value.

2.1.2.7 Rigging and Staging

The cost of rigging and staging is estimated to be $1.00 per LSW ton.[24] This includes ship-surrounding booms to capture oily discharge or runoff and landside soil protections, such as runoff curtains and geotextiles as well as materials handling slings and dunnage.

2.1.2.8 Subcontracted Costs

The principal subcontracted costs are (1) asbestos removal and disposal, (2) PCB and other hazardous materials disposal, and (3) tank cleaning and tankage disposal. Each will be discussed in turn.

Asbestos Removal and Disposal. No successful recycler interviewed for this report attempted to perform asbestos removal and disposal. Such work is subcontracted to certified removers who have the experience and technology available in a mature service to perform the work more cost-effectively than could be done by a recycler. Further, removal by such certified, bonded and

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[21] This rate includes reasonable laytime and despatch for one tug per vessel. Courtesy Moran Towing, Inc.

[22] Maritime Administration, Report No. MA-ENV-820-96003-A, *The Legal Environment for Environmentally Compliant Ship Breaking/Recycling in the United States*, July 1997.

[23] Wilmington Resources, Inc.

[24] Ibid.

insured sources tends to reduce the liability of the recycler. The estimated cost of subcontractor removal and disposal of asbestos is $19.52 per LSW ton.[25]

Other Hazardous Materials Disposal. Non-asbestos fluff is considered hazardous material. Such fluff can be divided into (1) a component which contains PCBs and (2) a component which contains all other hazardous materials, such as lead and cadmium. Inasmuch as non-asbestos fluff must be removed to reduce the ship, there is no reason to separate cost for removal of non-asbestos fluff.

(1) PCB Segregation and Disposal. Of the 190 LT of non-asbestos fluff on a C-4 vessel, a good estimate is that 17.5% by weight is contaminated with PCBs.[26] This amount is approximately 75,000 pounds of PCB-contaminated materials which must be disposed of. The cost of disposal in approved facilities[27] ranges from $0.50 to $0.60 to $0.70 per pound. This amounts to $4.84 per LSW ton, $5.82 per LSW ton and $6.79 per LSW ton, respectively.

(2) Non-PCB Disposal. The remaining fluff contains some hazardous materials such as lead, paint chips and cadmium. Cost of disposal varies from $250 to $300 to $350 per LT. This amounts to $5.10 to $6.12 to $7.14 per LSW ton, respectively.

Tank and Bilge Cleaning and Disposal. The candidate ships have 89 tanks with a mean capacity of 120 tons per tank as well as the engine room bilges and cargo hold bilge systems discussed elsewhere. For safety as well as for disposal of tankage which has become sludge, all tanks and bilges must be cleaned and gas-free. The going rate for outside cleaning varies between $25 and $40 per tank capacity ton, depending on last cargo carried and the complexity and degree of cleanliness required (ranging from food-grade to reload of black oil).[28] Assuming gas-free and black oil sludge, the cost to clean tanks and make them ready for hot work and to dispose of the tankage is estimated at $34.75 per LSW ton.

2.1.2.9 Cutting Gases and Other Reduction Consumables

Currently propane gas is used for ship reduction. Some mechanical shearing is performed requiring replacement of shearing and faying surfaces. The best estimate for this direct cost is approximately $2.00 per LSW ton[29] using current technology. In that some newer technologies use substantially more fuel, a good estimate of cutting gas for new technology is $4.00 per LSW ton.

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[25] Maritime Administration, Report No. MA-ENV-820-96003-D, *Sampling and Analysis*, July 1997.

[26] Ibid.

[27] Ibid.

[28] Courtesy Tidewater Tank Cleaning, Inc.

[29] Courtesy Wilmington Resources, Inc.

2.1.2.10 Summary of Direct Costs

The sum of the direct costs from the above discussions varies. However, taking lowest variable costs with the fixed direct costs, the low estimate is $113.84 per LSW ton, the middle estimate is $125.02 per LSW ton, and the high estimate is $136.19 per LSW ton. These direct costs are shown in Table 5, along with indirect costs as discussed below.

2.1.3 Indirect Costs

The categories of indirect costs were described earlier in Section 2.1. Each will be discussed in turn. The high rate of direct labor costs is used to estimate indirect costs.

2.1.3.1 Indirect Benefit Costs

For the purposes of this report, F.I.C.A., F.U.T.A., S.U.T.A. and mandatory Medicare contributions are taken to be 11% of direct labor costs; nonmandatory insurance coverage is included such as medical insurance or life insurance. A significant cost, however, is worker's compensation[30] insurance premium, which is substantial for both the shipyard and scrap trades. For this report it is estimated to be 47.5% of direct labor costs.[31] Leave is estimated at 7% of direct labor costs. No other benefits such as parking are considered here. No pension benefits are calculated. Neither medical nor life insurance benefits are considered. Personnel protection is deemed to be a direct cost. Accordingly, the indirect benefits cost for the purposes of this report amount to some 65.5% of direct labor costs. In other words, for each LSW ton reduced under current methods, indirect benefit costs amount to $20.96 per LSW ton reduced.

2.1.3.2 Non-financial General and Administrative Costs

Non-financial general and administrative costs include such things as accounting, secretarial, non-direct charged management, quality assurance, environmental oversight, non-overhead and non-bid and proposal indirect items, and so forth. A good manufacturing rule of thumb for such items for the ship breaking/recycling industry is 20% of direct labor costs. Accordingly, each reduced LSW ton cost should be burdened by $6.40 per LSW ton in the ranges discussed above.

2.1.3.3 Overhead Costs

Overhead costs include rental for pier space or equipment necessary for the reduction of ships but not directly chargeable to a specific ship. This, is of course, a function of how much equipment

[30] This is a statutory scheme in all states wherein liability to the employer for on-the-job injuries is limited and costs of such injuries are borne by a pooled insurance fund.

[31] Courtesy Liberty Mutual Insurance Co., Inc.

Table 5. Direct and Indirect Costs, Revenues and Profits in High-Price and High-Cost Markets, Mid-Price and Mid-Cost Markets, and Low-Price and Low-Cost Markets on $/LSW-Ton Basis

	Low	Medium	High
Expected Revenues	125.00	135.00	145.00
Direct Costs			
Labor	26.67	29.33	32.00
Ship/Feedstock	6.50	13.02	19.53
Towing	3.90	3.90	3.90
Personnel Protection	4.56	4.56	4.56
Consumables	3.00	3.00	3.00
Rigging and Staging	1.00	1.00	1.00
Asbestos	19.52	19.52	19.52
PCB Disposal	4.84	5.82	6.79
Tank	34.75	34.75	34.75
Other Fluff Disposal	5.10	6.12	7.14
Cutting Materials	4.00	4.00	4.00
Total Direct Costs	113.84	125.02	136.19
Gross Profit	11.16	9.98	8.81
Indirect Costs			
Indirect Benefits	20.96	20.96	20.96
Overhead	6.40	6.40	6.40
General and Administrative	6.40	6.40	6.40
Bid and Proposal	0.32	0.32	0.32
Total Indirect Costs	34.08	34.08	34.08
Profit (or loss) Before Taxes	(22.92)	(24.10)	(25.27)

is rented and for how long, how much wharfage is leased and for how long, and so forth. Clearly it is job specific. A good rule of thumb for overhead indirect costs appears to be approximately 20% of direct labor cost in the southeastern Virginia area. This also assumes that the recycler is a recycler of opportunity. Even so, the number is not unreasonable.[32] Therefore, each reduced LSW ton cost should be burdened by $6.40 in the ranges discussed above.

2.1.3.4 Bid and Proposal Costs

The costs for bid, proposal and marketing of the recycler's services are minimal and estimated to be 1% of direct labor costs. This amounts to a burden of $0.32 per LSW ton.

2.1.3.5 Total Indirect Costs

A good estimate of total indirect costs is shown in Table 5. Indirect costs for the high-price, high-cost market are approximately 106.5% of direct labor costs (conservatism of estimate requires use of the highest figure). Revenues and mid-range direct and mid-range indirect costs are shown in Table 5. Financial costs are discussed below as the cost of capital.

2.2 COMPARISON OF COSTS AND REVENUES

It is evident from examination of Table 5 that, on a one-ship accounting basis, (1) the model is prone to economies of scale and (2) there is no profit in ship breaking/recycling. Even the allocation of all overhead and general and administrative costs and bid and proposal costs would still render such a venture unprofitable in any of the metals markets described above. The number of ships necessary for a viable industry will be discussed in Chapter 4, along with the costs of capital. It is also evident, even before income taxes and interest for capital investment, that ship breaking/recycling is an unprofitable proposition unless all scrap can be sold at the highest market prices (cuprous scrap included) or that ways are found to reduce or reallocate costs. The expectation of high market prices is a risky basis upon which to build an industry, especially when there are few convenient hedging means available for its products in the bid market. However, the recycling business may be profitable if there is a reallocation of cost between buyer and seller or if there is enhancement of revenue. Reallocation of costs will be discussed in Chapter 4, as will enhancement of revenue.

[32] Courtesy Wilmington Resources, Inc., Jacobsen & Co., Inc., et al.

3.0 COSTS AND BENEFITS

3.1 COSTS AND BENEFITS IN GENERAL

There are some nine[1] relevant categories of project and societal costs and benefits which shed light on ship breaking/recycling.[2] These relate to air quality, water quality, noise, visual resources, biological resources, wetlands, cultural resources, socioeconomics, and geology and soils. Each will be discussed in turn. The overall quantitative and qualitative assessment of cost and benefit is indicated in Table 6.

Table 6. Qualitative and Quantitative Costs and Benefits to Nine Categories of Environmental Concern in Ship Breaking/Recycling

Category	Qualitative Assessment		Quantitative Assessment per LSW LT	
	Cost	Benefit	Cost	Benefit
Air Quality	Low	High	Nil	NMC*
Water Quality	High	High	$35	NMC
Noise	Low	Low	Nil	NMC
Visual Resources	Low	High	Nil	NMC
Biological Resources**	High	High	$71	NMC
Wetlands	High	High	$2	NMC
Cultural Resources	Low	High	Nil	NMC
Socioeconomics	Low	High	$32	$69
Geology and Soils	Low	High	$1	N/A

*Not meaningfully calculable.
**Includes hazardous and toxic materials.

[1] The costs and benefits resulting from the recycling of steel and copper were not estimated, in that these are secondary to the thrust of the report. These secondary costs and benefits are related to the net savings developed from not exploiting mineral resources in mines, reduction of air pollution from primary smelting, etc. These are offset by a decrease in jobs dealing with raw materials, etc. The analysis becomes complicated and ever more convoluted. Further, good data to estimate these costs and benefits are not readily available.

[2] Maritime Administration Report, No. MA-ENV-820-96003, *Environmental Assessment of the Sale of National Defense Reserve Fleet Vessels for Scrapping*, July 1997.

3.1.1 Method of Assessment

Quantitative cost was estimated for each category. Each of the nine categories was considered qualitatively by a panel of five marine professionals[3] familiar with ship breaking/recycling. A score was assigned to each category for both cost to society and benefit to society. A consensus score was reached after discussion. Society was defined as that existing in the United States in 1996. Cost and benefit impacts were bounded by the notion that in each category, all applicable laws and their enabling regulations in force at the time of this writing were followed in the ship breaking/recycling process. A score of 3 indicates a substantial or great benefit or cost to society. A score of 2 indicates some cost or benefit to society and a score of 1 indicates little or slight cost or benefit to society. Median scores are reported. The categories are neither exhaustive nor mutually exclusive.

3.1.1.1 Air Quality

There is no quantitative cost estimable for compliance with air quality standards. The qualitative costs to conform to air quality policy[4] in ship breaking/recycling was scored as 1. That is, the cost to comply with air quality standards from burning and cutting was deemed to be minimal, inasmuch as the emissions resulting from such standards are quite small and not regulated in accordance with current policy. Accordingly, the benefits of complying with air quality standards were deemed to be substantial (Score = 3), in that the ship breaking/recycling industry can contribute to air quality by its minimal emissions.

3.1.1.2 Water Quality

The quantitative cost of tank and bilge cleaning and disposal, runoff prevention, and solid waste containment is approximately $35 per LSW ton. The qualitative cost of complying with water quality standards[5] was scored as 3. Discharges to water from a vessel must be either captured and disposed of properly, as in the case of tankage, or contained and subsequently removed from the water at the berth as in the case of runoff. Pollutants such as avian waste cannot be merely shoveled into the water but must be removed by hand and disposed of properly. Booms and appropriate equipment are required to maintain water quality at the site of reduction. The benefits, however, were also deemed to be substantial (Score = 3), in that a clear effort to prevent water pollution was deemed quite beneficial to the ship breaking/recycling industry.

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[3] D. Rushworth, M. MacKinnon, G. Lewis, J. Cartner, S. Shaw.

[4] Maritime Administration, Report MA-ENV-820-96003-B, *Substantive Law on Environmentally Compliant Ship Breaking/Recycling in the United States*, January 1997 and Maritime Administration, Report MA-ENV-820-96003-A, *The Legal Environment for Environmentally Compliant Ship Breaking/Recycling in the United States,* July 1997.

[5] Ibid.

3.1.1.3 Noise

The quantitative cost of noise reduction is nil. Ship breaking/recycling is not a quiet business. However, ship breaking/recycling is typically not sited in areas in which noise is a difficulty. Most if not all recycling sites are remote or in industrial areas where noisy activities are concentrated. Further, ship breaking/recycling noise is not continuous noise but is best characterized by occasional noisy outbursts. Therefore, the cost of compliance with noise regulations was deemed to be small and was scored as 1. The benefit was also deemed to be small and scored as 1.

3.1.1.4 Visual Resources

There is no quantitative cost in preserving visual resources from the aesthetic predation of ship breaking/recycling. Ship scrapping is a dirty and foul activity. Its visual nuisance value is a function of its contextual locale. The visual impact of ship breaking/recycling is contained by siting, as is discussed in the matter of noise control. The cost of visual screening is minimal (Score = 1) and the benefit is substantial (Score = 3).

3.1.1.5 Biological Resources

The quantitative cost of protecting biological resources is the sum of the cost of protecting water (but not groundwater) resources in the case of ship breaking/recycling and the cost of disposal of hazardous and toxic materials. If done in accordance with current policy, however, ship breaking/recycling has limited impact on biological resources. But the cost is high (Score = 3). Here, however, it was felt by the evaluators that the benefits were also substantial (Score = 3).

3.1.1.6 Hazardous and Toxic Materials

The quantitative cost of handling and disposing of hazardous and toxic materials is estimated to be $71 per LSW ton. The qualitative cost is not so simple. As can be seen from the discussion above, substantial costs (Score = 3) are incurred in complying with the rules regarding PCBs, asbestos and hydrocarbon sludge. Compliance with federal and state PCB regulations during ship breaking/recycling is more costly than conventional PCB management and disposal due to the nature and condition of the PCB-containing materials in ships. Environmentally compliant systems exist for managing asbestos and hydrocarbon sludge in the maritime industries. Such systems do not exist for PCB-containing materials. Further, environmental rules designed for manufacturing and other industries are not easily adapted to problems associated with ships and the maritime and naval industries. Changing some of the regulations which govern PCB management, such as 40 CFR 761 and applicable state regulations, could increase the benefit greatly as well as reduce the cost.

3.1.1.7 Wetlands

The quantitative cost of protecting wetlands is coextensive with the cost of protecting water resources and the cost of geologic and soil preservation. The quantitative cost is estimated to be $2 per LSW ton. Some areas of the country have wetlands adjacent to the probable and current sites of ship breaking/recycling. The cost of protecting these wetlands was deemed to be high (Score = 3). The benefits were also deemed high (Score = 3). The benefits appeared to derive from the perception that wetlands, as a resource to the biota, must be maintained and ship recyclers should be a part of maintaining these wetlands.

3.1.1.8 Cultural Resources

The quantitative cost of protecting cultural resources in ship breaking/recycling is not reasonably measurable. Ship breaking/recycling suggested minimal cost (Score = 1) impact on cultural resources and substantial benefit (Score = 3) on preserving those nonimpacting artifacts recalling our maritime heritage.

3.1.1.9 Socioeconomics

The development of new jobs in ship breaking/recycling was deemed to be small. Quantitatively, this amounts to approximately 11 labor years per C-4 hull or 110 labor years at low wages per ten such hulls. Therefore, one should expect an injection of approximately $267,000 per month in a local economy if one MARINER-class ship is scrapped every other month. Further ripple effect is beyond the scope of this report. The estimate of minimal impact was based largely on the relatively small supply of ships for the industry (Score = 1). The social benefits, however, were deemed substantial, in that the removal of potentially harmful hulls would be of great benefit to all concerned (Score = 3) and the creation of jobs would be beneficial. The quantitative cost of $32 per LSW ton is derived from subtracting the geology/soil and wetlands costs from the water quality costs.

3.1.1.10 Geology and Soils

The quantitative cost of geotextiles, runoff curtains, and so forth to protect soils is estimated to be $1.00 per LSW ton. The qualitative cost impact associated with protecting geology and soils was deemed to be minimal (Score = 1) and the benefit from that minimal expenditure was felt to be substantial (Score = 3), largely as a result of the protection of groundwater and site soil resources. The notion that a site would have to be cleaned before sale or long-term lease suggested to the assessors that a minimal cost would have substantial benefits to the user of the site.

3.1.2 Overall Cost and Benefit Assessment

The quantitative cost impact, where measurable, on the nine categories is estimated to be $141 per LSW ton. The estimated benefits, where measurable, are in the amount of $69 per LSW ton, where immeasurable benefits are estimated at zero value. The mean qualitative cost score was calculated as 1.8. This implies that overall, the cost of ship breaking/recycling is of some

importance but is neither minimal nor overbearing. The mean benefit score was 2.6, implying that there is substantial benefit to ship breaking/recycling as a whole if done in accordance with the current laws in the United States. The quantitative cost of recycling and the quantitative benefits are not otherwise comparable in any meaningful fashion. Some of these findings will be used in the next chapter.

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4.0 INDUSTRIAL VIABILITY

4.1 IS THE SHIP BREAKING/RECYCLING INDUSTRY VIABLE?

The ship breaking/recycling industry is a risky, highly speculative[1] business in which bids are made "by the seat of [the] pants."[2] The answer to the question of whether the ship breaking/ recycling industry is viable is a qualified "yes." The qualifications, however, are numerous. The matter turns on the interactions of (1) the volume of tonnage regularly available to the recycler; (2) the rationalization of the selling and contract monitoring process; (3) the rationalization of the environmental rules with respect to the peculiar nature of the maritime endeavor; and (4) the rational transfer of cost and liability from the government owner to the recycler. Each of these will be discussed in turn.

4.1.1 Volume of Tonnage

It is clear that economies of scale will be helpful to the sustainment of the industry. Regular, predictable and adequate tonnage for recycling is necessary.

4.1.1.1 Regularity of Tonnage Supply

In order to either (1) invest new capital in resources or (2) allocate existing capitalized resources to a program of ship breaking/recycling, there must be a predictable regularity of supply. In other words, there can be some economies of scale if there is a regular supply for the demand. This has not been the case heretofore for MARAD-owned ships. If a $2.5 million dollar new investment[3] is necessary for advanced technology equipment such as shears and new methods of shipbreaking and handling, at 8% interest, some $200,000 per year is the required payment to the financier.[4] Assuming that this mid-cost scenario extends over 60 calendar days for one 7684-ton ship and no other ships are envisioned, the interest cost absorbable by the project for the year is $4.34 per LSW ton for the 2 months of work. The general and administrative cost, where interest is properly classified, is increased by $16,667 per month. With no ships to absorb this cost, two things happen. First, bid prices become lower and lower to recompense the cost of capital investment. Second, at some time the recycler will find another business since there is no reliable supply of feedstock on which to use his capital investment. Therefore, it is necessary that a regular and predictable supply of ships be available to maintain the ship breaking/recycling industry.

Maintaining Supply. A simple way to maintain supply is for MARAD to offer ships for recycling in lots of, say, six per lot every 3 months. This induces stable investment into

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[1] For an excellent summary of the nature of the business, see Munro Drydock, Inc. v. M/V *Heron*. 467 F. Supp. 513.

[2] Ibid.

[3] Maritime Administration, Report MA-ENV-820-96003-C, *Current and Advanced Technologies for the Ship Breaking/Recycling Industry*, July 1997.

[4] U.S. and state tax considerations are beyond the scope of this report.

resolution of the domestic recycling problem. Such administrative actions, to be discussed in greater detail in this chapter, would cost MARAD little.

Enhancing Demand. Demand for MARAD ships that are candidates for scrapping also could be enhanced by legislative fiat allowing MARAD to guarantee loans for the purpose of acquiring equipment for environmentally compliant ship breaking/recycling.

Labor Productivity Technology Not Necessarily the Answer. All the above being said, technology is not the complete answer to the recycling question. This turns on the matter of cost. Assuming that direct labor costs the recycler $29.33 per LSW ton, as described above, a target of direct labor cost reduction through productivity increase of $20.00 per LSW ton is not unreasonable. Assuming that the recycler chooses cutting technology as the source of this labor productivity, and assuming that his target is met, the costs attendant to the new technology must be considered. If the new technology costs $100,000 per year ($8,333 per month) in interest, and 60 calendar days are required to recycle a MARINER-class hull, the $9.33 savings in labor per LSW ton is offset by $2.17 in interest. Use of a cutting technology requiring twice as much fuel than older technology decreases the savings by an additional $2.00 per LSW ton. Further, assume that the machine requires $1.00 per LSW ton in additional maintenance over older technology. The net result in labor productivity from this simple exercise is $4.16, which is about the same as the cost of personnel protection. The target is only half-way met by technology of this sort, and clearly labor productivity gains alone will not make recycling profitable. And, as discussed above, this investment will not be made without a regular supply of ships being available to justify the new technology.

Revenue-Enhancing Technologies. It is clear that productivity techniques may make the recycling business more nearly viable. However, the greatest benefit can come from revenue-enhancing techniques that are possible through new technology. The two principal revenue streams from a recycled ship come from ferrous scrap and cuprous scrap. The intrinsic value of cuprous scrap makes it the more attractive candidate for revenue enhancement. Further, given that cuprous scrap is entwined with PCB regulation, a partial solution to the PCB disposal matter has substantial implications for the viability of the recycling industry. Copper wire will be taken as an example.

Copper and PCBs. The matter of copper and its presumed contamination with PCBs is discussed at length elsewhere,[5] as have various waste stream destruction technologies.[6] The vitrification technology appears to have a great deal of merit. Simply put, if a way can be found to maximize copper revenues to that of near-market prices, ship breaking/recycling becomes substantially more attractive to a recycler. Copper wire is an example. Approximately 20 tons (44,800 pounds) of copper wire are found in a MARINER-class vessel. Of this, approximately 80% is copper by weight and 20% is presumed to be PCB-contaminated insulation. This then leaves 35,840 pounds of pure copper available for sale. Currently, the bid price for high-grade copper

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[5] Maritime Administration, Report MA-ENV-820-96003-E, *Survey of Ships and Materials*, July 1997.

[6] Maritime Administration, Report MA-ENV-820-96003-C, *Current and Advanced Technologies for the Ship Breaking/Recycling Industry*, July 1997.

wire contaminated with PCBs is $0.10 per pound, which gives a revenue of $3584 per ship or $0.46 per LSW ton. Essentially, then, the wire is fluff. If copper can be inexpensively decontaminated and sold at, say, $1.00 per pound after transportation costs and other transaction costs, the potential revenue obtainable by selling the wire will be $35,840, or $4.66 per LSW ton. This tenfold increase becomes quite dramatic when applied to all copper found on a ship.

Vitrification. Vitrification is the process of creating a thermally active mass of silicon (molten glass), which is self-sustaining at a critical heat. The insertion of copper wire into this mass results in (1) gasification of PCBs and (2) liquefaction of metallic components of the wire. Due to the different specific densities of the metals and the glass, it is theoretically possible to tap off the copper as a pure metal. All other materials are solidly formed into the cooled vitreous material, which resembles obsidian. This material is inert for practical purposes. Further, there is no reason to limit the input copper-bearing materials to wire. Motor and generator armatures could just as well be considered.

Other Thermal Reduction Methods. There are other technologies available that can heat the copper and allow extraction. Similarly, nonthermal methods such as wire stripping are available. Many of these technologies are under development in the waste-stream reduction industry. Ship breaking/recycling alone is incapable of the capital investment necessary to produce such machines, but a broader base of funding may well bode well for ship copper wire and other copper.

4.1.2 Rationalization of the Selling and Contract Monitoring Process

The current process of offering candidates for recycling under Invitation for Bid (I.F.B.) rules[7] provides limited flexibility for arriving at unique solutions and discourages development of the recycling industry. A modified I.F.B. procedure could be used to greater benefit, or, better yet, a request-for-proposals (R.F.P.)[8] system should be used.

4.1.2.1 Selling Under Invitation-for-Bid Rules

In I.F.B. selling, the variability of the enforcement of the environmental laws on ship breaking/recycling with respect to hazardous materials produces artificially low bids. Additionally, there is insufficient flexibility in the I.F.B. process, as set out in the Federal Acquisition Regulations (FARs), to accommodate innovative bidding strategies and negotiations. This inflexibility drives bid prices down so that bidders can maintain a reasonable margin in the event that an unanticipated cost, such as an unplanned hazardous material removal, occurs. With the exception of some fairly simple rules relating to "responsive and responsible" bidders, the government has little control over the subsequent process of environmentally compliant ship scrapping. In response to this situation, MARAD currently requires a compliance plan to be submitted with any bid. The intent of this plan is to provide MARAD with information on the

[7] 48 CFR 14.

[8] 48 CFR 15.

bidders' environmental management strategies with regard to materials generated during ship scrapping operations.

4.1.2.2 Selling Under Request-for-Proposal Rules

In this method of selling, some technical assessment of the recycler's plans for recycling as well as the costs he proposes can be assessed by the seller. Negotiation is possible between buyer and seller. This method allows technically and financially marginal recyclers to be weeded out so that responsible and well-financed recyclers can perform the function of recycling. This process further allows the government substantial control of the disposition process, with a higher probability of successful disposal than the I.F.B. method.

4.1.2.3 Rationalization of Environmental Rules

It is clear from Chapter 3 that the benefits of environmental regulation outweigh the costs of such regulation if the costs are reasonable and reasonably applied. It appears, however, that such regulation has not fully dealt with the problems of ship breaking/recycling.[9] (The PCB problem is one example of this difficulty.) PCBs have been stringently regulated in commerce. The difficulty is in applying regulations that were developed for either generic problems or land-based matters to the problems of ship breaking/recycling. Exemptions have been granted to entire industries with respect to disposal of discarded products as potentially PCB-contaminated waste.[10] The reason for this is beyond the scope of this report. However, in the exemption of such industries, consideration presumably was made of a number of factors including the technical merit associated with the exemption.

Notwithstanding, shipborne PCB-contaminated waste is not now exempt from the application of PCB regulations. The method of sampling prescribed by the EPA for PCBs, as described elsewhere,[11] is expensive, time consuming and may not accurately depict PCB contamination in vessels.

The existing regulations invite "Region shopping"[12] and even less savory methods of interpretive action by financially marginal recyclers. One appropriate method MARAD may consider is providing a detailed survey of PCB-bearing locations to the recycler which the recycler can rely upon in formulating his bid and in negotiating with EPA for his environmentally compliant scrapping plan. This would increase the viability of the industry. Another method would be for MARAD to develop an appropriate PCB-controlling procedure and negotiate with the EPA to permit it in the case of ship breaking/recycling.

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[9] Maritime Administration, Report MA-ENV-820-96003-A, *The Legal Environment for Environmentally Compliant Ship Breaking/Recycling in the United States*, July 1997.

[10] E.g., automobile scrapping and white goods scrapping.

[11] Maritime Administration, Report MA-ENV-820-96003-E, *Survey of Ships and Materials*, July 1997.

[12] This is the process of negotiating various regulatory matters in different EPA Regions, looking for the most lenient Region.

4.1.2.4 Transfer of Cost and Liability

MARAD may have less difficulty selling its ships for recycling if it can adopt alternative methods for the transfer of ships.

Tanks and Bilges Clean and Gas-Free. A substantial cost to the recycler (see Chapter 3) is accepting a ship "as is, where is" and then being responsible for the cleaning and gas-freeing of the ship for (1) hot work and (2) disposal of the effluent from the tankage. Typically this cost is considered in the bid and can significantly reduce the bid price. By presenting the ships clean and gas-free to the recycler, MARAD may be able to increase the return for its ships. Presentation of the ship in this condition may increase the initial preparation costs to the government, but these costs must be balanced against the potential increased return. Moreover, the funds to perform such work may not be available in current budgets.

Clean of Asbestos. As discussed above, the cleaning of a ship of asbestos is a well-known process but adds substantial cost to the recycler. Most shipyards are adept in asbestos-cleaning processes, as are a number of independent contractors. MARAD could provide clean candidate vessels for sale. The combination of an asbestos-clean and tank-clean and gas-free ship enhances the recycling economies substantially and may enable MARAD to increase the return for its ships. Once again, however, presentation of the ship in this condition may increase the initial preparation costs to the government, but these costs must be balanced against the potential increased return.

PCBs and Other Hazardous Materials Identified. PCB-containing materials must be removed during the reduction process. Accordingly, it would create substantially less uncertainty to the recycler if MARAD were able to provide a PCB and Other Hazardous Materials Survey Report on the ships to be sold. This would allow for a more equitable bid process in competition. Such a survey could be costly but might enable MARAD to increase the return for its ships.

4.2 SCENARIOS FOR SHIP BREAKING/RECYCLING

Several scenarios can be developed for recycling ships in the United States. Each is illustrative of some of the matters expressed in this chapter.

4.2.1 Do-Nothing Scenario

An intuitively appealing but wholly impracticable scenario would be to continue to maintain MARAD's scrap candidate ships in the Reserve Fleets as they have been maintained in the past. This is not an option, however, inasmuch as the National Maritime Heritage Act uses the mandatory language "shall sell"[13] with respect to MARAD's disposition of the candidate ships. Accordingly, this option is not developed further in this report.

[13] 16 U.S.C.S. 5401.

4.2.2 Selling "Clean"

It is clear that the removal of tankage, removal of asbestos, and removal of PCB-bearing fluff are principal noncontrollable cost drivers for ship breaking/recycling. Table 7 shows how obtaining ships with tanks clean and gas free and the ship asbestos free and with PCBs identified impact costs in the middle-range cost and revenue case. Such cleaning makes recycling substantially more viable as an industrial process.

Table 7. Profits in $/LSW-LT for Clean Delivery of Ships by MARAD

Clean of Asbestos	
Expected Revenue (Mid-Range)	135
Direct Cost	(125)
Asbestos Removal by MARAD	20
Indirect Cost	(34)
Profit Before Tax and Interest	(4)
Tanks Clean and Gas-Free	
Expected Revenue (Mid-Range)	135
Direct Cost	(125)
Tank Cleaning by MARAD	35
Indirect Cost	(34)
Profit Before Tax and Interest	11

4.2.3 Enhancing Revenue with Technology

Table 8 compares the middle-range cost scenario with enhanced productivity and revenue produced from copper-recovery technological applications and no "clean" delivery. Such changes make the recycling industry more attractive than now. The enhanced revenue values in Table 8 are a result of the revenue values presented in Table 5 plus $20/LSW-ton revenue increase due to higher productivity and lower labor costs (see Section 4.1.1.1 for details).

Table 8. Profits in $/LSW-LT from Technology-Enhanced Copper and Ferrous Scrap and Other Revenues with Ships Sold in Unmodified Condition

	Low	Middle	High
Enhanced Revenue	145	155	165
Cost (Direct and Indirect) No transfer	148	159	170
Net Profit Before Tax and Interest	(3)	(4)	(5)

4.2.4 Selling for Non-Transportation Purposes

The hulls of a number of the Reserve Fleet ships are of adequate soundness to find buyers for non-transportation purposes. For example, one party in the United States is actively engaged in the business of buying naval hulls and converting them to floating electrical generation platforms for sale of electricity outside the United States.[14] MARAD hulls might well be able to perform similar non-transportation uses if marketed and if MARAD were to develop ways to encourage such innovative use in the market.[15]

4.2.5 General Caution

None of the scenarios described above will make certain the viability of the ship breaking/ recycling market in the United States, as will be discussed below. Neither are there sufficient data to draw more than speculative conclusions that MARAD will receive sufficient monies from bidders to recoup the costs attendant to the sales scenarios discussed above.

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[14] Florida Aggregates Co., Inc.

[15] The Maritime Administration has long had interest in floating production plants and other kinds of floating industrial platforms. This interest could be translated to placing such plants and activities on obsolete hulls which are candidates for scrapping.

4.3 CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations can be stated succinctly. Several steps could be taken to enhance the viability of the ship breaking/recycling industry.

4.3.1 Clean Ships

Ships could be cleaned to some extent prior to sale for disposal. MARAD should consider offering its ships to the recycling market with tanks clean and gas free and with asbestos removed and with a Survey of PCBs and Other Hazardous Materials Report. This could potentially allow MARAD to increase the return for its ships and make ship breaking/recycling profitable to the recycler. This activity would increase the initial preparation costs to the government; however, these costs must be balanced against the potential increased return.

4.3.2 Technically Managed Scrapping

MARAD should sell its ships to the recycler who offers a technically acceptable proposal and who is financially and experientially capable of performing the scrapping according to his/her proposal.

4.3.3 Volume of Ships

MARAD could offer its ships in groups of no fewer than six vessels at a time on a regularly scheduled basis.

4.3.4 Technology

MARAD could investigate thermal reduction technologies for the efficient destruction of hazardous materials and the simultaneous recovery of base metals in ship breaking/recycling. This longer-range concept could perhaps be repaid to MARAD in a substantial rise in bid prices for hulls.

4.3.5 Other Matters

MARAD should consider a program of financial guarantees for the acquisition of equipment for efficient and environmentally compliant ship scrapping. Further, MARAD should work with EPA to determine procedures for environmentally sound ship breaking/recycling that are acceptable to both parties and that recognize the peculiarities of the maritime endeavor.

APPENDIX 1

U.S. IRON AND STEEL SCRAP SPECIFICATIONS

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US iron and steel scrap specifications

The following specifications are reproduced by courtesy of the Institute of Scrap Recycling Industries Inc (Isri). Additional information or copies of the complete specification can be obtained from the Institute of Scrap Recycling Industries Inc, 1325 G. Street NW, Suite 1000, Washington, DC 20005-3104, USA. (Fax: +1 (202) 775 9109).

General

a. **Cleanness.** All grades shall be free of dirt, non ferrous metals, or foreign material of any kind, and excessive rust and corrosion. However, the terms 'free of dirt', non ferrous metals, or foreign material of any kind, are not intended to preclude the accidental inclusion of negligible amounts where it can be shown that this amount is unavoidable in the customary preparation and handling of the particular grade involved.

b. **Off-grade material.** The inclusion in a shipment of a particular grade of iron and steel scrap of a negligible amount of metallic material which exceeds to a minor extent the applicable size limitations, or which fails to a minor extent to meet the applicable requirements as to quality or kind of material, shall not change the classification of the shipment, provided it can be shown that the inclusion of such off-grade material is unavoidable in the customary preparation and handling of the grade involved.

c. **Residual alloys.** Wherever the term 'free of alloys' is used in the classifications given herein, it shall mean that any alloys contained in the steel are residual and have not been added for the purpose of making an alloy steel. Steel scrap shall be considered free of alloys when the residual alloying elements do not exceed the following percentages: Nickel 0.45%; Chromium 0.20%; Molybdenum 0.10%; Manganese 1.65%. The combined residuals other than manganese shall not exceed a total of 0.60%.

d. **Deviations.** Any deviations from the general classifications of iron and steel scrap may be consummated by mutual agreement between buyer and seller.

Code No.

200 **No. 1 heavy melting steel.** Wrought iron and/or steel scrap ¼ in. and over in thickness. Individual pieces not over 60 in. x 24 in. (charging box size) prepared in a manner to insure compact charging.

201 **No. 1 heavy melting steel 3 ft. x 18 in.** Wrought iron and/or steel scrap ¼ in. and over in thickness. Individual pieces not over 36 in. x 18 in. (charging box size) prepared in a manner to insure compact charging.

202 **No. 1 heavy melting steel 5 ft. x 18 in.** Wrought iron and/or steel scrap ¼ in. and over in thickness. Individual pieces not over 60 in. x 18 in. (charging box size) prepared in a manner to insure compact charging.

203 **No. 2 heavy melting steel.*** Wrought iron and steel scrap, black and galvanized, ⅛ in. and over in thickness, charging box size to include material not suitable as No. 1 heavy melting steel. Prepared in a manner to insure compact charging.

204 **No. 2 heavy melting steel.*** Wrought iron and steel scrap, black and galvanized, maximum size 36 in. x 18 in. May include all automobile scrap properly prepared. *The identical designations given for these two classifications are in accordance with established industry practices in specifying the materials desired.

205 **No. 2 heavy melting steel 3 ft. x 18 in.** Wrought iron and steel scrap, black and galvanized, maximum size 36 in. x 18 in. May include automobile scrap, properly prepared, however, to be free of sheet iron or thin gauged material.

206 **No. 2 heavy melting steel 5 ft. x 18 in.** Wrought iron and steel scrap, black and galvanized, maximum size 60 in. x 18 in. May include automobile scrap, properly prepared, however, to be free of sheet iron or thin gauged material.

207 **No. 1 busheling.** Clean steel scrap, not exceeding 12 in. in any dimensions, including new factory busheling (for example, sheet clippings, stampings, etc.). May not include old auto body and fender stock. Free of metal coated, limed, vitreous enameled, and electrical sheet containing over 0.5% silicon.

207A **New Black Sheet Clippings.** For direct charging, max. size 8 ft. x 18 in., free of old automobile body and fender stock, metal coated, limed, vitreous enameled and electrical sheet containing over 0.5% silicon, must lay reasonably flat in car.

208 **No. 1 bundles.** New black steel sheet scrap, clippings or skeleton scrap, compressed or hand bundled, to charging box size, and weighing not less than 75 lb. per cubic foot. (Hand bundles are tightly secured for handling with a magnet). May include Stanley balls or mandrel wound bundles or skeleton reels, tightly secured. May include chemically detinned material. May not include old auto body or fender stock. Free of metal coated, limed, vitreous enameled, and electrical sheet containing over 0.5% silicon.

209 **No. 2 bundles.** Old black and galvanized steel sheet scrap, hydraulically compressed to charging box size and weighing not less than 75 lb. per cubic foot. May not include tin or lead-coated material or vitreous enameled material.

210 **Shredded scrap.** Homogeneous iron and steel scrap, magnetically separated, originating from automobiles, unprepared No. 1 and No. 2 steel, miscellaneous baling and sheet scrap. Average density 50 lb. per cubic foot.

US iron & steel scrap specifications (continued)

211 **Shredded scrap.** Homogeneous iron and steel scrap magnetically separated, originating from automobiles, unprepared No. 1 and No. 2 steel, miscellaneous baling and sheet scrap. Average density 70 lb. per cubic foot.

212 **Shredded clippings.** Shredded 1000 series carbon steel clippings or sheets. Material should have an average density of 60 lb. per cubic foot.

213 **Shredded Tin Cans for Remelting.** Shredded steel cans, tin coated or tin free, may include aluminium tops but must be free of aluminium cans, non ferrous metals except those used in can construction, and non-metallics of any kind.

214 **No. 3 bundles.** Old sheet steel, compressed to charging box size and weighing not less than 75 lb. per cubic foot. May include all coated ferrous scrap not suitable for inclusion in No. 2 bundles.

215 **Incinerator bundles.** Tin can scrap, compressed to charging box size and weighing not less than 75lb. per cubic foot. Processed through a recognized garbage incinerator.

216 **Terne plate bundles.** New terne plate sheet scrap, clippings or skeleton scrap, compressed or hand bundled, to charging box size, and weighing not less than 75 lb. per cubic foot. (Hand bundles are tightly secured for handling with a magnet.) May include Stanley balls or mandrel wound bundles or skeleton reels, tightly secured.

217 **Bundled No. 1 steel.** Wrought iron and/or steel scrap ⅛ in. or over in thickness, compressed to charging box size and weighing not less than 75 lb. per cubic foot. Free of all metal coated material.

218 **Bundled No. 2 steel.** Wrought iron or steel scrap, black or galvanized, ⅛ in. and over in thickness, compressed to charging box size and weighing not less than 75 lb. per cubic foot. Auto body and fender stock, burnt or hand stripped, may constitute a maximum of 60% by weight. (This percent based on makeup of auto body, chassis, driveshafts, and bumpers.) Free of all coated material, except as found on automobiles.

219 **Machine shop turnings.** Clean steel or wrought iron turnings, free of iron borings, non ferrous metals in a free state, scale, or excessive oil. May not include badly rusted or corroded stock.

220 **Machine shop turnings and iron borings.** Same as machine shop turnings but including iron borings.

221 **Shoveling turnings.** Clean short steel or wrought iron turnings, drillings, or screw cuttings. May include any such material whether resulting from crushing, raking, or other processes. Free of springy, bushy, tangled or matted material, lumps, iron borings, non ferrous metals in a free state, grindings, or excessive oil.

222 **Shoveling turnings and iron borings.** Same as shovelling turnings, but including iron borings.

223 **Iron borings.** Clean cast iron or malleable iron borings and drillings, free of steel turnings, scale, lumps, and excessive oil.

224 **Auto slabs.** Clean automobile slabs, cut 3 ft. x 18 in. and under.

225 **Auto slabs.** Clean automobile slabs, cut 2 ft. x 18 in. and under.

226 **Briquetted iron borings.** Analysis and density to consumer's specifications.

227 **Briquetted steel turnings.** Analysis and density to consumer's specifications.

228 **Mill scale.** Dark colored, ranging from blue to black, ferro-magnetic iron oxide forming on the surface of steel articles during heating and working.

Electric Furnace Casting, and Foundry Grades

229 **Billet, bloom and forge crops.** Billet, bloom, axle, slab, heavy plate and heavy forge crops, containing not over 0.05% phosphorus or sulphur and not over 0.5% silicon, free from alloys. Dimensions not less than 2 in. in thickness, not over 18 in. in width, and not over 36 in. in length.

230 **Bar crops and plate scrap.** Bar crops, plate scrap, forgings, bits, jars, and tool joints, containing not over 0.05% phosphorus or sulphur, not over 0.5% silicon, free from alloys. Dimensions not less than ½in. thickness, not over 18 in. in width, and not over 36 in. in length.

231 **Plate and structural steel, 5 ft. and under.** Cut structural and plate scrap, 5 ft. and under. Clean open hearth steel plates, structural shapes, crop ends, shearings, or broken steel tires. Dimensions not less than ¼ in. thickness, not over 5 ft. in length and 18 in. in width. Phosphorus or sulphur not over 0.05%.

232 **Plate and structural steel, 5 ft. and under.** Cut structural and plate scrap, 5 ft. and under. Clean open hearth steel plates, structural shapes, crop ends, shearings, or broken steel tires. Dimensions not less than ¼ in. thickness, not over 5 ft. in length and 24 in. in width. Phosphorus or sulphur not over 0.05%.

233 **Cast steel.** Steel castings not over 48 in. long or 18 in. wide, and ¼ in. and over in thickness, containing not over 0.05% phosphorus or sulphur, free from alloys and attachments. May include heads, gates, and risers.

234 **Punchings and plate scrap.** Punchings or stampings, plate scrap, and bar crops containing not over 0.05% phosphorus or sulphur and not over 0.5% silicon, free from alloys. All materials cut 12 in. and under, and with the exception of punchings or stampings, at least ⅛ in. in thickness. Punchings or stampings under 6 in. in diameter may be any gauge.

235 **Electric furnace bundles.** New black steel sheet scrap hydraulically compressed into bundles of size and weight as specified by consumer.

US iron & steel scrap specifications (continued)

236 **Cut structural and plate scrap, 3 ft. and under.** Clean open hearth steel plates, structural shapes, crop ends, shearings, or broken steel tires. Dimensions not less than ¼ in. in thickness, not over 3 ft. in length and 18 in. in width. Phosphorus or sulphur not over 0.05%.

237 **Cut structural and plate scrap, 2 ft. and under.** Same as cut structural and plate scrap, 3 ft. and under, except for length.

238 **Cut structural and plate scrap, 1 ft. and under.** Same as cut structural and plate scrap, 3 ft. and under, except for length.

239 **Silicon busheling.** Clean silicon bearing steel scrap, not exceeding 12 in. in any dimensions, including new factory busheling (for example, sheet clippings, stampings, etc.), having a silicon content of 0.05% to 5.0%.

240 **Silicon clippings.** Clean steel scrap, including new factory busheling (for example, sheet clippings, stampings, etc.), may not include old auto body and fender stock. Free of metal coated, limed, vitreous enameled, and electrical sheet containing minimum 1% silicon.

241 **Chargeable ingots and ingot butts.** Chargeable ingots and ingot butts for material to be suitable and acceptable to the consumer containing not over 0.05% phosphorus or sulphur and not over 0.05% silicon free of alloys.

242 **Foundry steel, 2 ft. and under.** Steel scrap ⅛ in. and over in thickness, not over 2 ft. in length or 18 in. in width. Individual pieces free from attachments. May not include non ferrous metals, cast or malleable iron, cable, vitreous enameled, or metal coated material.

243 **Foundry steel, 1 ft. and under.** Same specifications as 2 ft. material, except for length.

244 **Springs and crankshafts.** Clean automotive springs and crankshafts, either new or used.

245 **Alloy free turnings.** Clean shoveling steel turnings free from lumps, tangled or matted material, iron borings, or excessive oil containing not more than 0.05% phosphorus or sulphur, and free of alloys.

246 **Alloy free short shoveling steel turnings.** Clean shoveling steel turnings, free of lumps, tangled or matted material, iron borings, or excessive oil, containing not more than 0.05% phosphorus or sulphur, and free of alloys.

247 **Alloy free machine shop turnings.** Clean steel turnings, free of iron borings or excessive oil, containing not more than 0.05% phosphorus or sulphur, and free of alloys. May not include badly rusted or corroded stock.

248 **Hard steel cut 30 in. and under.** Automotive steel consisting of rear ends, crankshafts, driveshafts, front axles, springs, and gears prepared 30 in. and under. May not include miscellaneous small shoveling steel or any pieces too bulky for gray iron foundry use.

249 **Chargeable slab crops.** Chargeable slab crops for material to be suitable and acceptable to the consumer containing not over 0.05% phosphorus and 0.05% sulphur and not over 0.05% silicon; free of alloys.

250 **Silicon bundles.** Silicon sheet scrap, clippings or skeleton scrap, compressed or hand bundled, to charging box size, and weighing not less than 75 lb. per cubic foot, having a silicon content of 0.50% to 5.0%.

251 **Heavy turnings.** Short, heavy turnings, containing not over 0.05% phosphorus or sulphur and free of alloys. May include rail chips. May not include machine shop or other light turnings and must weigh not less than 75 lb. per cubic foot in the original state of production.

Specially Processed Grade to Meet Consumer Requirements

Grades of scrap prepared especially to meet with steel mill or foundry requirements, individual specifications to be agreed on between consumer and supplier.

Cast Iron Grades

252 **Cupola cast.** Clean cast iron scrap as columns, pipes, plates, and castings of a miscellaneous nature, including automobile blocks and cast iron parts of agricultural and other machinery. Free from stove plate, burnt iron, brake shoes or foreign material. Cupola size, not over 24 in. x 30 in., and no piece over 150 lb. in weight.

253 **Charging box cast.** Clean cast iron scrap in sizes not over 60 in. in length or 30 in. in width, suitable for charging into an open hearth furnace without further preparation. Free from burnt iron, brake shoes, or stove plate.

254 **Heavy breakable cast.** Cast iron scrap over charging box size or weighing more than 500 lb. May include cylinders and driving wheel centers. May include steel which does not exceed 10% of the casting by weight.

255 **Hammer block or bases.** Cast iron hammer blocks or bases.

256 **Burnt iron.** Burnt cast iron scrap, such as stove parts, grate bars and miscellaneous burnt iron. May include sash weights or window weights.

257 **Mixed cast.** May include all grades of cast iron except burnt iron. Dimensions not over 24 in. x 30 in. and no piece over 150 lb. in weight.

258 **Stove plate, clean cast iron stove.** Free from malleable and steel parts, window weights, plow points, or burnt cast iron.

US iron & steel scrap specifications (continued)

259 **Clean auto cast.** Clean auto blocks; free of all steel parts except camshafts, valves, valve springs, and studs. Free of non ferrous and non-metallic parts.

260 **Unstripped motor blocks.** Automobile or truck motors from which steel and non ferrous fittings may or may not have been removed. Free from driveshafts and all parts of frames.

261 **Drop broken machinery cast.** Clean heavy cast iron machinery scrap that has been broken under a drop. All pieces must be of cupola size, not over 24 in. x 30 in., and no piece over 150 lb. in weight.

262 **Clean auto cast, broken, not degreased.** Clean auto blocks, free of all steel parts except camshafts, valves, valve springs and studs. Free of non ferrous and non-metallic parts, and must be broken to cupola size, 150 lb. or less.

263 **Clean auto cast, degreased.** Free of all steel parts except camshafts, valves, valve springs, and studs. Free of non ferrous and non-metallic parts, and must be broken into cupola size, 150 lb. or less.

264 **Malleable.** Malleable parts of automobiles, railroad cars, locomotives, or miscellaneous malleable iron castings. Free from cast iron and steel parts and other foreign material.

265 **Broken ingot molds and stools.** Broken ingot molds and stools, cast iron, maximum size 2 ft. x 3 ft. x 5 ft.

266 **Unbroken ingot molds and stools.** Unbroken ingot molds and stools, cast iron.

Special Boring Grades

267 **No. 1 chemical borings.** New clean cast or malleable iron borings and drillings containing not more than 1% oil, free from steel turnings, or chips, lumps, scale, corroded or rusty material.

268 **Briquetted cast iron borings, hot process.** Cast iron borings, heated, briquetted, to a density of approximately 85%, oil and water content under 1%.

269 **Briquetted cast iron borings, cold process.** Cast iron boring briquettes, free of steel and non ferrous material, hydraulically compressed into a cohesive solid, reasonably free of oil, and having a density of not less than 60%.

270 **Malleable borings.**Clean malleable iron borings and drillings, free of steel turnings, scale, lumps and excessive oil.

271 **No. 2 chemical borings.** New clean cast or malleable iron borings and drillings, containing not more than 1.5% oil, free from steel turnings, or chips, lumps, scale, corroded or rusty material.

APPENDIX 2

U.S. NON-FERROUS SCRAP SPECIFICATIONS

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US non-ferrous scrap specifications

The following specifications are reproduced by courtesy of the Institute of Scrap Recycling Industries Inc (Isri). Additional information or copies of the complete specification can be obtained from the Institute of Scrap Recycling Industries Inc, 1325 G Street NW, Suite 1000, Washington DC 20005-3104, USA (Fax: +1 (202) 775 9109).

ISRI Code Word	Item
Apple	**Nonferrous Terms.** (a) Delivery of more or less of the specified quantity up to 3 per cent is permissible. (b) A ton shall be understood to be 2000 pounds, unless otherwise specified. (c) If any portion of the goods covered by a contract are unshipped or undelivered within the time specified in a contract, then that portion is subject to cancellation by the buyer, and/or the buyer has the right to hold the seller responsible for substantiated damages. If because of embargo and/or other conditions of force majeure, a delivery or shipment cannot be made by the time specified, the contract shall remain valid and shall be completed promptly upon lifting of the embargo, and/or conditions of force majeure and the terms of said contract shall not be changed. (d) If for any portion of a contract the buyer fails in a timely manner to open a Letter of Credit, and/or fails to provide proper conveyance and/or shipping instructions as specified in the contract, then that portion is subject to cancellation by the seller and/or the seller has the right to hold the buyer responsible for substantiated damages. If, because of embargo and/or other conditions of force majeure, a delivery or shipment cannot be made by the time specified, the contract shall remain valid and shall be completed promptly upon lifting of the embargo, and/or conditions of force majeure and the terms of said contract shall not be changed. (e) If a significant weight or quality difference is apparent, the seller should be notified promptly and, if requested, another weight or quality determination should be taken. Seller and/or buyer should be given the opportunity to appoint an independent surveyor or a representative to verify weights and/or quality. For purposes of this section, the meaning of the word "significant" shall be determined by agreement between buyer and seller, depending on the commodities and their values. (f) If it is mutually determined that goods delivered do not conform to the description specified in the contract, then the shipment is subject to rejection or downgrade. Disposition of, replacement of, and/or financial adjustment for rejected material shall be subjected to mutual agreement between buyer and seller. Seller is responsible for freight costs. Buyer is expected, however, to exert every effort to limit rejections only to that portion of the shipment which is unsortable and to return the rejected portion promptly upon request, if government regulations permit.
Barley	**No. 1 Copper Wire.** Shall consist of No. 1 bare, uncoated, unalloyed copper wire, not smaller than No. 16 B & S wire gauge. Green copper wire and hydraulically compacted material to be subject to agreement between buyer and seller.
Berry	**No. 1 Copper Wire.** Shall consist of clean, untinned, uncoated, unalloyed copper wire and cable, not smaller than No. 16 B & S wire gauge, free of burnt wire which is brittle. Hydraulically briquetted copper subject to agreement.
Birch	**No. 2 Copper Wire.** Shall consist of miscellaneous, unalloyed copper wire having a nominal 96% copper content (minimum 94%) as determined by electrolytic assay. Should be free of the following. Excessively leaded, tinned, soldered copper wire; brass and bronze wire; excessive oil content, iron, and non-metallics; copper wire from burning, containing insulation; hair wire; burnt wire which is brittle; and should be reasonably free of ash. Hydraulically briquetted copper subject to agreement.
Candy	**No. 1 Heavy Copper.** Shall consist of clean, unalloyed, uncoated copper clippings, punchings, bus bars, commutator segments, and wire not less than 1/16 of an inch thick, free of burnt wire which is brittle; but may include clean copper tubing. Hydraulically briquetted copper subject to agreement.
Cliff	**No. 2 Copper.** Shall consist of miscellaneous, unalloyed copper scrap having a nominal 96% copper content (minimum 94%) as determined by electrolytic assay. Should be free of the following: Excessively leaded, tinned, soldered copper scrap; brasses and bronzes; excessive oil content, iron and non-metallics; copper tubing with other than copper connections or with sediment; copper wire from burning, containing insulation; hair wire; burnt wire which is brittle; and should be reasonably free of ash. Hydraulically briquetted copper subject to agreement.
Clove	**No. 1 Copper Wire Nodules.** Shall consist of No. 1 bare, uncoated, unalloyed copper wire scrap nodules, chopped or shredded, free of tin, lead, zinc, aluminum, iron, other metallic impurities, insulation, and other foreign contamination. Minimum copper 99%. Gauge smaller than No. 16 B & S wire and hydraulically compacted material subject to agreement between buyer and seller.

US non-ferrous scrap specifications (continued)

ISRI Code Word	Item
Cobra	**No. 2 Copper Wire Nodules.** Shall consist of No. 2 unalloyed copper wire scrap nodules, chopped or shredded, minimum 97% copper. Maximum metal impurities not to exceed 0.50% aluminum and 1% each of other metals or insulation. Hydraulically compacted material subject to agreement between buyer and seller.
Cocoa	**Copper Wire Nodules.** Shall consist of unalloyed copper wire scrap nodules, chopped or shredded, minimum 99% copper. Shall be free of excessive insulation and other non-metallics. Maximum metal impurities as follows: Aluminum — .05% Tin — .25% Nickel — .05% Antimony — .01% Iron — .05% Hydraulically compacted material subject to agreement between buyer and seller.
Dream	**Light Copper.** Shall consist of miscellaneous, unalloyed copper scrap having a nominal 92% copper content (minimum 88%) as determined by electrolytic assay and shall consist of sheet copper, gutters, downspouts, kettles, boilers, and similar scrap. Should be free of the following: Burnt hair wire; copper clad; plating racks; grindings; copper wire from burning, containing insulation; radiators, fire extinguishers; refrigerator units; electrotype shells; screening; excessively leaded, tinned, soldered scrap; brasses and bronzes; excessive oil, iron and non-metallics; and should be reasonably free of ash. Hydraulically briquetted copper subject to agreement. Any items excluded in this grade are also excluded in the higher grades above.
Drink	**Refinery Brass.** Shall contain a minimum of 61.3% copper and maximum 5% iron and to consist of brass and bronze solids and turnings, and alloyed and contaminated copper scrap. Shall be free of insulated wire, grindings, electrotype shells and non-metallics. Hydraulically briquetted material subject to agreement.
Drove	**Copper-Bearing Scrap.** Shall consist of miscellaneous copper-containing skimmings, grindings, ashes, irony brass and copper, residues and slags. Free of insulated wires; copper chlorides; unprepared tangled material; large motors; pyrophoric material; asbestos brake linings; furnace bottoms; high lead materials; graphite crucibles; and noxious and explosive materials. Fine powdered material by agreement. Hydraulically briquetted material subject to agreement.
Druid	**Insulated Copper Wire Scrap.** Shall consist of copper wire scrap with various types of insulation. To be sold on a sample or recovery basis, subject to agreement between buyer and seller.
Ebony	**Composition or Red Brass.** Shall consist of red brass scrap, valves, machinery bearings and other machinery parts, including miscellaneous castings made of copper, tin, zinc, and/or lead. Should be free of semi-red brass castings (78% to 81% copper); railroad car boxes and other similar high-lead alloys; cocks and faucets; closed water meters; gates; pot pieces; ingots and burned brass; aluminum, silicon, and manganese bronzes; iron and non-metallics. No piece to measure more than 12" over any one part or weigh over 100 lbs.
Enerv	**Red Brass Composition Turnings.** Shall consist of turnings from red brass composition material and should be sold subject to sample or analysis.
Elder	**Genuine Babbitt-Lined Brass Bushings.** Shall consist of red brass bushings and bearings from automobiles and other machinery, shall contain not less than 12% high tin base babbitt, and shall be free of iron-backed bearings.
Eland	**High Grade—Low Lead Bronze Solids.** It is recommended these materials be sold by analysis.
Elias	**High Lead Bronze Solids and Borings.** It is recommended that these materials be sold on sample or analysis.
Engel	**Machinery or Hard Brass Solids.** Shall have a copper content of not less than 75%, a tin content of not less than 6%, and a lead content of not less than 6%—nor more than 11%, and total impurities, exclusive of zinc, antimony, and nickel of not more than 0.75%; the antimony content not to exceed 0.50%. Shall be free of lined and unlined standard red car boxes.
Erin	**Machinery or Hard Brass Borings.** Shall have a copper content of not less than 75%, a tin content of not less than 6%, and a lead content of not less than 6%—nor more than 11%, and the total impurities, exclusive of zinc, antimony, and nickel of not more than 0.75%, the antimony content not to exceed 0.50%.
Fence	**Unlined Standard Red Car Boxes (Clean Journals).** Shall consist of standard unlined and/or sweated railroad boxes and unlined and/or sweated car journal bearings, free of yellow boxes and iron-backed boxes.
Ferry	**Lined Standard Red Car Boxes (Lined Journals).** Shall consist of standard babbitt-lined railroad boxes and/or babbitt-lined car journal bearings, free of yellow boxes and iron-backed boxes.
Grape	**Cocks and Faucets.** Shall consist of mixed clean red and yellow brass, including chrome or nickel-plated, free of gas cocks, beer faucets, and aluminum and zinc base die cast material, and to contain a minimum of 35% semi-red.

US non-ferrous scrap specifications (continued)

ISRI Code Word	Item
Honey	**Yellow Brass Scrap.** Shall consist of brass castings, rolled brass, rod brass, tubing and miscellaneous yellow brasses, including plated brass. Must be free of manganese-bronze, aluminum-bronze, unsweated radiators or radiator parts, iron, excessively dirty and corroded materials.
Ivory	**Yellow Brass Castings.** Shall consist of yellow brass castings in crucible shape, no piece to measure more than 12 inches over any one part; and shall be free of brass forgings, silicon bronze, aluminum bronze and manganese bronze, and not to contain more than 15% nickel plated material.
Label	**New Brass Clippings.** Shall consist of the cuttings of new unleaded yellow brass sheet or plate, to be clean and free from foreign substances and not to contain more than 10% of clean brass punchings under ¼ inch. To be free of Muntz metal and naval brass.
Lace	**Brass Shell Cases without Primers.** Shall consist of clean fired 70/30 brass shell cases free of primers and any other foreign material.
Lady	**Brass Shell Cases with Primers.** Shall consist of clean fired 70/30 brass shell cases containing the brass primers and which contain no other foreign material.
Lake	**Brass Small Arms and Rifle Shells, Clean Fired.** Shall consist of clean fired 70/30 brass shells free of bullets, iron and any other foreign material.
Lamb	**Brass Small Arms and Rifle Shells, Clean Muffled (Popped).** Shall consist of clean muffled (popped) 70/30 brass shells free of bullets, iron and any other foreign material.
Lark	**Yellow Brass Primer.** Shall consist of clean yellow brass primers, burnt or unburnt. Free of iron, excessive dirt, corrosion and any other foreign material.
Maize	**Mixed New Nickel Silver Clippings.** Shall consist of one or more nickel silver alloys and the range of nickel content to be specified, free of chrome or any other plating material. Leaded nickel silver clippings should be packed and sold separately. Not to contain more than 10% of clean punchings under ¼ inch.
Major	**New Nickel Silver Clippings and Solids.** Shall consist of new, clean nickel silver clippings, plate, rod and forgings, and other rolled shapes, free of chrome or any other plating material. Must be sold on nickel content specifications such as 10%—12%—15%—18%—20%. Leaded nickel silver clippings should be packed and sold separately. A description as to its physical characteristics should be made in offering all nickel silver material.
Malar	**New Segregated Nickel Silver Clippings.** Shall consist of one specified nickel silver alloy. Not to contain more than 10% of clean punchings under ¼ inch.
Malic	**Old Nickel Silver.** Shall consist of old nickel silver sheet, pipe, rod, tubes, wire, screen, soldered or unsoldered. Must not be trimmed seams alone and it is also to be free of foreign substances, iron rimmed material and other metals.
Melon	**Brass Pipe.** Shall consist of brass pipe free of plated and soldered materials or pipes with cast brass connections. To be sound, clean pipes free of sediment and condenser tubes.
Naggy	**Nickel Silver Castings.** To be packed and sold separately.
Niece	**Nickel Silver Turnings.** To be sold by sample or analysis.
Night	**Yellow Brass Rod Turnings.** Shall consist of strictly rod turnings, free of aluminum, manganese, composition, Tobin and Muntz metal turnings; not to contain over 3% free iron, oil or other moisture; to be free of grindings and babbitts; to contain not more than 0.30% tin and not more than 0.15% alloyed iron.
Noble	**New Yellow Brass Rod Ends.** Shall consist of new, clean rod ends from free turning brass rods or forging rods, not to contain more than 0.30% tin and not more than 0.15% alloyed iron. To be free of Muntz metal and naval brass or any other alloys. To be in pieces not larger than 12 and free of foreign matter.
Nomad	**Yellow Brass Turnings.** Shall consist of yellow brass turnings, free of aluminum, manganese and composition turnings, not to contain over 3% of free iron, oil or other moisture; to be free of grindings and babbitts. To avoid disupute, to be sold subject to sample or analysis.
Ocean	**Mixed Unsweated Auto Radiators.** Shall consist of mixed automobile raidators, to be free of aluminum radiators, and iron finned radiators. All radiators to be subjected to deduction of actual iron. The tonnage specification should cover the gross weight of the radiators, unless otherwise specified.
Pales	**Admiralty Brass Condenser Tubes.** Shall consist of clean sound Admiralty condenser tubing which may be plated or unplated, free of nickel alloy, aluminum alloy, and corroded material.
Pallu	**Aluminum Brass Condenser Tubes.** Shall consist of clean sound condenser tubing which may be plated or unplated, free of nickel alloy and corroded material.
Palms	**Muntz Metal Tubes.** Shall consist of clean sound Muntz metal tubing which may be plated or unplated, free of nickel alloy, aluminum alloy, and corroded material.
Parch	**Manganese Bronze Solids.** Shall have a copper content of not less than 55%, a lead content of not more than 1%, and shall be free of aluminum bronze and silicon bronze.

US non-ferrous scrap specifications (continued)

ISRI Code Word	Item
Racks	**Scrap Lead—Soft.** Shall consist of clean soft scrap lead, free of all foreign materials such as drosses, battery lead, lead covered cable, hard lead, collapsible tubes, foil, type metals, zinc, iron and brass fittings, dirty chemical lead. Free of radioactive materials.
Radio	**Mixed Hard/Soft Scrap Lead.** Shall consist of clean lead solids, free of foreign materials, such as drosses, battery lead, covered cable, collapsible tubes, type metals, zinc, iron and brass fittings, dirty chemical lead. Free of radioactive materials.
Rails	**Battery Plates.** If cells (plates, separators, and lugs) or battery plates, must be reasonably free of rubber. May be bought and sold by assay or as agreed between buyer and seller.
Rains	**Drained Whole Batteries.** Batteries to be free of liquid and extraneous material content. Aircraft (aluminum or steel cased) and other special batteries subject to special agreement.
Rakes	**Battery Lugs.** Shall be free from battery plates, rubber and foreign material. A minimum of 97% metallic content is required.
Ranks	**Pewter.** Shall consist of tableware and soda-fountain boxes but should contain a minimum of 84% tin. Siphon tops to be accounted for separately. Material must be free of brass, zinc, and other foreign metals.
Ranch	**Block Tin.** Block Tin must assay minimum of 98% tin, and to be free of liquids, solder, and brass connections, pewter, pumps, pot pieces, dirt.
Raves	**High Tin Base Babbitt.** Shall contain a minimum of 78% tin and be free of brassy or zincy metals.
Relay	**Lead Covered Copper Cable.** Free of armored covered cable, and foreign material.
Rents	**Lead Dross.** Should be clean and reasonably free of foreign matter, iron, dirt, harmful chemicals or other metals. Free of radioactive materials. Assay basis, or as agreed between buyer and seller. Other metals present such as antimony, tin, etc. to be accounted for as agreed between buyer and seller.
Ropes	**Lead Weights.** May consist of lead balances with or without iron, as may be specified. Free of foreign materials.
Roses	**Mixed Common Babbitt.** Shall consist of lead base bearing metal containing not less than 8% tin, free from Allens metal, ornamental, antimonial and type metal. Must be free from all zincy and excessive copper in the alloy.
Saves	**Old Zinc Die Cast Scrap.** Shall consist of miscellaneous old zinc base die castings, with or without iron and other foreign attachments. Must be free of borings, turnings, dross pieces, chunks, melted pieces and skimmings. All unmeltables, dirt, foreign attachments, and volatile substances (such as rubber, cork, plastic, grease, etc.) are deductible. Material containing in excess of 30% iron will not constitute good delivery.
Scabs	**New Zinc Die Cast Scrap.** Shall consist of new or unused, clean, zinc base die castings. Castings to be unplated, unpainted, and free from corrosion.
Scope	**New Plated Zinc Die Cast Scrap.** Shall consist of new or unused clean, plated zinc base die castings, free from corrosion.
Scoot	**Zinc Die Cast Automotive Grilles.** Shall consist of clean, old or used zinc base die cast automotive grilles, free from soldered material. All foreign attachments and extraneous materials are deductible.
Score	**Old Scrap Zinc.** Shall consist of clean dry scrap zinc, such as sheets, jar lids, clean unalloyed castings and anti-corrosion plates. Borings and turnings are not acceptable. Material must not be excessively corroded or oxidized. All foreign attachments and extraneous materials are deductible.
Screen	**New Zinc Clippings.** Shall consist of any new pure zinc sheets or stampings free from corrosion. To contain no foreign material or attachments. Printers zinc, such as engravers zinc, lithograph sheets and addressograph plates subject to special arrangements. Printers zinc to be free of routings.
Scull	**Zinc Die Cast Slabs or Pigs.** Shall consist of melted zinc base die cast materials, in smooth clean solid slabs or pigs. Material to be free from drosses and to contain a minimum zinc content of 90%. To contain a maximum of 0.1% nickel and maximum of 1% lead. Blocks are acceptable upon mutual agreement.
Scribe	**Crushed Clean Sorted Fragmentizers Die Cast Scrap, as produced from Automobile Fragmentizers.** To be clean, free of dirt, oil, glass, rubber, and trash. To contain a maximum of 5% unmeltables such as free iron, copper, aluminum and other metals.
Scroll	**Unsorted Zinc Die Cast Scrap.** Produced from automobile fragmentizers. Material to contain about 65% zinc-bearing scrap. Other nonferrous metals such as aluminum, stainless steel, red metal, etc., to be about 40%. Insulated copper wire about 1%. Trash, dirt, glass, rubber, oil, iron not to exceed 5%. Any variations to be sold by special arrangement between buyer and seller.
Scrub	**Hot Dip Galvanizers Slab Zinc Dross (Batch Process).** Shall consist only of galvanizers unsweated zinc dross in slab form from hot dip galvanizing (Batch Process) with a minimum zinc content of 92% and shall be free of skimmings and tramp iron. Broken pieces under 2" in diameter shall not exceed 10% of the weight of each shipment. Slabs shall not weigh over 100 pounds each. Heavier pieces acceptable upon mutual agreement between buyer and seller. Material from continuous galvanizing operation is not acceptable. Blocks are acceptable upon mutual agreement.

US non-ferrous scrap specifications (continued)

ISRI Code Word	Item
Seal	**Continuous Line Galvanizing Slab Zinc Top Dross.** Shall consist of unsweated zinc dross removed from the top of a continuous line galvanizing bath, in slab form not weighing in excess of 100 pounds each, with a minimum zinc content of 90%. Heavier pieces acceptable upon mutual agreement between buyer and seller. Shall be free of skimmings. Broken pieces under 2" in diameter shall not exceed 10% of the weight of each shipment.
Seam	**Continuous Line Galvanizing Slab Zinc Bottom Dross.** Shall consist of unsweated zinc dross removed from the bottom of a continuous line galvanizing bath, in slab form not weighing in excess of 100 pounds each, with a minimum zinc content of 92%. Heavier pieces acceptable upon mutual agreement between buyer and seller. Shall be free of skimmings. Broken pieces under 2" in diameter shall not exceed 10% of the weight of each shipment.
Shelf	**Prime Zinc Die Cast Dross.** Shall consist of metal skimmed from the top of pot of molten zinc die cast metal. Must be unsweated, unfluxed, shiny, smooth, metallic and free from corrosion or oxidation. Should be poured in molds or in small mounds weighing not over 75 pounds each. Zinc shall be minimum of 85%.
Tablet	**Clean Aluminum Lithographic Sheets.** To consist of alloys 1100 and/or 3003, to be free of paper, plastic, excessively inked sheets and other contaminants. Minimum of three inches in any direction.
Tabloid	**New, Clean Aluminum Lithographic Sheets.** To consist of alloys 1100 and/or 3003, uncoated, unpainted, to be free of paper, plastic, ink, and any other contaminants. Minimum of three inches in any direction.
Taboo	**Mixed Low Copper Aluminum Clippings and Solids.** Shall consist of new, clean, uncoated and unpainted low copper aluminum scrap of two or more alloys and to be free of 7000 series, foil, hair wire, wire screen, dirt, and other foreign substances. Grease and oil not to total more than 1%. Also free from punchings less than ½ in size. New can stock subject to arrangement between buyer and seller.
Taint/Tabor	**Clean Mixed Old Alloy Sheet Aluminum.** Shall consist of clean old alloy aluminum sheet and sheet utensil scrap of two or more alloys, free of 7000 alloy series, foil, venetian blinds, castings, hair wire, screen wire, food or beverage containers, pie plates, hub caps, radiator shells, airplane sheet foil, oil cans, bottle caps, plastic, dirt, and other foreign substances. Oil and grease not to total more than 1%. Up to 10% painted sheet, siding, and awnings permitted. Shall consist of new low copper aluminum can stock and clippings, clean, lithographed or not lithographed, and coated with clear lacquer but free of lids with sealers, iron, dirt and other foreign contamination. Oil not to exceed 1%.
Take	**New Aluminum Can Stock.** Shall consist new low copper aluminum can stock and clippings, clean, lithographed or not lithographed and coated with clear lacquer but free of lids with sealers, iron, dirt and other foreign contamination. Oil not to exceed 1%.
Talap	**Old Can Stock.** Shall consist of clean old aluminum cans, decorated or clear, free of iron, dirt, liquid and/or other foreign contamination.
Talcred	**Shredded Aluminum Used Beverage Can (UBC) Scrap.** Shall have a density of 12 to 17 pounds per cubic foot. Material should contain maximum 5% fines less than 4 mesh (U.S. standard screen size) and no more than 2.5% fines less than 12 mesh (U.S. standard screen size). Must be magnetically separated material and free of steel, lead, bottle caps, plastic cans and other plastics, glass, wood, dirt, grease, trash, and other foreign substances. Any free lead is basis for rejection. Any and all aluminum items, other than used beverage cans, are not acceptable. Items not covered in the specification, including moisture, are subject to special arrangement between buyer and seller.
Taldak	**Densified Aluminum Used Beverage Can (UBC) Scrap.** Shall have a biscuit density of 35 to 45 pounds per cubic foot. Each biscuit not to exceed 60 pounds. Nominal biscuit size range from 10" to 13" x 10¼" to 20" x 6¼" to 9". Shall have banding slots in both directions to facilitate bundle banding. All biscuits comprising a bundle must be of uniform size. Size: Bundle range dimensions acceptable are 41" to 44" x 51" to 54" x 54" to 56" (height). The only acceptable tieing method shall be as follows: Using minimum ⅝" wide by .020 thick steel straps the bundles are to be banded with one vertical band per row and a minimum of two girth (horizontal) bands per bundle. Use of skids and/or support sheets of any material is not acceptable. Must be magnetically separated material and free of steel, lead, bottle caps, plastic cans and other plastic, glass, wood, dirt, grease, trash, and other foreign substances. Any free lead is basis for rejection. Any and all aluminum items, other than used beverage cans, are not acceptable. Items not covered in the specification, including moisture, and any variations in the specification are subject to special arrangement between buyer and seller.
Taldon	**Baled Aluminum Used Beverage Can (UBC) Scrap.** Shall have a minimum density of 14 lbs. per cubic foot, and a maximum density of 17 lbs. per cubic foot for unflattened UBC and 22 lbs. per cubic foot for flattened UBC. Size: minimum 30 cubic feet, with bale range dimensions of 24" to 40" by 30" to 52" by 40" to 84". The only acceptable tieing method shall be as follows: four to six ⅝" x .020" steel bands, or six to ten no. 13 gauge steel wires (aluminum bands or wires are acceptable in equivalent strength and number). Use of skids and/or support sheets of any material are not acceptable. Must be magnetically separated material and free of steel, lead, bottle caps,

US non-ferrous scrap specifications (continued)

ISRI Code Word	Item
TALDON—*Cont.*	
	plastic cans and other plastics, glass, wood, dirt, grease, trash and other foreign substances. Any free lead is basis for rejection. Any and all aluminum items, other than used beverage cans, are not acceptable. Items not covered in the specification are subject to special arrangement between buyer and seller.
Taldork	**Briquetted Aluminum Used Beverage Can (UBC) Scrap** Shall have a briquette density of 50 pounds per cubic foot minimum. Nominal briquette size shall range from 12" to 24" x 12" to 24" in uniform profile with a variable length of 8" minimum and 48" maximum. Briquettes shall be bundled or stacked on skids and secured with a minimum of one vertical band per row and a minimum of one girth band per horizontal layer. Briquettes not to overhang pallet. Total package height shall be 48" maximum. Banding shall be at least ⅝" wide by .020" thick steelstrapping or equivalent strength. The weight of any bundle shall not exceed 4,000 pounds. Material must be magnetically separated and free of steel, plastic, glass, dirt and all other foreign subsances. Any and all aluminum items, other than UBC are unacceptable. Any free lead is a basis for rejection. Items not covered in the specification, including moisture, and any variation in the specification are subject to special arrangement between buyer and seller.
Tale	**Painted Siding.** Shall consist of clean, low copper aluminum siding scrap, painted one or two sides, free of iron, dirt, corrosion, fiber backing or other types of foreign contamination.
Talent	**Coated Scrap.** Shall consist of awnings, venetian blinds, vinyl, plastic, etc. Shall be subject to special arrangements between buyers and sellers.
Talk	**Aluminum Copper Radiators.** Shall consist of clean aluminum and copper radiators, and/or aluminum fins on copper tubing, free of brass tubing, iron and other foreign contamination.
Tall	**E.C. Aluminum Nodules.** Shall consist of clean E.C. aluminum, chopped or shredded, free of screening, hair-wire, iron, insulation, copper and other foreign contamination. Must be free of minus 20 mesh material. Must contain 99.45% aluminum content.
Talon	**New Pure Aluminum Wire and Cable.** Shall consist of new, clean, unalloyed aluminum wire or cable free from hair wire, wire screen, iron, insulation and any other foreign substance.
Tann	**New Mixed Aluminum Wire and Cable.** Shall consist of new, clean unalloyed aluminum wire or cable which may contain up to 10% 6000 series wire and cable free from hair wire, wire screen, iron, insulation and any other foreign substance.
Taste	**Old Pure Aluminum Wire and Cable.** Shall consist of old, unalloyed aluminum wire and cable containing not over 1% free oxide or dirt and free from hair wire, wire screen, iron, insulation and any other foreign substance.
Tassel	**Old Mixed Aluminum Wire and Cable.** Shall consist of old, unalloyed aluminum wire and cable which may contain up to 10% 6000 series wire and cable with not over 1% free oxide or dirt and free from hair wire, wire screen, iron, insulation and any other foreign substance.
Tarry	**Aluminum Pistons.** (a) Clean Aluminum Pistons. Shall consist of clean aluminum pistons to be free from struts, bushings, shafts, iron rings and any other foreign materials. Oil and grease not to exceed 2%. (b) Aluminum Pistons with Struts. Shall consist of clean whole aluminum pistons with struts to be free from bushings, shafts, iron rings and any other foreign materials. Oil and grease not to exceed 2%. (c) Irony Aluminum Pistons. Should be sold on recovery basis, or by special arrangements with purchaser.
Teens	**Segregated Aluminum Borings and Turnings.** Shall consist of clean, uncorroded aluminum borings and turnings of one specified alloy only and subject to deductions for fines in excess of 3% through a 20 mesh screen and dirt, free iron, oil, moisture and all other foreign materials. Material containing iron in excess of 10% and/or free magnesium or stainless steel or containing highly flammable cutting compounds will not constitute good delivery.
Telic	**Mixed Aluminum Borings and Turnings.** Shall consist of clean, uncorroded aluminum borings and turnings of two or more alloys and subject to deductions for fines in excess of 3% through a 20 mesh screen and dirt, free iron, oil, moisture and all other foreign materials. Material containing iron in excess of 10% and/or free magnesium or stainless steel or containing highly flammable cutting compounds will not constitute good delivery. To avoid dispute should be sold on basis of definite maximum zinc, tin and magnesium content.
Tense	**Mixed Aluminum Castings.** Shall consist of all clean aluminum castings which may contain auto and airplane castings but no ingots, and to be free of iron, dirt, brass, babbitt and any other foreign materials. Oil and grease not to total more than 2%.
Tepid	**Wrecked Airplane Sheet Aluminum.** Should be sold on recovery basis or by special arrangements with purchaser.
Terse	**New Aluminum Foil.** Shall consist of clean, new, pure, uncoated, unalloyed aluminum foil, free from anodized foil, radar foil and chaff, paper, plastics, or any other foreign materials. Hydraulically briquetted material by arrangement only.
Testy	**Old Aluminum Foil.** Shall consist of clean, old, pure, uncoated, unalloyed aluminum foil, free from anodized foil, radar foil and chaff, paper, plastics, or any other foreign materials. Hydraulically briquetted material by arrangement only.

US non-ferrous scrap specifications (continued)

ISRI Code Word	Item
Thigh	**Aluminum Grindings.** Should be sold on recovery basis or by special arrangements with purchaser.
Thirl	**Aluminum Drosses, Spatters, Spillings, Skimmings and Sweepings.** Should be sold on recovery basis or by special arrangements with purchaser.
Throb	**Sweated Aluminum.** Shall consist of aluminum scrap which has been sweated or melted into a form or shape such as an ingot, pig or slab for convenience in shipping; to be free from corrosion, drosses or any foreign materials. Should be sold subject to sample or analysis.
Tooth	**Segregated New Aluminum Alloy Clippings and Solids.** Shall consist of new, clean, uncoated and unpainted aluminum scrap of one specified aluminum alloy only and to be free of foil, hair, wire, wire screen, dirt, and other foreign substances. Oil and grease not to total more than 1%. Also free from punchings less than ½" in size. New can stock subject to arrangement between buyer and seller.
Tough	**Mixed New Aluminum Alloy Clippings and Solids.** Shall consist of new, clean, uncoated and unpainted aluminum scrap of two or more alloys free of 7000 series and to be free of foil, hair wire, wire screen, dirt, and other foreign substances. Oil and grease not to total more than 1%, Also free from punchings less than ½" in size. New can stock subject to arrangement between buyer and seller.
Tread	**Segregated New Aluminum Castings, Forgings and Extrusions.** Shall consist of new, clean, uncoated aluminum castings, forgings, and extrustions of one specified alloy only and to be free from sawings, stainless steel, zinc, iron, dirt, oil, grease and other foreign substances.
Trump	**Aluminum Auto Castings.** Shall consist of all clean automobile aluminum castings of sufficient size to be readily identified and to be free from iron, dirt, brass, babbitt bushings, brass bushings, and any other foreign materials. Oil and grease not to total more than 2%.
Twang	**Insulated Aluminum Wire Scrap.** Shall consist of aluminum wire scrap with various types of insulation. To be sold on a sample or recovery basis, subject to agreement between buyer and seller.
Twist	**Aluminum Airplane Castings.** Shall consist of clean aluminum castings from airplanes and to be free from iron, dirt, brass, babbitt bushings, brass bushings, and any other foreign materials. Oil and grease not to total more than 2%.
Twitch	**Fragmentizer Aluminum Scrap (from Automobile Shredders).** The material, as received, must be dry and not to contain more than 3% maximum free zinc, 1% maximum free magnesium, and 1.5% maximum free iron and stainless. Not to contain more than a total 5% maximum of non-metallics, of which no more than 1% shall be rubber and plastics. To be free of excessively oxidized material. Any variations to be sold by special arrangement between buyer and seller.
Wafer	**Magnesium Clips.** Shall consist of clean magnesium clips in crucible size, free of copper, aluminum, and zinc flashings and excessive oil and grease. To be free of all foreign attachments.
Walnut	**Magnesium Scrap.** Shall consist of magnesium castings, magnesium engine blocks and transmission casings, bomber and car wheels, extrusions, and sheet. Material to be free from brass and copper inserts and all foreign attachments. To be free of anodes, hollow castings and explosives. Percentages of and penalties for dirt, oil, grease, and iron to be subject to agreement between buyer and seller. Excessively large pieces to be negotiated between buyer and seller.
Wine	**Magnesium Engraver Plates.** To be free of copper, aluminum, zinc, and electrotype plates. To be clean and free of all foreign attachments. Magnesium plates shipped loose by agreement between buyer and seller.
Wood	**Magnesium Dockboards.** Shall consist of clean magnesium dockboard cut or broken to size agreed upon by buyer and seller. To be free of all foreign attachments.
World	**Magnesium Turnings.** It is recommended that these materials be sold by special arrangement between buyer and seller.
Aroma	**New Nickel Scrap.** Shall consist of clean new sheet, plate, bar, tube, and any other wrought nickel scrap solids. Nickel minimum 99%; Cobalt maximum 0.25%; Copper maximum 0.50%. Free of castings, as well as any foreign attachments or other contamination.
Burly	**Old Nickel Scrap.** Shall consist of old and/or new sheet, plate, bar, tube, and any other wrought nickel scrap solids. Material to contain a minimum of 98% nickel; Copper maximum 0.50%. This grade to be free of castings, soldered, brazed, sweated, or painted material, other metallic coating, foreign attachments, and any other contamination.
Dandy	**New Cupro Nickel Clips and Solids.** Shall consist of clean, new, segregated (normally accepted analysis grades) either 70/30, 80/20, or 90/10 cupro nickel tube, pipe, sheet, plate, or other wrought solid forms. Must be free of foreign attachments or any other contamination.
Daunt	**Cupro Nickel Solids.** Shall consist of old, and/or new, segregated (normally accepted analysis grades) either 70/30, 80/20, 90/10 cupro nickel tube, pipe, sheet, plate, or other wrought solid forms. Maximum 2% sediment allowable. Any other forms of cupro nickel solids such as castings, gates, risers, spills, etc., packaged separately, may or may not be included, only upon agreement

US non-ferrous scrap specifications (continued)

ISRI Code Word	Item
Daunt—*Cont.*	between buyer and seller. Must be free of foreign attachments and all other contamination. Other particulars concerning physical description, analysis and packaging to be agreed upon between buyer and seller.
Delta	**Soldered Cupro Nickel Solids.** Shall consist of segregated (normally accepted analysis grades) either 70/30, 80/20, 90/10 cupro nickel solids, soldered, brazed, or sweated, must be free of trimmed seams and edges and all other contamination.
Decoy	**Cupro Nickel Spinnings, Turnings, Borings.** Shall consist of clean segregated (normally accepted analysis grades) either 70/30, 80/20, 90/10 cupro nickel spinnings, turnings, or borings. Particulars concerning physical description, analysis, packaging, to be agreed upon between buyer and seller.
Depth	**Miscellaneous Nickel-Copper and Nickel-Copper Iron.** Shall consist of miscellaneous scrap in which the basic elements, by weight, are nickel and copper, such as copper nickel peelings, plating racks, and hangers, and all nickel and copper in attached or combined form. In all cases, miscellaneous nickel copper scrap should be sold by description and analysis.
Hitch	**New R-Monel Clippings and Solids.** Shall consist of clean, new, R-Monel sheet, plate, bar, rod, tube, pipe, or any other wrought scrap, free of any foreign attachments or any other contamination.
House	**New Mixed Monel Solids and Clippings.** Shall consist of new, clean R and K-Monel solids and clippings. Free of cast material, foreign attachments and all other contamination.
Ideal	**Old Monel Sheet and Solids.** Shall consist of clean R and K-Monel solids such as sheet, plate, pipe, rods, forgings, screen and wire cloth. Must be free of soldered, brazed, welded or sweated material, cast material, foreign attachments, and all other contamination.
Indian	**K-Monel Solids.** Shall consist of clean K-Monel solids.
Junto	**Soldered Monel Sheet and Solids.** Shall consist of soldered and/or brazed miscellaneous grades of Monel alloys in either wrought or cast form. Must be free of trimmed seams and edges, non-metallic filling, foreign attachments, and all other contamination. Particulars concerning physical description, assay, and packaging to be agreed upon between buyer and seller.
Lemon	**Monel Castings.** Shall consist of various types of clean Monel castings, assaying minimum 60% nickel. Must be free of foreign attachments or any other contamination.
Lemur	**Monel Turnings.** Shall consist of mixed Monel turnings and borings containing a minimum of 60% nickel content, on a dry basis.
Pekoe	**200 Series Stainless Steel Scrap Solids.** Shall consist of all types of clean AISI Series Stainless Steel Scrap Solids, which contain a maximum of .5% copper, free of foreign attachments and other contamination.
Sabot	**Stainless Steel Scrap.** Shall consist of clean 18-8 type stainless steel clips and solids containing a minimum 7% nickel, 16% chrome, and have a maximum of .50% molybdenum, .50% copper, .045% phosphorous, and .03% sulfur, and otherwise free of harmful contaminants. Particulars concerning physical description, grading, additional analysis, and preparation to be agreed upon between buyer and seller.
Ultra	**Stainless Steel Turnings.** Shall consist of clean 18-8 type stainless steel turnings containing a minimum 7% nickel and 16% chrome, and to be free of nonferrous metals, nonmetallics, excessive iron, oil and other contaminants. Particulars concerning physical description, assay, packaging to be agreed upon between buyer and seller.
Vaunt	**Edison Batteries.** Nickel-iron batteries to be sold free of crates, copper terminal connectors, and excess liquid. Free of nickel cadmium batteries.

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