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Vendor Weight Control for the Marine Industry

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Contents

1.0 Scope

This Recommended Practice is sponsored by the Society of Allied Weight Engineers Marine Systems Government - Industry Workshop. Its purpose is to supplement Recommended Practice 12 (Reference 1) which provides the requirements for weight control, Recommended Practice 13 (Reference 2) which defines a standard coordinate system for reporting mass properties information, and Recommended Practice 14 (Reference 3) which describes best practices and industry conventions for estimating and determining mass properties for ships.

This Recommended Practice focuses on the role that third party suppliers play in the marine industry practices which best satisfy the requirements for a comprehensive weight control program. As a Recommended Practice, this document is advisory in nature; however, it may be invoked as specified in a contractual agreement such as a design and construction contract or a purchase order. It is intended to applicable both to the suppliers of builder-furnished equipment and owner- or Government- furnished equipment for the marine industry.

The primary focus of this document is on the acquisition stage of a ship's life rather than its in-service stage although many of the elements presented may be applied throughout the life of the vessel.

This Recommended Practice is intended for use by ship designers/builders and the marine vendor community. For the designer/builder, it outlines an effective methodology for involving marine industry suppliers in the shipyard's comprehensive weight control plan. For the vendors of shipboard equipment, it provides a framework of what the shipyard needs in terms of mass properties input to effectively manage the overall mass properties of the ship. It is hoped that this Recommended Practice will help establish the foundation for a productive ship designer/builder – marine supplier working relationship.

2.0 Introduction and Purpose

A ship is a composite of material fabricated by the shipbuilder (shell, bulkheads, etc.), components built by the shipbuilder (foundations, piping systems, etc.), and various components procured from outside suppliers, or vendors (pumps, combat systems, generators, etc.). Each of these main classes of material can have a major impact on the mass properties of the ship as a whole. Components of the first two classes fall well within the control of the shipyard and, and, as a result, can usually be measured, estimated, or calculated with reasonable accuracy. The third class of items, those procured from a supplier, are more difficult to measure or calculate and frequently receive the least attention from the shipyard's mass properties engineers and analysts. However, the total impact of the contribution of as many as 1000 different suppliers to the ship can be very significant, as great as 30% of light ship weight or more depending on the ship and the builder.

In order to accurately predict the mass properties of the ship, a shipbuilder must impose some form of weight control on the suppliers. This Recommended Practice presents recommended levels of weight control for the suppliers of shipboard equipment, components, and systems. The traditional term "weight" as used throughout this document refers to refers to all pertinent mass properties such as center of gravity as well.

For the purposes of this Recommended Practice the terms "vendor" and "supplier" are considered completely interchangeable and both are used throughout this document.

There are three main purposes of vendor weight control:

- To identify the most accurate weight of a given supplied item at any given point during ship design and construction.
- To track mass properties trends so that adverse impacts to the ship can be forecast at such a point in time that corrective action can be taken to ensure that the ship has acceptable naval architectural characteristics.
- To establish proactive measures that ensure the weight of supplier-furnished equipment receives the appropriate priority and attention necessary to result in a ship with acceptable naval architectural characteristics.

Although it is certainly of great importance, the shipboard vertical, longitudinal, and transverse location of a given item generally falls within the control of the ship designer and builder, not the supplier, and is therefore not a major focus of vendor weight control.

The elements of weight control recommended by this document are well proven in practice at various shipyards, as well as numerous other industries which concentrate on products which may be weight and moment critical. These elements can be successfully implemented on all external suppliers whether they provide equipment directly to a shipyard or provide their products via the owner or navy in the form of owner-furnished equipment or government-furnished equipment.

3.0 Acronyms and Definitions

Calculated Weight –The weight computed from approved ship construction drawings, computer models, and/or vendor drawings.

Center of Gravity, or CG – The center through which all weights that make up an item and its contents may be assumed to act. For further definition, refer to Reference 2.

Concept Design – The translation of the owner's requirements, or mission requirements, into a broad definition of an item of hardware that can be produced and operated in a manner that will satisfy the stated mission.

Contract Design – The design phase which consists of the preparation and formalization of the drawings, computer models, specifications, and other technical data required to establish the contractual base for negotiation of a construction contract with a shipbuilder(s).

Designer/builder – The organizations responsible for design of the ship and the construction and delivery of the ship to the customer. The designer and builder may be separate entities or the design and construction may be the responsibility of a single organization. Builder is synonymous with shipyard.

Detail Design – The preparation of detail working drawings and computer models for ship construction, procurement specifications for the purchase of materials, and planning for the ship construction, testing, and trials.

Estimated Weight- Estimate of weight of an item based on preliminary data that is subject to revision when more accurate information is available.

Government-furnished Equipment, or GFE – Equipment purchased directly by the government and shipped to the builder for installation on a ship. Typically included on US Navy contracts as Schedule A attachment to the contract.

KG - The height of the ship's vertical center of gravity as measured from the bottom of the keel (includes keel thickness).

Light Ship Weight – The condition of the ship complete and ready for service in every respect, including permanent and liquid ballast, onboard repair parts, and liquids in machinery at operating levels, without any items of variable load. See Reference 1.

Longitudinal Lever –The perpendicular distance from a transverse plane though the ships longitudinal reference to the center of gravity of an item. See Reference 2.

Mass Properties Data - Those physical characteristics which define the magnitude, location, and distribution of weight in the ship. They include weights, centers of gravity, location, moments, and weight moments of inertia.

Mass Properties Engineer – Technical person responsible for the mass properties of the ship as part of the overall management of the ship's naval architectural characteristics.

Moment –The product of a weight and its lever. See Reference 1.

NTE Weight – Not-to-Exceed weight established by the supplier that will be the maximum weight of the supplied item including all manufacturing tolerances and margins.

Owner-furnished Equipment – Ship equipment specified and purchased directly by the owner of the ship and shipped to the builder for installation.

Preliminary Design – Development of the final ship proportions, arrangements, power plant type, and structural layout that will satisfy the mission requirements.

Ship – Any vehicle designed to operate in a marine environment including commercial and military vessels, vessels and platforms used in the offshore industry, and pleasure vessels such as yachts.

Shipping Weight – The weight of an item in the "as-shipped" condition as determined by the supplier for the purpose of transportation.

Subcontractor – A single supplier responsible for and/or acting as systems integrator for a large, complex, multi-component shipboard system who is obligated to report mass properties data to the builder.

Supplier – A company which furnishes material or equipment to the shipbuilder, owner (or Government) for installation on the ship. Supplier is synonymous with the term vendor.

TPOC – Technical Point of Contact

Transverse Lever –The perpendicular distance from a vertical plane through the molded baseline of the ship to the center of gravity of an item.

Weighed Weight – Actual weight obtained by measurement on an accurate scale or other weighing device.

Weight Control – See References 1 and 3.

Weight Control Plan – A document that outlines the practices and procedures that will be employed to meet contractual weight control responsibilities. See Reference 1 for details.

Weight Reporting –The preparation and submission of the most accurate and current weight and moment data available at designated intervals throughout the design and construction phases. See Reference 1 for details.

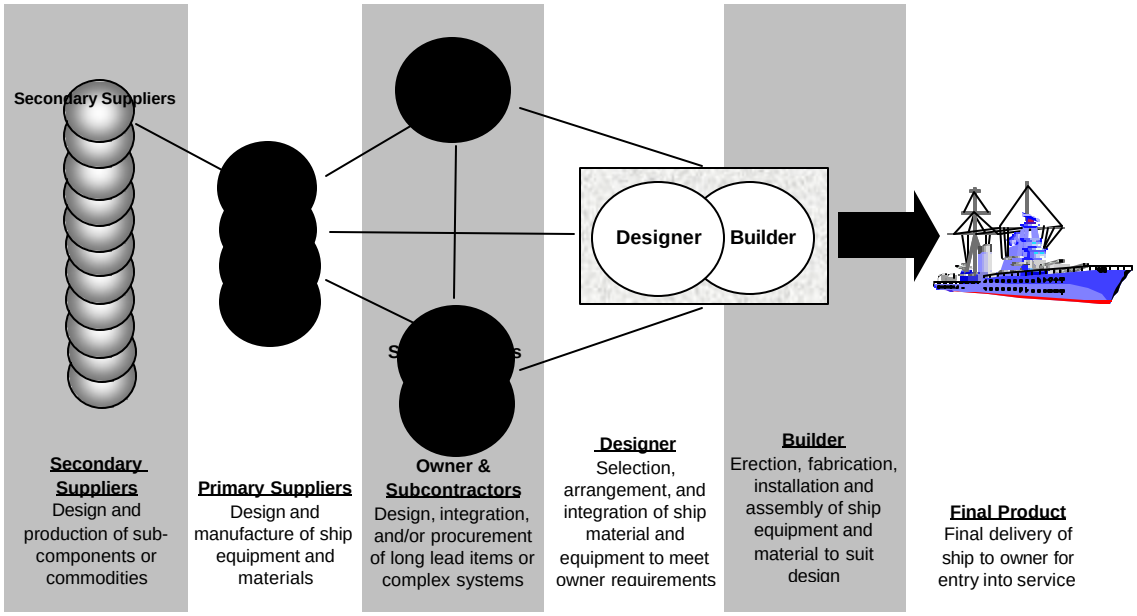
Vendor – A company which provides material or equipment to the shipyard, owner (or Government) for installation on the ship. Vendor is used synonymously with the term "supplier".

Vertical Lever – The perpendicular distance from a horizontal plane through the molded baseline of the ship to the center of gravity of an item.

4.0 Ship Equipment and Material Supply Chain

The foundation of the vendor weight control program described by this Recommended Practice is the Ship Equipment and Material Supply Chain that is prevalent in the shipbuilding industry today. This supply chain, as well as a summary of the role of each participant, is presented in Figure 1.

Figure 1
Ship Equipment and Material Supply Chain



The entities that figure predominantly in this chain are the builder, the ship designer, the owner (or government for military ships), suppliers both primary and secondary, and a unique entity called a subcontractor.

Depending on the situation, the designer and builder may be two separate organizations or they may be two divisions of the same organization. Small shipyards typically work with a separate outside design agent, while the largest yards include in-house both a design organization and a ship construction organization. For the purposes of this document, the term "designer/builder" or just "builder" will be used.

In some cases, the owner may be responsible for procuring certain equipment directly from the supplier for shipment to the builder for installation. Such equipment which bypasses the purchasing function of the designer/builder is called Owner-furnished Equipment, or OFE. For military ships, the same situation is common, but the equipment is termed Government-furnished Equipment, or GFE.

The majority of shipboard equipment and material is procured by the designer/builder directly from its suppliers. Primary suppliers are those who supply directly to the builder. Secondary suppliers are those who supply small components or material to primary

suppliers for incorporation into larger components to be installed on the ship by the builder. This Recommended Practice is directed toward primary suppliers, although the principles in this document may be flowed down to the secondary supplier by the primary supplier, as appropriate.

Subcontractors represent a unique type of supplier responsible for the design, integration, and delivery of large, complex, multi-component systems for the ship. Subcontractors may be under contract to the Owner or Government or directly to the builder. However, in either case, the subcontractor is responsible for reporting mass properties information in much greater magnitude than a typical supplier. The subcontractor is becoming more common in military ship programs and represents a unique application of vendor weight control.

Effective weight control as described by this Recommended Practice takes into full consideration the relationships between the various parties in the ship equipment and material supply chain as part of an overall weight control program.

5.0 Approach

The approach to vendor weight control described by this Recommended Practice is based on the application of progressively greater levels of weight control on progressively higher priority items over the three phases of ship design development.

5.1 Ship Design Phases – The three main phases of ship design development are Concept Design, Preliminary/Contract Design, and Detail Design and Construction. These phases are particularly important to the Mass Properties Engineer because the level of detail involved continues to change depending on the phase. Reference 1 - Figure 1 relates these traditional design phases with US Navy's acquisition milestones, A, B, and C, for military programs. At the concept level (essentially Milestone A though Milestone B), the very start of the traditional design spiral, the level of detail is very low and attention is directed mostly to the major weight and moment items. At this point in time, contact with suppliers typically consists of requests for information and the transfer of high level information on cost, schedule, and technical attributes. The level of detail increases during the Preliminary/ Contract Design phase (essentially Milestone B though C) as ship drawings, specifications, and other technical data are developed and documented. During this phase, shipyards typically send out Requests for Bid to prospective suppliers of major equipment for cost and technical data sufficient for a specific supplier to be selected. The level of detail reaches its highest level during Detail Design and Construction (essentially activities subsequent to Milestone C). During this phase, the ship designer develops the detail drawings and/or product model which will support procurement and construction activities. Procurement activity typically consists of the preparation of Purchase Orders for all material, equipments, and systems which are issued to selected suppliers.

The definition of the start and finish of each design phase must be determined by the owner and/or designer/builder. In many cases, there is no clear cut point in time that a

design transitions from one phase to another. In unique circumstances, different parts of the ship may be in different phases of design at the same time. Therefore, the ship owner/ designer/builder must decide the appropriate design phase for a given vendor-supplied item and therefore invoke the appropriate level of vendor weight control.

5.2 Weight Criticality – It is desirable to focus the greatest weight control on the items with greatest impact and less on the items of minimal impact. Not all items on a ship are of equal importance to a ship's mass properties. Some are major determinants of a ship's naval architectural characteristics while others have only minor or negligible impact. This approach promotes the greatest accuracy for the least investment of time and money. The Weight Criticality of any given item or system obtained from a supplier is a function of three main factors:

- The sensitivity to weight and/or moment changes of the specific ship on which the equipment will be installed
- The weight and moment of the equipment, a function of its total weight and location onboard ship
- The weight maturity of the equipment

Weight Criticality is essentially a subjective means of determining the importance of weight control for shipboard equipment in a predictable, consistent, and repeatable manner.

Ships vary widely in their ***Sensitivity*** to weight and moment impacts of individual equipment or systems. Some are highly sensitive demonstrating significant and undesirable response in terms of ship motions, stability, trim, list, draft, maneuvering, survivability, speed, or service life allowance. For example a large oil tanker would have a very low KG and would be relatively unaffected by the addition of an 800 lb. piece of equipment anywhere on the ship. Other ships, however, are highly sensitive to weight and moment impact. A small high speed craft such as yacht or offshore crew boat, for example, could suffer degradation in speed, stability, or experience adverse list or trim if the same 800 lb. piece of equipment were added onboard.

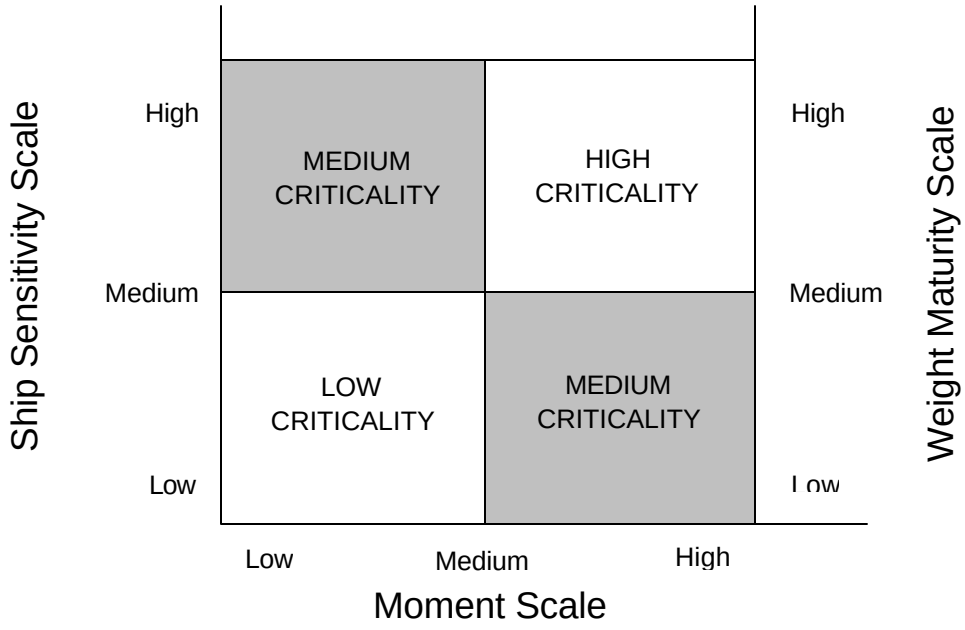
Moment is a function of the weight of the item and its location onboard the ship in terms of its vertical distance above the baseline of the ship, its transverse distance from the centerline of the ship, or its fore and after location relative to the longitudinal center of gravity of the ship. Reference 4 provides a good overview of the various naval architectural parameters of a ship and how they are affected by weight and moment changes due to the addition of a piece of equipment. Basically, a relatively small weight added to the ship can have a pronounced effect if its location is at a position that is a long distance from the ships center of gravity.

The last determinant of Weight Criticality is the ***Weight Maturity*** of the item in question. If an item is an off-the-shelf item that is sold in quantity to the marine industry, its weight is likely well established, subject to only minimal manufacturing variability, and well documented in supplier literature or in the weight reports of previous ships. Such items

represent very little uncertainty with regard to weight and moment impact. However, a new piece of equipment that is custom designed and manufactured for a given ship or a stock item that has been modified significantly represents much greater uncertainty to the mass properties engineer or analyst. The item that represents the greatest uncertainty should be subjected to the greatest degree of weight control.

These three factors together determine whether the weight criticality of a given item is high, medium, or low. As these factors vary widely from one circumstance to the next, it must be ascertained on a case-by-case basis. However, Figure 2 can be used as a quick guide to establishing criticality.

Figure 2
Weight Criticality Quad Chart



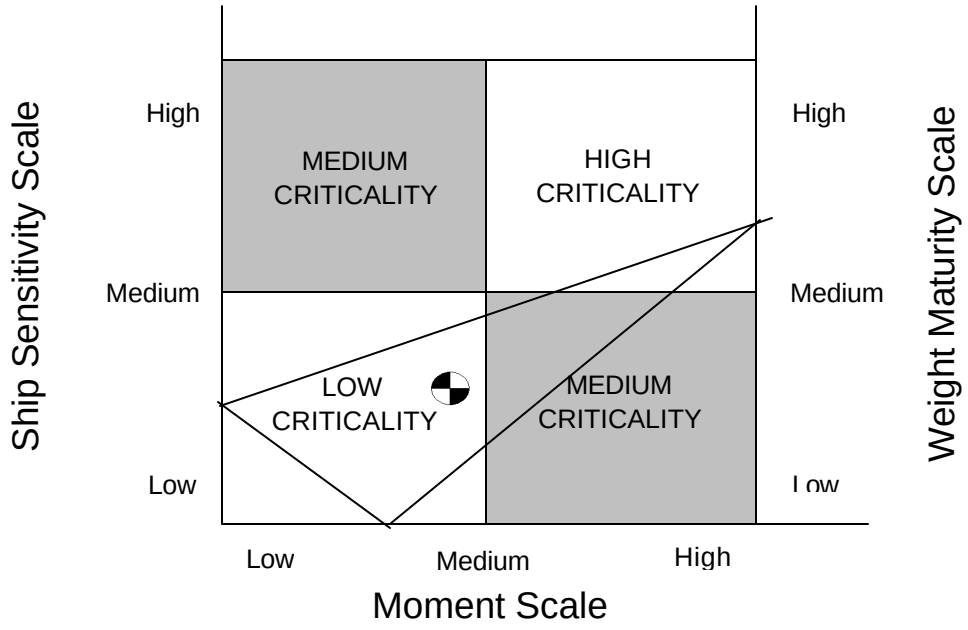
On the Ship Sensitivity scale, low refers to a ship that is relatively insensitive to weight and moment changes, in other words a ship on which weight is not a significant concern. The other extreme, high, refers to a ship that is highly sensitive to weight and moment changes. For US Navy ships, this would mean they fall in Stability Status 2, 3, or 4 per Reference 5.

The Weight Maturity scales starts with low, off-the-shelf items which are common in the marine industry and whose weight is known and well documented. The upper end of the spectrum refers to items that are new, probably custom designed for each shipboard application, and whose weight entails significant uncertainty.

The Moment scale goes from low, an arbitrary level which is considered to have minor or negligible impact to the ship, to high, a level of moment which causes noticeable change

in naval architectural properties. For each of these scales, select a point that best characterizes the particular system or ship. Connect the points on the three scales. The quadrant in which the centroid of the resulting triangle falls determines the Criticality of the item. If the centroid falls on a boundary between two Weight Criticality levels, the higher level should be used. Figure 3 demonstrates the use of Weight Criticality Quad Chart.

Figure 3
Example of Weight Criticality Determination



6.0 Recommended Vendor Weight Control Activities during Concept Design

Although in many instances, contact with vendors during this first stage of design is limited to potential vendors of major equipment, it is not too early to begin to exercise vendor weight control. Typically, the role of vendors during the concept phase of design is limited to those who supply items identified by the designer/builder as being of ***high criticality***. For items of ***low criticality***, no information is typically required as the items are either of small mass properties impact to the ship or are considered off-the-shelf items which entail very little uncertainty. From suppliers of ***medium criticality*** items, a Not-to-Exceed weight is desirable to obtain from any potential vendor with whom contact is made during concept design. The NTE weight is an estimate by the vendor of the maximum delivered weight of the item in question and includes any and all margins or allowances for manufacturing tolerance. It should have an analytical or parametric basis that reflects the vendor's history with the item in question. This weight is used for the purpose of setting an upper limit for the ship designer/builder to use in his early stage design activities, establishes an objective for the vendor's weight control efforts and

serves as the initial value for negotiation of the items contracted weight. The NTE should not be exceeded without notifying the designer/builder in writing. If changes or revisions by the owner or designer/builder have significant impact on the NTE, a revised NTE should be prepared by the vendor and submitted to the designer/builder.

For ***high criticality items***, an NTE weight limit is required from all potential vendors. The designer/builder may also inform the vendor that weight will be a selection criterion. This means that the NTE weight supplied by the vendor will be a major decision making factor in the selection of the vendor to whom a purchase order will be awarded. In this case, the vendor should make every effort to minimize the weight of the item and to accurately predict the final weight. Other factors that are typical selection criteria are cost, delivery time, and experience or past history with the item in question.

7.0 Recommended Vendor Weight Control Activities during Preliminary/Contract Design

The Preliminary/Contract phase of ship design is when the main configuration, arrangement, and major equipment of the ship is defined and documented in a form that becomes the basis for the ultimate design and construction award. During this phase more detailed mass properties information is required from the potential vendor. Purchase orders for long lead time equipment, major ship components, and materials are also placed during this phase. A preliminary weight estimate is usually developed by the designer/builder during this phase. In the Preliminary/Contract phase of design, the designer/builder continues to determine the weight criticality of supplied items, especially those in the high and medium categories. As in the previous phase, mass properties information is typically not required for ***low criticality items*** except to confirm their published weight. For ***medium criticality items***, vendors are requested to supply a weight range for the item in question. The range includes a minimum and maximum weight for the supplied item that will not be violated without a written waiver from the designer/builder. The minimum weight of an item can be just as important as the maximum weight to the ship designer. If equipment low in the ship is lighter than predicted, ship stability may be degraded or trim or list problems may result. A center of gravity may also be requested for certain items.

For ***high criticality items***, a weight range is requested from the vendor. In establishing a minimum/maximum weight range the supplier should establish a weight budget based on historical data, their past experience with a given item, and their knowledge of the weight added by various manufacturing steps and then factor in the weight variables, such as manufacturing tolerances. A weight control plan identifying how the supplier will control these factors and stay within the minimum/maximum weight range may also be requested by the designer/builder.

This plan requires the vendor to describe how the weight of the item will monitored during its manufacture to fall within the identified weight range. It will identify how often the weight will be assessed, by what means the weight will be measured, and what steps will be taken if an adverse trend is noted. It may also require a resume or

background information on the person or persons responsible for overseeing the weight of the manufactured item to establish his qualification for such a role. At this point, the designer/builder may also impose penalties for exceeding the weight limits established or incentives for minimizing the weight. The penalty is typically a percentage, from 1% to 10%, of the total purchase order price correlated to the amount by which the weight range is exceeded and is intended to offset the additional redesign effort required to compensate for excess weight. Weight updates will be required at regular intervals specified by the designer/builder, usually quarterly, to support the preparation of weight reports by the designer/builder.

8.0 Recommended Vendor Weight Control Activities during Detail Design

During the detail design and construction phase, a weighed weight for ***low criticality items*** should be requested for any items over 500 lbs. in accordance with Reference 1. Vendors of items below this limit are encouraged to confirm the published weight of their item. The weight should be measured using standard industrial practice and equipment prior to its shipping to the builder. The "weighed" weight reflects the measured weight of an item in the condition as it will be installed in the ship in either a dry condition (contains no operating fluids) or wet condition (contains any operating fluids needed for normal operation). Dry condition is the preferred state of a "weighed" weight and should be assumed unless otherwise noted. For components in a wet condition, a detail accounting of fluids (amount, type and location in the item) should be provided. Other conditions for "weighed" weights are as follows:

- The "weighed" weight must be adjusted to reflect deductions for the weight of any skid, pallet, packaging material or dunnage, temporary support, or other extraneous additions included in the weight determined. The weight for those items may be estimated, calculated or determined by separate weighing. Weighing is the preferred method.
- Any items or portions that would also normally comprise the completed item / unit weighed that were not included in the "weighed" weight should be identified and listed separately. The actual weight should comprise at least 75% of the shipboard weight of the item in question.
- Any other additional items included in the "weighed" weight that may be part of another additional assembly should be identified and documented. Care is to be exercised to describe exactly what was weighed.
- For multiple quantities of the item to be weighed, the "weighed" weight shall reflect the averaged result of weighing a statistically significant quantity of the items in accordance with Reference 6.

A "weighed" weight shall be determined by use of weighing equipment / instrumentation operated in accordance with manufacturers' recommendations or company standards regarding range and calibration. This requirement is part of the purchase order that the builder issues to the vendor. An example of a Purchase Order requirement for weighing

is included in Appendix A and an example of a form which can be used to provide weight data to the builder is presented in Appendix B.

For ***medium criticality items***, the weighing requirement in invoked in the purchase order for all items over 500 lbs. and an updated weight estimate is requested during manufacture to support the development of periodic weight reports by the builder. Typically, the mass properties data supplied to the builder will start as an estimate and progress to a calculated weight and then result in a weighed weight just prior to shipping. During this phase of design, the builder may also exercise the right to conduct a weight audit to verify that the final weight of the item supplied will not exceed the range specified during preliminary design. See Reference 7 for more information. An active weighing program at the shipyard conducted in accordance with the guidance provided earlier in
this section is the most effective way of verifying the weight of vendor-supplied components and ensuring that NTE requirements and ranges are being met, even if employed on a spot-check basis only.

For ***high criticality items***, the weighing requirement is invoked for items over 500 lbs. in the purchase order. Penalties may be assessed for weight excess or insufficiency if the delivered item fails to meet previously agreed to weight range. The builder will usually reserve the right to conduct a weight audit to verify that the weight of the item reported is accurate and that acceptable weight control measures are in place in accordance with the Weight Control Plan submitted by the vendor. A weight audit is a detailed, bottom-up review and evaluation of engineering documentation and manufactured components completed to date including all weight estimates and calculations. It may include a detailed design review at the vendor's facility. See Reference 7 for a breakdown of the considerations to be addressed during a weight audit. The builder may also reserve the right to witness the weighing of the item in question. As mentioned previously in this section, in-yard weight verification is the best way to ensure that weight requirements are being met by vendors. Throughout detail design and construction, the vendor should be requested to report mass properties data on a regular basis, typically every three months, to support the preparation of periodic weight reports by the builder. The purchase order for an item will specify the frequency of weight reporting required of the vendor.

9.0 Summary of Vendor Weight Control Requirements

Figure 4 summarizes the various vendor weight control responsibilities for each design phase by its weight criticality over the three phases of ship design:

Figure 4
Vendor Weight Control Activities Summary

		SHIP DESIGN PHASE		
		Concept Design Activities	Prelim. / Contract Design Activities	Detail Design and Construction Activities
WEIGHT CRITICALITY	Low	No need for mass properties information from the Supplier	No need for mass properties information from the Supplier	**Supplier** required to weigh all items over 500 lbs and report to the Builder
	Medium	**Supplier** provides NTE weight to the Designer/Builder if requested.	**Supplier** provides minimum/ maximum weight range to the Builder. **Supplier** provides weight updates to Builder	**Supplier** submits periodic weight updates to builder. **Supplier** to weigh items over 500 lbs. prior to shipment and report to Builder.
	High	**Supplier** provides NTE weight to the Designer/Builder. **Designer/Builder** makes weight a selection criterion for award.	**Supplier** provides minimum/maximum weight range to Builder. **Supplier** develops Weight Control Plan for submittal to Builder. **Supplier** provides periodic weight updates to Builder.	**Supplier** submits periodic weight updates to builder. **Builder** reserves right to conduct weight audit. **Supplier** weighs item prior to shipment and submits to Builder. **Builder** may perform in-yard verification of delivered weight.

10.0 Special Applications of Vendor Weight Control

Traditionally, the builder – supplier relationship was the only one that needed to be taken into consideration in the establishment of a vendor weight control program. This relationship placed the builder in a position to effectively enact an overall weight control program. However, today there are several variations of the builder – supplier relationship that bypass the purchasing function of the builder, but which must not be neglected in a comprehensive weight control program. These unique contractual relationships pose special challenges to effective weight control as does the situation in which a class of multiple hulls is the subject of vendor weight control. Low weight, high quantity and bulk materials also deserve consideration as part of a vendor weight control program.

10.1 Weight Control for Subcontractors - The majority of suppliers for a ship are individual companies that supply a limited number of components for the ship. Mass properties data from these suppliers is reviewed and then entered into the weight database

for the ship by the builder. However, there are instances when the responsibility for large, complex, multi-component systems is placed with a single supplier who acts in a system integrator capacity. Acting as a general contractor, this type of supplier, termed a subcontractor, is responsible for providing to the builder weight and moment data for large quantities of shipboard equipment and material. Subcontractors such as this are becoming common in naval ship construction.

Weight control as described in this Recommended Practice can be applied to a subcontractor just as it is a single individual supplier during the different ship phases. However, in this case, the NTE weight, weight reporting, weight control plan, or weighing, etc. covers a complete population of multiple components. The entire system can be treated as a single net, composite ship impact similar to that of a single component.

Due to the volume of mass properties data that may be required from a subcontractor, it is advisable for the builder to establish a standard format for weight reporting that is consistent in style, convention, and format with the builder's normal practice. A standard reporting format can minimize the time, difficulty, and cost of entering subcontractor-generated mass properties into the builders weight accounting system. It presents specific format requirements, details on the specific data required, and instructions on how to treat additions and deletions. The standard format can be invoked as a contractual requirement in a contractual agreement between the builder and the subcontractor. An example of a typical standard format is included in Appendix D. Each builder must develop a standard format that is tailored to its individual practice and weight accounting software.

10.2 Weight Control for Owner or Government-furnished Equipment – For some ships, the owner or, in the case of ships for the navy, the government is responsible for providing equipment for the ship. Although this equipment is not procured directly by the builder, its impact to the total may be significant and should not be neglected in a comprehensive weight control program.

There are two ways to approach Owner or Government-furnished Equipment. First, the owner or government can include requirements in their purchase agreements similar to that described in this Recommended Practice for builder-generated purchase orders. The data (NTE weights, weighed weights, etc.) is received by the owner or Government and then forwarded to the builder.

The second approach is to treat the owner or government as a subcontractor as described in Section 10.1. The owner or government is then responsible for periodically compiling the mass properties data and forwarding it to the builder for integration into the ship weight database.

If the non-builder furnished equipment for a ship comprises a significant portion of the light ship weight, cooperation between the builder and the owner or Government is imperative to exercising consistent, effective weight control for the ship.

10.3 Vendor Weight Control for Ships of a Class - In theory, vendor weight control need only be imposed on the first ship of a class because, by definition, sisterships should be identical copies of the first ship of the class. However, in reality, many ship classes are in a continual state of transition that may stretch over many hulls. This situation is particularly true in naval ship construction. In such cases, vendor weight control may be imposed on the areas of change only. This means treating all legacy items as low weight criticality and treating changes as medium or high criticality. The changes are then integrated with the remainder of the ship that is unchanged to result in an accurate weight database.

10.4 Low weight/High Quantity Items - Typically, weight control is focused on the individual items of greatest weight. Reference 1 recommends the weighing of all items over 500 lbs. However, on large vessels, there are numerous items of less than 500 lbs. that exist in large quantities and whose total impact is far greater than 500 lbs. An item as seemingly minor as a chair may be found in quantities of 4000 or more on aircraft carriers or large cruise ships. It is often relatively easy to obtain an actual, or weighed, weight on a low weight item either from the supplier or in the shipyard. In many cases, the manufacturer may already have an accurate weight based on a statistical accounting of his production over a long period of time if the item is a high volume, stock product. The designer/builder should be aware of the impact of low weight/ high quantity items and use the total weight rather the individual weight rather than the individual weight when determining weight criticality. Such items may also be worthy of consideration as potential candidates during a weight reduction program. A small weight reduction on a high quantity item may offer a significant total weight reduction with a minimum of rework or redesign for the designer/builder. Other examples of low weight/high quantity items may include fire extinguishers, berths, computer monitors, and plumbing fixtures.

10.5 Bulk Materials - Bulk materials, or commodities, are sometime overlooked with respect to weight control. Bulk materials include such things as steel plates and shapes, cable, insulation, pipe, paint, and fasteners. These commodities are the basic elements with which the builder fabricates the ships hull and distributed systems. The total of such commodities constitutes a significant proportion of the ships weight, usually in excess of 50% of light ship weight. Like equipment components, these materials should be included during the determination of weight criticality. For bulk commodities, the total weight of all identical material should be used as the basis for determining weight criticality. All weight control requirements that are applicable to equipment such as NTE weights, weighed weights, and weight control plan are applicable to commodities as well.

11.0 Vendor Role in Weight Reduction Programs

Weight Reduction Programs are efforts usually directed by the designer/builder to seek design and construction alternatives that will reduce the weight of the ship to assure the satisfaction of contractually required naval architectural characteristics. The need for a weight reduction program is usually the result of an adverse trend that indicates the likelihood that the delivered ship will exceed contractual requirements for measurable

characteristics such as service life allowance, list, trim, KG, displacement, or draft. It may also be triggered by weight excess or moment problems on previous hulls or a ship upon which the current design is based. The need for a weight reduction program should be identified and the endeavor initiated as early as possible in the design process to minimize the cost and redesign/rework effort.

Because of the large proportion of the ship that is usually supplied by vendors, it is important for builders to involve vendors in the weight reduction program. Typically, the involvement is initiated by the designer/builder in the form of a weight reduction solicitation that goes out to many or selected vendors depending on the severity of the circumstances.

The first stage of a weight reduction should be directed at those shipboard items that are easiest revised with the least impact to cost and the greatest impact on weight. For example, many weight reduction programs focus first on bulk items or commodities such as steel, cable, or insulation. Such materials can frequently be changed with minimum design and construction impact. Subsequent efforts focus on the items of greatest weight on the ship or those in the high weight criticality category.

Some of the ways suppliers may reduce the weight of the shipboard items they supply include material substitution, product redesign, or greater control of manufacturing tolerances. Other alternatives that may be suggested by the supplier could include alternate configurations or arrangements of their equipment or the proposal of new technology. The designer/builder should first request cost proposals to reduce weight so that a cost/weight tradeoff can be conducted with regard to contractual penalties or liquidated damages for failure to meet contractual requirements.

The typical role of the marine supplier in a weight reduction program can be characterized in three steps:

1. The builder seeks weight reduction ideas by means of a widespread or selective solicitation to vendors. A submittal form such as that contained in Appendix C may be used to obtain consistent information on each proposed idea. The submittals are then subjected to a technical and preliminary cost evaluation to determine the best candidates to pursue.

2. The vendors of the best candidate ideas are contacted for a technical/cost proposal or bid which receives further evaluation and management review by the builder.

3. Selected vendors are notified that their proposal or bid has been accepted and the technical and/or cost provisions of the purchase order are revised.

12.0 Cost of Vendor Weight Control

The cost and schedule impact of any new activity is important to the ship designer/builder. Many Purchasing Departments are concerned about the implementation of vendor weight control such as weight predictions and weighed weights for fear of increasing the cost of procurement. However, in practice, most companies implementing vendor weight control find that cost increases are minimal or negligible. This may be because many vendors also supply to other industries which require vendor control such as the aerospace industry or perhaps because the weight of their products is considered an indicator of quality and is therefore already tracked closely. The benefits of vendor weight control such as improvement in the quality of weight estimates and predictions justify any slight increase in cost that may be incurred due to vendor weight control.

While invoking the requirement that the supplier provide weighed weights upon delivery and quality weight predictions throughout the design phases has minimal impact on cost, vendor participation in a weight reduction program may entail additional cost for the vendor. The magnitude of the cost increase is dependent on the degree of additional redesign, material substitution, etc. that must be conducted by the vendor in order to reduce the weight.

13.0 Summary of Mass Properties Responsibilities

Designer/builder

Major responsibility: The mass properties of the total ship and the satisfaction of all naval architectural requirements as defined by the design and construction contract.

Specific responsibilities:

- Determine the Weight Criticality of shipboard equipment starting with the major equipment and progressing to the minor components. **(Refer to Section 5.2)**
- Define the phases of ship design for use in applying weight control requirements**.(Refer to Section 5.1)**
- Send Requests for Information or Proposal to potential vendors identifying the appropriate level of importance of mass properties as a basis for vendor selection **(Refer to Section 6.0)**
- Select vendors with appropriate emphasis on mass properties characteristics and place purchase orders with selected vendors incorporating mass properties clauses **(Refer to Section 6.0)**
- Determine if mass properties penalties and/or incentives are applicable and determine scale. **(Refer to Section 7.0)**
- Track mass properties trends and margin consumption in accordance with the Weight Control Plan to determine the need for weight reduction program. Contact vendors of selected vendors for potential weight saving suggestions.

Select best candidates/solutions for implementation and revise purchase agreements as necessary. **(Refer to Section 11.0)**

- In purchase orders for items of low weight criticality, invoke requirements for weighing. **(Refer to Section 8.0)**
- In purchase orders for items of medium weight criticality, invoke requirements for NTE, min/max range, periodic mass properties reporting, and weighing. **(Refer to Sections 6.0, 7.0, and 8.0)**
- In purchase orders for items of high weight criticality, invoke requirements for NTE, min/max range, periodic mass properties reporting, weight audits, weight control plan, and weighing. **(Refer to Sections 6.0, 7.0, and 8.0)**
- Incorporate vendor, subcontractors, and owner (or government) mass properties data into applicable weight reports and estimates.

Suppliers

Major responsibility: Mass properties of the material, systems, or components which it provides to the builder for installation on the ship and those of all secondary suppliers' products which are incorporated in their manufacture.

Specific responsibilities:

- For low weight criticality items, confirm weight upon request of designer/builder and provide weighed weight for all items over 500 lbs. **(Refer to Section 8.0)**
- For medium weight criticality items, provide a NTE weight, a min/max range, periodic weight updates, and a weighed weight. **(Refer to Sections 6.0, 7.0, and 8.0)**
- For high weight criticality items, provide a NTE weight, a min/max weight range, weight control plan, comply with weight audit requests, and provide a weighed weight prior to shipping. **(Refer to Sections 6.0, 7.0, and 8.0)**
- Provide weight reduction suggestions/alternatives upon request of designer/builder, owner (or Government), or subcontractor. (**Refer to Section 11.0)**
- Flow mass properties requirements to secondary suppliers as necessary to meet designer/builder requirements.

Owner (or Government)

Major responsibility: Mass properties characteristics of all OFE or GFE which are provided to the builder for installation on the ship (Refer to Section 10.2)

Specific responsibilities:

- Identify equipment and/or material to be procured directly by the Owner.
- In conjunction with the designer/builder, determine weight criticality of the OFE/GFE items. **(Refer to Section 5.2)**

- Invoke weight control on the suppliers of OFE as appropriate with the weight criticality of the items which they supply. **(Refer to Sections 6.0, 7.0, and 8.0)**

Subcontractor

Major responsibility: Mass properties characteristics of the total system including the contribution of all individual suppliers to be provided to the builder for installation on the ship. (Refer to Section 10.1)

Specific responsibilities:

- Identify all equipment and/or material to be included in the shipboard installation of the system
- In conjunction with the designer/builder, determine the weight criticality of the total system **(Refer to Section 5.2)**
- Flow down the weight requirements to suppliers and secondary suppliers as appropriate
- If the total system to be provided is considered high weight criticality, provide the designer/builder with an NTE weight and center, a min/max range, a weight control plan, periodic weight updates in accordance with standard format provided by the designer/builder, comply with requests for weight audit, and provide weighed weights of all system components over 500 lbs. **(Refer to Sections 6.0, 7.0, and 8.0)**
- If the total system to be provided is considered medium weight criticality, provide the designer/builder with an NTE weight and center, a min/max weight range, periodic weight reports in accordance with standard format provided by the designer/builder, and weighed weights for all components over 500 lbs. **(Refer to Sections 6.0, 7.0, 8.0)**
- If the total system to be provided is considered low weight criticality, provide the designer/builder with weighed weights for all components over 500 lbs. **(Refer to Section 8.0)**

14.0 References

1. RP 12, *Weight Control Technical Requirements for Surface Ships*, SAWE.

2. RP 13, *Standard Coordinate System for Reporting Mass Properties of Surface and Submarines*, SAWE.

3. RP 14, *Weight Estimating and Margin Manual for Marine Vehicles*, SAWE.

4. *Weight Engineers Handbook*, SAWE 2002.

5. NAVSEA Instruction 9096.3D, Weight and Moment Compensation and Limiting Drafts for Naval Surface Ships, 16 August 2001.

6. American National Standards Institute ANSI/ASQC Z1.4 – 1993.

7. Mathews, Glen *Considerations for Performing Weight Reviews and Audits* 62nd Annual Conference of Society of Allied Weight Engineers, New Haven, Connecticut May, 2003.

15.0 Appendices

A. Example Purchase Order Requirements

B. Typical Example of Vendor Weight Reporting Form

C. Typical Example of Vendor Weight Reduction Survey Form

D. Example of Standard Subcontractor Reporting Format

Appendix A

Example Purchase Order Requirements

The following are examples of requirements relating to weight and moment control based on past or current practice at several different shipyards that can be used in purchase orders for shipboard equipment

General

The Supplier shall be conscious of the mass properties of the component throughout the design and manufacture of the component and its impact on the ship on which it will be installed.

Weight and moment control is critical to the Builder meeting its naval architectural contractual requirements for list, trim, service life allowance, and performance. Therefore, it is imperative that the Supplier submit accurate weight data for the purchased item.

NTE

The maximum weight of the component shall not exceed ___lbs. in the dry condition. If any design change or feature would result in this limit being exceeded, the Supplier is not to take this action, but shall notify the Builder immediately that the weight will increase.

Reporting of Weight Data

The Supplier shall report weight information to the Builder as follows:

1. **Preliminary Weight Estimate** – Within X days of Purchase Order award, the Supplier shall submit to the Builder an estimated dry and wet weight for the component.

2. **Periodic Weight Reports** – The Supplier shall submit a weight report every X X days to the Builder listing the latest weight breakdown. As the design of the component progresses, this estimated weight shall be updated and shall reflect all changes. As the manufacture of the component progresses, the actual weights shall be determined to evaluate the effects of manufacture and the calculated weight adjusted accordingly. The reports shall indicate the percentage of the weight for estimated, calculated, and measured. Additionally, centers of gravity for major components shall also be reported, referenced to a set of clearly defined reference planes perpendicular to each other.

3. **Supplier Drawings** – The following supplier drawings shall show the latest known weight and location of the center of gravity in three orthogonal planes.
    a. Outline drawing – The Outline shall show unit weight and location of the center of gravity in three orthogonal planes

    b. Certification Data Sheet – The Certification Data Sheet shall contain calculated weight of all accessories which are to be furnished with the component, but which are not clearly included in the master drawings.

Weight Control Plan

The Supplier shall furnish the Builder with a Weight Control Plan that describes the following:

1. The Supplier's approach and plans to monitor the weight of the components throughout the design and manufacture. It should identify how often the weight will be measured and by what means the weight will be measured or otherwise determined.

2. The actions that will be taken if an adverse weight trend is identified

3. An organization chart indicating the position of the weight control function relative to that of design, manufacturing, and management.

4. Background information on the weight control TPOC including experience and qualifications.

Weighed Weight

Prior to crating of the component for shipment, the Supplier shall weigh the unit. The following information shall be forwarded to the Builder within one week after shipment:

1. Scale weight of the component, dry
2. List of accessories and other parts of the component which have not been included in the above weight
3. Brief description of the weighing device:
    a. Type and make of scale
    b. Accuracy
    c. Maximum rated capacity
    d. Sensitivity
    e. Date of last calibration

The Supplier shall notify the builder at least X days prior to weighing to provide the opportunity for a designated representative of the Builder to witness the weighing.

Penalties or Liquidated Damages

Liquidated Damages will be charged to the Suppliers account if the actual weight varies from the original estimated value. These damages shall be assessed as follows:

Variation in Weight	Damage Amount
0 to X%	None
X to XX%	Y% of purchase price
Greater than XX%	YY% of purchase price

Changes made to the design and/or manufacture of the component by the Builder shall be excluded when comparing the actual weight to the budget weight for the purpose of establishing liquidated damages.

Appendix B

Typical Example of Supplier Weight Reporting Form

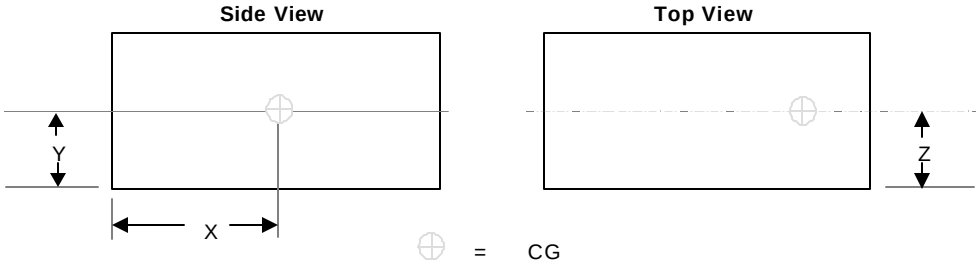
A. ***Supplier Information:***

Supplier Name:	
Manufacturer (If different from Supplier):	**Model No. (If applicable):**
Purchase Order No. and Item No.:	
Description:	
Shipyard Part No.:	**Supplier Drawing No(s):**
Hull No.:	**Shipyard Drawing Number(s):**
☐ **Components *more* than 500 lbs.**	☐ **Components *less* than 500 lbs.**

B. ***Weight and CG Information:***

Weighed Component/Item	*Dry Weight (Lbs.)*	*Weight of Operating Fluids*	*Calculated or Estimated Center of Gravity*			*Remarks*
			Dry CG X	*Dry CG Y*	*Dry CG Z*	

C. ***CG Sketch:***



D. ***Weighing Equipment Information:***

Weighing Equipment
Make:
Type:
Range:
Calibration Date:
Date Weighed:

E. ***Approval Signature:***

The technical information furnished on this form is considered to accurately and completely describe the item(s) furnished.	
Name:	
Date:	**Phone:**

F. For *Notes* pertaining to this form, see Page 2

F. Notes for Completion of Supplier Component Weight Reporting Form:

Each individual or separate item supplied should be reflected on this form. Additional sheets may be added as necessary to provide the information requested.

A. ***Supplier Information:***

1. Enter name of your company for Supplier Name.
2. Provide the name of the original manufacturer, if you are acting as an agent for a product produced by another firm. If you are both the supplier and the manufacturer, this box may be left blank.
3. Provide the model number of the supplied item(s) if applicable.
4. Provide the Purchase Order No. and Item No. under which you are providing this component.
5. Provide a brief description of the item(s) being supplied.
6. Provide the Shipyard Part Number of the item(s), if known. Otherwise, leave blank.
7. Provide the Vendor-Supplied Drawing Number, which describes the item(s) supplied.
8. Enter shipyard Hull Number if known, otherwise, leave blank.
9. Enter shipyard Drawing Number if known, otherwise, leave blank.
10. This sheet needs to be returned regardless of the weight magnitude. The appropriate block is to be checked; weight is 500 lbs. or ***more***; the weight is ***less*** than 500 lbs., then sections B through D do not apply; however, a signature is required in Section E.

B. ***Weight and CG Information:***

10. Enter name of Weighed Component/Item.
11. Provide the unit dry weight (e.g. no operating fluids of any kind) of each item. This weight should not include any packaging, dunnage, or temporary additions. The weight reported should be the dry weight of the item, as it will be installed on the ship. Use appropriate unit of measure, *for example:*
    A. For Pipe and Cable, weight should be reported as lbs. per linear foot.
    B. For Tile, weight should be reported as lbs., per cubic feet or lbs. per square feet.
12. Enter the weight of any operating fluids required for a normal operating ship condition.
13. Provide the calculated or estimated center of gravity (CG) for each item.
    A. **Dry CG X** measured from a reference point on the rear of the equipment
    B. **Dry CG Y** measured from a reference point on the bottom of the equipment
    C. **Dry CG Z** measured from a reference point on the centerline of the equipment

Note: Input into these columns should be in feet and decimal feet.

14. Provide an estimated location of the Center of Gravity of the component in an operating condition by a very rough sketch in the space provided. If already provided on a vendor drawing, then just attach the vendor drawing; a sketch would not be required.

D. ***Weighing Equipment Information:***

15. Provide the information on the weighing equipment used to measure weight.

E. ***Approval Signature:***

16. Provide signature/name signifying that the data provided for use in weight estimating accurately and completely describes the item furnished to the best of your capability.

Appendix C

Typical Example of Vendor Weight Reduction Submittal Form

Name:
Company:
Div./Dept:
Phone:
E-mail address:

Description of Weight Reduction Idea:

Primary System Affected:

Secondary System(s) Affected:

Expected Weight Reduction (1LT = 2240 pounds):

Basis of Weight Reduction Estimate: (e.g. estimated, calculated, weighed weight):

Has this idea been previously implemented on ships for the US Navy? Elsewhere in the marine industry? Other industries? Please describe.

How will this idea affect acquisition cost?

How will this idea affect lifecycle cost?

Please add additional sheets if necessary to convey your suggestion. Feel free to attach drawings, sketches, etc. as appropriate.

Appendix D

Example of Standard Subcontractor Weight Reporting Format

The subcontractor weight report should be in Microsoft EXCEL spreadsheet format as shown in Figure 1. This format consists of 16 individual columns (Navy Group (BSCI), Item Description,….through CG Z-axis) that provide pertinent information for each weight element. The maximum number of characters (numbers or letters) for each is shown in Figure 5. Decimal points are considered as a character.

Column 1, **Navy Group (BSCI)** and 3, **Navy Group (ESWBS)**, refer to the contract-applicable ship work breakdown structure category in which this item falls. BSCI is the Bureau of Ships Classification Index. ESWBS is the Expanded Ship Work Breakdown Structure. Both systems are still in use on Navy vessels today. The requirement for BSCI Information may be waived for certain programs.

Subcontractor Weight Report Format

Figure 5

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
NAVY GROUP (BSCI)	ITEM DESCRIPTION	NAVY GROUP (ESWBS)	PARENT SYSTEM	COMPARTMENT NUMBER	STATUS CODE	GOVT FURNISHED? (Y or N)	COMPLEX	HEIGHT (FT)	WIDTH (FT)	LENGTH (FT)	ITEM WEIGHT (LBS)	QUANTITY	CG X - AXIS	CG Y - AXIS	CG Z - AXIS
5	30	6	15	15	2	6	10	8	8	8	8	8	8	8	8

NOTES:

1. PARENT - SYSTEM TO WHICH THE ITEM BELONGS.

2. STATUS CODE:
   - E1 = ESTIMATED WEIGHT BASED ON RATIOED OR SCALED WEIGHT
   - E2 = ESTIMATED WEIGHT BASED ON VOLUMETRIC DENSITY
   - E2 = ESTIMATED WEIGHT BASED ON HISTORICAL DATA
   - E3 = ESTIMATED WEIGHT BASED ON BOTTOM-UP ESTIMATE OF PARTS
   - E5 = ESTIMATED WEIGHT BASED ON PERCENT COMPLETE
   - E6 = ESTIMATED WEIGHT BASED ON BASELINE MODIFICATION
   - C = CALCULATED WEIGHT
   - W = WEIGHED WEIGHT
   - S = REMOVED WEIGHT
   - M = VENDOR PROVIDED WEIGHT

3. MAXIMUM NUMBER OF CHARACTERS PER COLUMN IS LISTED IN FIRST ROW

Column 2, **Item Description**, contains the name or title of the weight element and may contain up to 30 characters. The description should be as specific as possible.

Parent, Column 4, and **Complex**, Column 8, are used to describe the system and function to which this weight element belongs. These component relationships are usually defined by the system breakdown structure.

Compartment, Column 5, refers to the number of the compartment on the ship in which that weight element is located. If location and arrangement are to be determined by NGNN, this column may be left empty.

The **Status Code**, Column 6, refers to the origin of the weight data for this element defined as follows:

Status Code	Code Description
C	Calculated from drawings or product model
E1	Estimated weight based on ratioed or scaled estimate
E2	Estimated weight based on volumetric density
E3	Estimated weight based on historical data
E4	Estimated weight based on bottom-up estimates of component parts
E5	Estimated weight based on percent complete
E6	Estimated weight based on modification of an existing baseline
W	Weighed resulting from the use of weighing equipment
S	Weight removed or deleted which is no longer applicable to the system
M	Weight reported to you by a vendor or supplier

For those items whose weight was estimated, the second digit provides the basis of the estimate. E1 refers to an estimate based on the extrapolation from a known product to an unknown using a ratio or scaled approach. E2 refers to an estimate based on volumetric density. E3 indicates that the weight estimate was based on historical data. E4 refers to an estimate generated by summing the estimates of the weight of all component parts. E5 indicates an estimate based on weight vs. a known metric such as percent complete by multiple identical units in the same compartment or location, the weight provided should reflect the weight of a single unit. Weight should be for the item in a dry condition (e.g. no operating fluids). The weight of all fluids associated with this item in a normal operating condition should be entered as a separate line item immediately following the line containing the item itself. It should be clearly identified in the Description column (e.g. Lube Oil for Discharge Pump). Reference 4 is a good reference source for unit weights for common marine materials. **Quantity**, Column 13, is the number of identical units in the same compartment or location cost or time. E6 refers to an estimate that is derived by using a known baseline and adding or deleting the differences. Of these alternatives, weighed weights are the most preferred.

Government Furnished, Column 7, indicates whether or not the item is furnished by the Government. Y indicates that the Government supplies this item to you and N indicates the item is procured directly by you as a contractor or subcontractor.

Columns 9, 10, and 11, **Height, Width, and Depth**, contain the physical dimensions of this weight element in feet. This column should reflect fractions of a foot in decimal form (e.g. 19.82 ft. or 93.25 ft.). Input should be limited to two decimal places.

Column 12 is the **Weight** of the system component expressed in standard English pounds. Input to this column should be rounded to the nearest pound. If there are

Columns 14, 15, and 16, **X-AXIS, Y-AXIS, and Z-AXIS**, refer to the location of the center of gravity of the element in all three axes measured from a reference point on the rear of the equipment, a reference point on the centerline of the equipment, and a reference on the bottom of the equipment, respectively. Input into these columns should be in feet and decimal feet as in the columns that report physical dimensions.

How to Handle Additions/Deletions

After the first weight report submitted, there will be changes to the weights previously reported as a normal consequence of design development and shipboard arrangement. These changes, both additions and deletions, should be reflected in the subcontractor's weight report. Deletions should be entered as a weight element with a negative weight and additions should be entered as a positive weight element.

To highlight the source(s) of significant change from one weight report to another, a **Change Summary Table** should be provided as part of the report. Included in this table should be equipment changes, electrical or mechanical, structure (including foundations), power distribution and lighting, auxiliary systems, power distribution and lighting, outfitting, armament, and component fluids. The summary should include the description of the item, weight change in pounds, locations, and reason for the change (i.e. replaced by…, new, etc.). Weight additions should be identified as positive (+) and deletions (items shown in the weight report with a Status of "S") or reductions should be identified as negative (-).

This summary should take the following form:

Item Description	Weight	Location	Reason for Change