Position Classification Standard for Naval Architecture Series, GS-0871

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SERIES DEFINITION

This series includes all classes of positions the duties of which are to advise on, administer, supervise, or perform professional engineering work in the field of naval architecture which primarily concerns the form, strength, stability, performance, and operational characteristics of ships. The work of positions in this series includes research, design, development, construction, investigation, testing, arrangement, installation, and maintenance for all types of ships. This work involves the consideration and application of naval architectural principles and concepts; the making of stability and buoyancy calculations and developing data for launching, loading, operation, and drydocking of ships in a safe, efficient, and economical manner; and naval architectural investigations and development of data and criteria leading to improved ship design.

This standard supersedes the standard for the Naval Architecture Series published in June 1949 under the code P-872-0.

DISTINGUISHING CHARACTERISTICS OF NAVAL ARCHITECTURAL POSITIONS

For the purposes of this standard, naval architecture includes basic and applied research, design, development, design evaluation, and ship calculations during all stages of a ship's life. This includes work found in such functional activities as research and preliminary design for a ship through its detail design, construction, testing, operation, maintenance, launching, drydocking, and storage. Ship design and calculations are required for ships being altered (by means of conversion, rebuilding, modernization, or repair) as well as for new ships. Also included is naval architectural work in the formulation of safety regulations and damage control rules and in the approval and certification of ship designs to meet such requirements.

Naval architectural positions are those concerned with ship design as a whole, and not with the internal design of pieces of equipment to be placed in or on the ship. This includes positions concerned with the arrangement and installation of equipment or systems on shipboard when such work requires application of naval architectural principles and concepts pertaining to centers of gravity, buoyancy, stability, strength, ship motions, water-tight integrity of hull subdivisions, freeboard, stresses imposed by water pressures and other loads, local arrangements for ship function, damage control, and other hydromechanic, structural, or architectural characteristics.

Naval architecture, as herein defined, does not include the design and development of any equipment installed on shipboard, or the arrangement and installation design and development of electrical systems and machinery arrangements normally found on shipboard. However, naval architect positions at higher levels may involve active participation in such phases, when installation and performance characteristics are materially influenced by or subordinate to consideration of ship structural strength, stability, or functional arrangement.

Since naval architecture is a broad field of engineering and includes positions concerned with vessels as total entities, some naval architect positions involve supervision of marine engineers, electrical engineers, mechanical engineers, electronic engineers, and specialists in other fields. Such generalist positions resemble positions in the General Engineering Series, GS-0801, in that they may be appropriately filled by engineers who are broadly qualified in ship design and construction but whose background of education and training may have been largely concerned with marine, electrical, or mechanical engineering aspects of the work. On the other hand, positions concerned with naval architecture and other engineering fields, where the work does not entail responsibility for design of a vessel as a total entity, may be classifiable to the General Engineering Series. In maintenance and repair organizations where the emphasis may be largely on the power plant and related machinery, positions concerned with both marine engineering and naval architecture aspects may be properly classifiable to the Marine Engineering Series. In the situations outlined above, cross-discipline movement of engineers from any of the fields involved would appear to be appropriate and justified. In some situations the interdisciplinary procedures outlined in Section II (J) of the introductory material to position-classification standards may be particularly helpful.

EXCLUSIONS

Excluded from this series are the following classes of positions:

1. Positions which involve similar but nonprofessional engineering type work. (See the Engineering Technician Series, GS-0802 and other appropriate series.)

2. Engineering positions engaged in the design and development of shipboard mechanical systems concerned with propulsion, service, safety, and operation of ships, and the components of such systems. (See the Mechanical Engineering Series, GS-0830.)

3. Engineering positions which combine the functions of naval architecture, engineering, and other professional fields where there is no continuing predominant requirement for any particular specialized branch or branches. (See the General Engineering Series, GS-0801.)

4. Engineering positions engaged in the design of electrical and electronic equipment for use on ships or electrical and electronic system installations on shipboard. (See the Electrical Engineering Series, GS-0850, and the Electronic Engineering Series, GS-0855.)

5. Positions of physicists engaged in fluid mechanics studies and investigations. These positions are similar to naval architect positions in many respects, and at times their duties and responsibilities may overlap certain phases of naval architect positions concerned with hydromechanics, but are distinguished from the latter positions because knowledge and consideration of naval architectural principles and practices are not primary requirements. (See the Physics Series, GS-1310.)

CLASS TITLES AND SPECIALIZATIONS

In the light of differences in required knowledge and abilities which govern the selection of personnel for various naval architect positions, a number of subject-matter specializations have been established. These specializations are indicated parenthetically following the basic title. In general, the specializations are appropriate for use at grades GS-9 and above. Since naval architecture is a diversified but highly specialized branch of engineering for which persons trained in other disciplines often are recruited, the specializations are particularly useful for identifying positions suitable for recruitment of persons with training in related fields, such as structural engineering or fluid mechanics. Also, there is typically less freedom of movement between specializations for such persons recruited from related disciplines.

Naval Architect (Arrangements). -- This specialization includes positions concerned primarily with the functional arrangement of a ship so that the complete ship will be a convenient and competent unit. The work usually concerns compartmentation and access, which involves the allocation of all shipboard space, both interior and exterior. This includes the determination of size, shape, location of all shipboard compartments and related access or passageways between compartments, between decks, and to life-boat stations and battle stations (for warships). This requires functional studies, with consideration of effect on the stability and safety of the ship, for such spaces as machinery rooms, messing, berthing, and crew quarters, passenger staterooms, public and recreation spaces, galleys, laundries, hospitals, ship offices, storage and cargo spaces, passages for handling cargo and ammunition, repair shops, etc. Also included is the determination of deck heights and the selection of the general locations for deck machinery such as winches, cranes, and cargo-handling gear in terms of the functions of the overall ship.

Naval Architect (Hydromechanics). -- This specialization includes positions involving application of basic physical theory and experimental techniques in the field of naval architecture for the purpose of developing design criteria and providing engineering data relating to hydromechanics aspects of all types of hull forms, ship appendages, and other marine devices, both surface and underwater bodies. Work involves the conduct of studies on such problems as resistance, propulsion, boundary layer surveys, wake surveys, pressure distribution, dynamic stability, steering and turning, propeller cavitation, and propeller noise. Solutions to problems are obtained by research, design, development, and test of experimental models, experimental test on full-scale ships, and thorough application of mathematics and other analytical approaches.

Frequently, positions classifiable to this specialization (in addition to the conduct and analysis of model or full-scale ship tests) may include the establishment of performance requirements for and the development or modification of test instruments and other apparatus. Such work occurs because of the need for additional or modified equipment in order to carry out progressive and thorough testing programs. Positions engaged in full-time work of this nature, and not requiring the special knowledge and abilities of naval architecture peculiar to this specialization, are classifiable to other appropriate series.

Naval architectural positions classifiable to the hydromechanics specialization are found predominantly at model basins or other laboratories. Incumbents are engaged in work of a

research and developmental nature for the purpose of developing data and criteria to be used in the hydromechanics aspects of ship design, or for the purpose of predicting the hydromechanics aspects of proposed ships and eliminating faulty forms and other hydromechanics characteristics, or both. The work is performed mostly by means of controlled experimental tests. However, the conduct of tests on full-scale ships or the analysis of results from ship trials is also classifiable to this specialization.

Naval Architecture (Ship Design). -- This specialization includes positions concerned primarily with the basic design of ships (excluding small boats) involving various combinations of the following areas: hull form, hull structural strength, stability, weights, general arrangements, ship motions, trim, seaworthiness, speed, power, and endurance, in order to produce a well-balanced ship design where the work is in terms of basic design features and the desired characteristics of the ship as a whole. While the work occurs most frequently in the preliminary design stages, it is not necessarily synonymous with the term "preliminary design."

Naval Architect (Small Craft and Boats). -- This specialization includes positions concerned primarily with all aspects of naval architectural work involved in the design, development, construction, repair, and maintenance of self-propelled boats or small craft, including hull, form, arrangements, weight control and displacement, and stability and trim. As a general rule, boats and small craft are vessels of 23 meters (75 feet) or less in length, although occasionally craft up to 30 meters (100) feet in length may be included. Many small craft hulls are constructed primarily of wood; however, steel, plastics, or other materials may be used. Much of small craft design must be adapted to mass production methods to a degree not practical for the larger type of ship.

Naval Architect (Stability). -- This specialization includes positions concerned primarily with work in connection with the buoyancy and stability of ships, such as inclining experiments, intact stability at various angles of inclination, stability of ship under various loading conditions, floodable length and subdivision studies, damaged stability studies and development of damage control data, and calculations and studies made for launching, drydocking, mooring, or towing vessels. Included are calculations and studies of submarine trim dives, and other stability studies and calculations required for a body which both floats upon the surface of and moves submerged in water. Positions classifiable to this specialization are found in the broad areas of research, ship design, and ship construction and operation. That is, stability (and thus seaworthiness and safety of operation) must first be designed into a ship, and then the ship must be launched and operated in such a manner as to take advantage of these design features under all probable operating conditions.

Naval Architect (Structures). -- This specialization includes positions concerned primarily with structural engineering work on ships for the purpose of insuring that size, shape, method of support, and kinds of materials used in the main hull girder and structural members of the ship are adequate for the loads imposed, and meet standards of safety, efficiency, and economy. The structural and strength portions of the ship include (a) hull form or shell with the main structural connections, including keels, innerbottoms, decks, bulkheads, webs, longitudinals, frames, beams, pillars, girders, armor, and other protective plating; (b) underwater ship appendages, such as propeller struts, bilge keels and docking keels; and (c) foundations for machinery or

other heavy equipment installed on shipboard, in which the stresses and strains of local loads are related to or interact with the main hull structural members to distribute loading forces throughout the ship's structure.

Naval Architect. -- This basic nonspecialized title is used at all grade levels for those naval architectural positions not classifiable to one of the established subject-matter specializations (structures, arrangements, ship design, stability, hydromechanics, and small crafts and boats); or for positions which combine work typical of two or more subject-matter specializations where no one is predominant.

Typical, but not all-inclusive, of naval architectural work classifiable to this title are: (1) work involved in the preparation or review of specifications for the construction, conversion, maintenance, and repair of ships, which includes the development and definition of performance requirements, standards of construction, and all design features that cannot readily be shown in plans, together with the consolidation and coordination of data from the different specialty groups in such a manner to insure thorough coverage, technical adequacy, and consistency of the specifications as a whole; (2) work involved in the preparation or review of cost estimates and analyses for the construction, conversion, maintenance, and repair of ships, and in the cost evaluation of ships; (3) work in the conduct of sea trials, acceptance of completed vessels, inspection and survey of vessels, etc.; (4) work at beginning levels where definite specializations have not yet emerged; (5) work at administrative and supervisory levels where there is control of activities falling in two or more specialized areas; (6) work in connection with the promulgation of safety regulations and certification of vessels meeting such requirements, development of damage control criteria, and similar work which cuts across two or more specialized fields; and (7) work in connection with facilities and systems for handling and storage of weapons, ammunition, boats, and cargo.

Supervisory Classes. -- Supervisory positions will be titled by addition of the prefix "Supervisory" to the nonsupervisory titles. Although supervisory classes are not described in the grade level standards, these classes are established for naval architectural positions involving supervisory duties and responsibilities which are of such significance as to require supervisory qualifications.

GRADE LEVEL CRITERIA

See the multiseries standards immediately following.

NAVAL ARCHITECTURE SERIES, GS-0871

This standard includes general occupational information and grade level criteria for the Marine Engineering Series, GS-0870, and the Naval Architecture Series, GS-0871. The introductory material concerning series coverage is contained separately in standards for each series under codes GS-0870 and GS-0871.

This standard covers the variety of types of positions in the closely allied and frequently overlapping fields of naval architecture and marine engineering. While each series has its distinct features, there is a common core of knowledge and a common requirement for adaptation of engineering principles and practice to fit the marine environment, which characterize all positions in these fields. For purposes of position evaluation, the working relationships, characteristic problems, and methods of operations of these positions are sufficiently similar that the same standard can be used.

Wherever the term "engineer" is used in this standard, it applies equally to naval architects and marine engineers unless otherwise specified.

FUNCTIONAL AREAS

Characteristically, positions in these series are concerned with one or more of the following functional areas of work:

1. *Research.* -- Ship design is undergoing a period of intense study and experimentation which has in turn created more new basic ship types in the past few years than years of previous development had produced. The present shipbuilding program is dramatic evidence of the changes that are taking place. Today's ship types are a radical break with the past. In the field of naval architecture, research consists primarily of laboratory experiments based upon mathematical and empirical formulas and model experiments. These concern such subjects as displacement, weight, stability, speed, structural strength, form resistance, materials, and performance of equipment. Knowledge resulting from this process is directed toward the general improvement of ship design and the preparation of overall dimensions and specifications. In the field of marine engineering, research consists primarily of laboratory investigation of energy conversion, power conversion, power transmission, vibration, shock, machinery noise, and automation; special studies of ship maneuvering characteristics affecting machinery operation; and design investigations of combined propulsion machinery systems of diesel, nuclear, steam, and gas turbines.

The most significant trend in research and development is the narrowing gap between the advance of scientific principles and the application of engineering art. The emphasis on "breakthroughs" to advance the technology has required that science and engineering must proceed virtually concurrently, with the result that the engineer must be ready to deal with systems or equipment operating on radically different principles from those which might be expected on a normal evolutionary basis. His work becomes more scientific in nature and even extends to areas where the science is imperfect or incomplete.

2. *Design.* -- Ships are designed for a specific purpose and, the larger ones especially, are not normally mass produced but are more or less "tailor made." Any ship designed and built is a result of compromises among the desired performance characteristics, which may be conflicting in nature. The purpose for which a ship is built will thus determine what compromises can be made, what are the more and what are the less important characteristics, what features must be built in, and what features may be sacrificed.

Ships, the larger ones especially, have an estimated life of anywhere from 15 to 50 years. During this period they require not only design for repairs for normal maintenance, but also design for modernization and other improvements that are constantly being made. Conversion design (change from one class to another, or from one purpose to another) may be required. Planning for conversion of the merchant marine fleet for military use in time of emergency is a constant
requirement. Modernization and conversion design programs may vary extremely in scope and complexity, and some may approximate or equal the range and difficulty of work found in the initial design of ships. In the latter case, the design procedures may require the same kind of study and investigation that occurred when the ship was first designed and constructed.

The design period is divided into (1) the preliminary ship design stage, (2) the contract plans and specification stage, and (3) the development design or working plans stage.

Preliminary ship design. -- The principal dimensions of the vessel are determined during the preliminary ship design stage. Engineers work with or for ship operators or others who specify performance of operating characteristics. Engineering personnel, as a rule, do not decide what these characteristics will be; but, during the period when studies and approximations are being made, the engineer does determine, if desired characteristics cannot be met, what alternatives exist, and what would be the optimum performance in terms of cost, available materials and methods of fabrication. They must have a knowledge of operating needs in order to anticipate ship design characteristics and to work intelligently with those persons (operators, naval boards) who are responsible for ship operation.

Given the performance requirements, engineers make studies, investigations and calculations to determine the hull form, hull strength, ratings and overall characteristics of main propulsion systems, displacement and center of gravity, and stability of a vessel that will meet the requirements or come nearest to meeting those requirements. The initial studies are usually known as pre-characteristic plans and dozens of these may be made before the ship operator makes a final selection. Once this selection has been made, the engineers complete the preliminary ship design studies, using calculations rather than the original estimates and

approximations. This post-characterization period includes the delineation of the lines, the displacement and stability calculations, general arrangement plans, weight calculations, and strength calculations. Propeller design calculations are made to insure that the propeller characteristics are properly matched to the hull and main propulsion machinery characteristics. Calculations are made of heat balances, shafting size, bearing loadings, main propulsion system vibration, and main circulating water scoop systems to determine ratings and overall characteristics of main propulsion equipment. Also, as soon as the preliminary lines are completed, a model or models are usually made (particularly for new forms) and towed in a model basin. This permits a close estimate to be made of the shaft horsepower required for the desired speeds, and revision in the body lines, if necessary, to eliminate unnecessary resistance.

Normally, when there is assurance that the ship can be built on the displacement assigned to it, and that it will have adequate strength, watertight integrity, stability, and satisfactory space for the arrangement of its major features; and when the type and size of power plant needed to meet requirements of speed, cruising radius, and horsepower capacity have been determined; the preliminary ship design period is completed. However, subsequent major changes affecting vessel stability or the purpose for which it was designed, are considered to be a part of the preliminary stage. Depending upon the size and type of ship, this period may require anywhere from one to six months, and the results of the completed work may be presented in anywhere from six to twenty plans and reports.

Contract designs. -- The preparation (or review, or both) of contract plans and specifications is essentially the process of expanding the preliminary ship design, checking it in great detail, improving it in many respects, and putting all the requirements in a form that will serve as a basis for a shipbuilding contract. As such, it becomes a guide for the preparation of all detailed working drawings of the ship, for making reasonable estimates of the amount of money the ship will cost and the amount of time it will take to build, for conducting the final trial and acceptance runs which test the ship's performance and for a number of other related negotiations and actions that frequently arise during the construction of a ship.

By the time the plans enter the contract plans period, the size, form, speed, cruising range, and other basic ship characteristics have been determined. However, in the earlier stages there may be changes required in these characteristics as more detailed studies indicate; substantial changes will affect the basic ship characteristics and will be the basis for a new preliminary ship design. By the time the contract plans are finally completed the feasibility of the proposed ship design is assured.

In addition to expansion of the preliminary design plans, the contract design period includes preparation of plans and specifications for auxiliary machinery and other shipboard mechanical systems, electrical installations and systems, hull piping and air conditioning diagrammatic plans, hull fitting arrangement plans, and interior arrangement plans. Specification and cost estimate work are typical of this period.

Depending upon the size and type of ship, it may require anywhere from three to nine months to complete the contract plans and specifications, and there may be anywhere from a dozen to fifty plans (this does not include the specifications).

Development design. -- The biggest part of a ship design job is the preparation of the working drawings for all portions of the ship, which for a large ship may amount to 5,000 or 6,000, or even as many as 10,000 on a large aircraft carrier. For the larger ships the usual procedure is to develop the detailed working plans during the actual construction period, with the preparation of plans kept well ahead of construction in order to permit ordering material for each part of the ship in plenty of time. A great deal of time is saved by having the construction period run concurrently with the detailed design period rather than waiting to start construction until all working plans are finished. In addition, there are other advantages, such as incorporation of the latest equipment installations without duplication of work.

The same general development design procedure is also followed for conversion, repair, alterations, and modernization of vessels in service. (Conversions in ships and sometimes modernization programs are, in effect, new construction programs.) Periodically vessels in service are drydocked for overhauls at which time engineers prepare working plans as required for installation of equipment, etc.

Engineers responsible for the preparation of the development design or working plans usually review contract plans and specifications or discuss design problems with the professional personnel who prepared the preliminary and contract designs or other design specialists, in order to prevent or eliminate the proposal of faulty or difficult design concepts from either the practical construction or maintenance viewpoint.

3. *Construction, Maintenance, and Operation.* -- During the construction, maintenance, and operation periods many problems occur which require the attention of professional engineers in addition to the major design changes incident to the conversion, alteration, repair, or modernization of vessels. Some typical examples are as follows:

a. Weight control during the construction, maintenance, and operation periods is important. It is comparatively easy for a ship to become overweight or unstable, especially if the desires of every group interested in the ship were satisfied. During the preliminary design stage, the engineers try to anticipate the required weights; additional weights, which may be required because of later developments in equipment, desires of operators, or other factors beyond the control of the preliminary ship designer, are extremely difficult to take care of and usually demand sacrifices in the basic characteristics of deadweight, capacity, and speed. Loading and operation of a completed vessel must be done in such a manner to maintain proper stability. Thus it is necessary to make weight and stability calculations and studies during these periods. The inclining experiments and trim dives are conducted for completed vessels. Studies are made and plans prepared for launching, drydocking, and mooring. While most of this work is performed by specialized personnel in the earlier stages of ship design studies, the actual control and coordination of such activities is the responsibility of on-site professional personnel during the construction and maintenance of the vessels. These on-site personnel must have a good knowledge of the methods employed and the effects of weight and stability upon safe ship operation.

b. The preparation of cost estimates for construction or repair and alteration occurs in the ship construction, maintenance, and operation periods. During the preliminary design stage cost estimates are made for advance budget planning and to assure economical construction and at the time contracts are issued for bids, more detailed or exact cost figures are required. Engineering personnel may determine that the costs included in bids made by shipbuilders are reasonable, may develop criteria for evaluating such estimates, or may prepare independent cost estimates themselves prior to bid openings. During the building period, design changes are practically inevitable if the most efficient, economical, and modern ship is to be produced. Every change in a ship design may increase or decrease costs; it thus becomes necessary to analyze designs to ascertain how much material is required and what methods of construction are required under the alternate plans, and hence what the differences in costs are. Because the shipbuilding industry is highly competitive, one of the inherent problems of cost estimating work is obtaining previous cost data (especially labor costs) upon which to base estimates. Shipyard prices are affected by the amount of work in the shipyard, by variations in wage rates and material costs, and similar economic factors. Also, the lack of complete design information, particularly in the preliminary design stage, or the non-existence of cost data on unique equipment or for ships of radical design, can be additional complicating factors. Thus, it requires sound engineering judgment and extensive and frequently complicated engineering calculations to develop the necessary cost estimates accurately at early design stages. At later stages much of the work may be performed by technicians.

c. Engineers may be required to perform professional work in making estimates of the time required to construct, alter, convert, or repair vessels. This information is used in scheduling ships to drydock for repairs or over-haul, in a manner to reduce laid-up time of the ship and to maintain a steady level of work at the shipyards.

d. As trainees, engineers may participate in the inspection of vessels to determine what repairs are required, and the inspection of completed shipbuilding work to determine compliance with contract requirements. Such inspection work is normally found in nonprofessional shipbuilding inspection and ship surveying positions. In connection with such nonprofessional activities, professional engineers are available for review and approval or disapproval of alterations or development changes in approved plans and specifications on the basis of conformance with contract requirements as to basic design, weight, and stability. They also advise shipbuilders on the interpretation of plans and specifications, changes in design and specifications and sufficiency of materials and work, in order to increase seaworthiness and efficiency of ships, and to reduce costs.

e. Engineers specify the requirements for trials or other performance tests of shipboard systems, observe such tests, review calculations of performance data, and recommend approval, modification, or disapproval of systems and their installation. Sea trials are conducted to determine, under operating conditions, whether the vessel has met all the requirements of the specifications and conditions under which it was contracted to be built. These performance tests are participated in by many groups of people engaged in many type of work. Engineering personnel are responsible for furnishing technical assistance in conducting the trial runs, making observations, taking readings, making scientific calculations, and giving expert advice and recommendations. They may serve as members of acceptance boards. In this capacity, they

participate in the complete physical surveys, conferences, and negotiations upon completion of the construction, conversion, alteration, or repair of the vessel.

EXPLANATORY NOTES

1. This standard does not include grade-level criteria for research positions or closely related laboratory positions. Instructions for the grade level evaluation of research positions appear in the Research Grade Evaluation Guide.

2. This standard does not include grade-level criteria for supervisory positions. Supervisory positions will be covered in part by the General Schedule Supervisory Guide.

3. Naval architects and marine engineers in positions covered by this standard for nonsupervisory classes may supervise the work of professional, technical, crafts, or clerical personnel on a project basis. Such supervisory duties may include planning and assigning the work and assuming responsibility for timely completion and adequacy of the work. These supervisory duties are significant in the evaluation of project leader or coordinator positions primarily as a measure of the scope and complexity of the project or block of work.

4. Grade-level criteria pertaining to nature of work are of necessity expressed in somewhat general terms. Employees in different grades may perform duties which are similar in some respects. Thus, consideration of the illustrative work situations, while of considerable assistance in the evaluation process, does not eliminate necessity for thorough study and review of the essential, grade-influencing classification factors to determine grade level. The grade of positions in these series will depend largely upon the scope and difficulty of engineering assignments, the original thinking that is required, the supervision received, the personal contacts required to be maintained, the decisions and recommendations which are relied upon without detailed review, and the qualifications required to perform the work.

5. In the fields of naval architecture and marine engineering, certain guides, precedents, methods, and techniques are considered standard. For the purposes of grade-level discussion these will be considered to include (a) agency manuals of instructions and operations, (b) standard text books, (c) manufacturers' catalogs and handbooks, (d) standard designs developed and prescribed by the central engineering staff of the agency, (e) master or guide specifications developed and prescribed by the central engineering staff of the agency, (f) files of previous projects undertaken by the agency, (g) standard work practices in the area of application as taught in naval architecture and marine engineering courses or generally accepted by engineers as the result of experience, (h) codes and standards published by engineering societies and organizations such as the American Bureau of Shipping, (I) codes and standards published by regulatory bodies such as the United States Coast Guard, and (j) the governing policies and procedures of the agency.

6. The qualifications required for full per performance at each grade level above GS-5 are cumulative; that is, the qualification requirements for GS-9, for example, include all the

knowledge, abilities, and other qualities stated in the standards for GS-5 and GS-7 and, in addition, those specifically described at GS-9.

NONSUPERVISORY CLASSES OF POSITIONS

NAVAL ARCHITECT, GS-0871-05

Nature of work. -- This is the beginning level with work assignments designed to train graduate engineers without experience in the application of basic scientific and engineering knowledge. Assignments usually consist of unrelated specific tasks that are selected with a view toward orienting an employee in the practical application of theory and basic principles; toward ascertaining his interest and aptitude; and toward relieving experienced personnel of detailed and simple work. The beginning employee is expected to know and apply basic principles and elementary theory, and to utilize readily available data. Assignments are not complicated by conflicting ideas, principles or theories; the work can be performed readily by application of basic principles and practices.

Mental demands. -- Written guides and instructions are usually fully applicable to specific assignments. Situations not covered by the beginning employee's basic knowledge of engineering principles, written guides, or initial instructions are referred to others. Employees at this level are encouraged to work out and suggest solutions to problems assigned, within the limits of guidelines and work methods suggested by experienced personnel with whom they are working.

Supervision received. -- Work is performed under the close supervisory control of higher grade professional personnel. The supervisor makes work assignments, furnishing detailed information and giving specific instructions as to methods of accomplishing the assignment, but encourages the use of the beginner's basic professional knowledge. The supervisor advises on any problems encountered and checks work in progress. Completed work is reviewed in detail for technical accuracy, adherence to sound engineering practices, and conformance to instructions. As experience is gained and progress is demonstrated, the supervision received becomes progressively less; however, all technical determinations are carefully reviewed prior to official acceptance.

Qualifications required: Full performance of the work requires:

Knowledge of basic engineering theory and practice acquired through the completion of a full four-year engineering curriculum leading to the bachelor's degree in an accredited college or university; knowledge of ordinary sources of technical information; ability to carry out under close supervision simple design projects with respect to the field of work; ability to make or check simple design calculations; and ability to conduct simple tests and inspections of equipment or systems.

NAVAL ARCHITECT, GS-0871-07

Nature of work. -- The GS-7 level is typically a continuing professional development level. GS-7 engineers assist experienced engineers of higher grade by performing work of limited scope and complexity. Assignments are typically minor phases of broader assignments. Assignments at this level are characteristically screened by supervisors to eliminate unusual or difficult problems but require performance of a variety of detailed operations which can be accomplished by the use of standard engineering methods and techniques. Duties are similar to those of the preceding level, but are performed typically in related sequences or series rather than as isolated tasks.

The following illustrative work situations, while not all-inclusive, are considered typical of GS-7 positions:

1. Develops, modifies, or reviews arrangement and detail plans and diagrams for equipment, machinery, and systems, or for the installation of such equipment. These plans cover standard arrangements or installations where no complex or unusual problems exist. Design work is concerned with standard single elements to which standard methods are applied. Normally, these assignments are concerned with a small phase (e.g., development of one or two plans) of a larger project.

2. Assists in making professional investigations of shipboard installations for use in plan preparation, engineering reports, and test agenda preparation. Accompanies higher grade personnel on shipboard investigation when a problem exists or when nonstandard considerations are involved. Accomplishes ship checks independently when they are of a repetitive nature or when the supervisor outlines the points to be checked.

3. Prepares or revises three dimensional isometric diagrams of the damage control systems to indicate features such as accesses, fittings, valves, covers, fans, and terminals. Provides damage control basic location numbers and closure classifications for each of these features. Makes calculations for the flooding effect and liquid loading diagrams which indicate the capacities of compartments in tons of salt water and the results of flooding such as lists to the nearest 0.1 degree.

4. Conducts standard tests on marine equipment and systems. Normally, these tests are of such scope that no other assistance is required. On large testing projects, assists by gathering technical data for one phase. Prepares engineering reports reflecting data collected, calculations as required, and appropriate recommendations.

Mental demands. -- GS-7 engineers are expected to have acquired a working knowledge of pertinent policies and procedures, and to have learned to relate these to assignments and make practical application of basic engineering principles and techniques. Required guidelines and background reference material are either directly applicable or supplemented by instruction and guidance in their application.

The requirement for original thinking is limited at this level by the nature and explicitness of assignments or by the presence of close supervisory control. Even so, some judgment is required in selecting the most appropriate guides. Some resourcefulness is required in relating a working knowledge of pertinent policies and procedures to basic training in the professional field of work. Also, some initiative is required in independently planning the details to accomplish assignments governed by established, specially applicable procedures.

Supervision received. -- Engineers at this level are under the general supervision of higher grade professional personnel when engaged in day-to-day repetitive type assignments, which are usually covered by specific and detailed procedures. On receipt of assignments of this type, the GS-7 engineers are expected to proceed independently with the investigation and analysis of the problem involved, apply established methods and procedures appropriate for a satisfactory solution, secure approval for any deviations therefrom, and present findings, designs, and conclusions in comparatively completed form. Whenever they encounter procedural or technical difficulties in the accomplishment of an assignment, they discuss them with the supervisor or other experienced engineers to secure advice or a different viewpoint from which to approach the problem. Completed projects are reviewed by the supervisor, who may require further investigation of the problem, question the accuracy and adequacy of technical data and conclusions presented, indicate change in proposed design or specifications prepared, or suggest exploration of an alternative course of action.

When assisting higher grade professional personnel by accomplishing segments of projects for which the latter are responsible, GS-7 engineers are ordinarily under closer supervisory control. In these instances, they are given assignments which are screened to remove unusual or difficult problems and they usually receive specific instructions as to lines of approach and work sequences to follow. Problem matters arising, such as choice between alternative methods, are referred to the supervisor and discussed with him to get further explanation and advice or approval to proceed. Any need to deviate from established procedures requires the supervisor's prior approval. Work operations involving new processes, procedures, or lines of approach are reviewed during various stages of accomplishment to assure proper application of methods and techniques.

Qualifications required: Full performance of the work requires:

Sufficient working knowledge of engineering principles and practices to perform a variety of routine tasks without detailed and specific instructions; general knowledge of regulatory and procedural issuances applicable to the assignments at this level; working knowledge of shipbuilding practices and methods; working knowledge of the basic principle of ship design, main propulsion and other shipboard systems design and installation, mathematics, and properties of materials; and ability to select and apply standard guides, methods, and techniques within the area of assignment.

NAVAL ARCHITECT (APPROPRIATE TITLE), GS-0871-09

Nature of work. -- Assignments at this level typically require (1) judgment in the application of regulatory material, established procedures and policies, and pertinent precedents; and (2) a good understanding of engineering principles, practices, and techniques in the fields of naval architecture or marine engineering.

At this level incumbents typically perform a variety of work operations relating to an area of specialization which necessitates their familiarity with and proficiency in application of established methods, procedures, and techniques. Assignments usually constitute a block of work which is either a complete but limited project or a project segment. If complete projects are assigned they usually relate to conventional ship plans and diagrams or marine equipment and systems and are covered by established methods, techniques, and precedents. If phases or segments of projects are assigned, they may require consideration of alternate methods and some deviations or adaptations in previous plans or techniques for application to current assignment. In such cases, assistance is received from the supervisor who provides information, methods, and procedures for application of new or unconventional criteria and techniques. Specifically, the GS-9 engineer may perform the necessary computations for determining draft, trim, and various coefficients. Assistance is given by the supervisor as to methods and references to use. The final results are submitted to the supervisor for review.

Assignments may be of a coordinating nature. That is, assignments may be composed of several phases, each requiring analysis and solution, in sequence or simultaneously. Certain phases or details may be performed by other groups or personnel outside the organizational unit and not under the direct supervision of incumbents, in which case the result must be reviewed, analyzed, and integrated for final solution. In addition, assignments at this level require a good understanding of the effect that recommendations made or other results of subject assignment may have on an entire system and its end-use application.

The following illustrative work situations, while not all-inclusive, are considered typical of GS-9 work in the various classes:

1. Reviews manufacturers' working plans, instructions books, and calculations for marine pumps and other auxiliary machinery to determine compliance with contract requirements and other applicable specifications, and for conformance with good engineering practices. Makes suggestions for changes or modifications in design details to improve the operating characteristics of the pumps or other machinery, or to improve ease of manufacturing, installation, or maintenance. Checks instruction books to see that text descriptions are clear and concise, that photographs, drawings, and sketches identify clearly all parts, and that there is consistency between text and drawings and that both conform to agency requirements. Recommends approval or rejection of plans or instruction books.

2. Reviews or prepares the design calculations for and the initial working diagrams of the heating, ventilating, and air-conditioning of various compartments of ships under construction. Checks or ascertains the factors used to arrive at the heat loss or gain to or from a space to determine the amount of heat, volumes of air, and refrigerating capacities required to maintain specified temperature and humidities. Checks or prepares diagrams to see that they contain such design information as the watertight and airtight subdivision, the

types, capacities, and system number of each ventilating set, volumes of air, rates of changes of air temperature rises of each of the compartments, locations and types of watertight and airtight closures and operating gear for remote operation, heating arrangements, armor gratings and armor covers, test head levels, insect screen area, etc. Checks the working drawings of such systems to determine that they meet specified design requirements. Determines that the designs are consistent with the minimum of space, weight, and electric power, provide adequate resistance to damage flooding, and are within noise level limitations. Indicates required corrections or changes in working plans to meet requirements.

3. Makes a variety of complex calculations for operating characteristics of experimental turbines and gears. These calculations are based on standard formulae and practices but require deviations or adjustments because of variations in operating conditions. For example, makes stress calculations of reduction gears to determine beam strength, surface compressive stress, and pressure velocity factors; makes calculations to determine bearing loads induced by tooth loading, gear element weights, and centrifugal force; etc.

4. Prepares general shipboard arrangements for alteration and repair of ships. The plans and calculations which are prepared form the basis for decisions by higher grade engineers for the modification of ships. Prepares working plans, including layouts of ships, and determines interior arrangements for passenger and troop accommodations, crew quarters, hospital spaces, office spaces, galley, and expendable stores. Checks list of stores required, figures weight and size, and determines size and arrangement of storage bins and lockers. Locates fittings, furniture and spaces to make use of living and stowage area aboard ship within the limits of convenience, accessibility, maritime rules and regulations, agency practice, and rules for the safety of life at sea. Completes plans and layouts, making necessary adjustments and arrangements, except where major alterations are required.

5. Makes calculations involved in the inclining experiment of a vessel, including the preparation of the vessel for the experiment (free surface deduction, liquid loading, inventory of miscellaneous weights, calculation of the inclining weight from curves of form, etc.) and calculation of the results of the experiment; makes weight and moment analysis of a ship undergoing repair to determine stability of the ship; develops curves of form for underwater launch vessel.

6. Checks scale detailed working plans of machinery piping systems for conformance to diagrammatic contract requirements. Proposed steam piping systems are checked for size, thickness, and thermal stresses. Calculations are made to see if ample allowance is made for expansion, either by loops or bulkhead expansion joints. The location of all piping runs are checked to see that ample drain connections are provided and that pockets are avoided. Recommends changes, approval, or disapproval.

7. Estimates or calculates the weight and center of gravity of items making up the structural framework of ships during the preliminary design of new vessels. Uses structural plans prepared or in preparation and construction plans prepared for similar vessels, and is under the guidance of a higher-grade engineer who furnishes data relative to items not covered by or varying from previous ships. Lists the weight and location of center of gravity of each

plate, each plate supporting member, the deck covering, and other items; uses these figures to get total weight and center of gravity of entire plating; calculates the weight and vertical center of typical frames at several points along the length of the ship; pilots on a base of the ship length curves representing weight per frame and vertical center of gravity; and determines weight and vertical and longitudinal center of entire frame. Makes summation of foregoing and other comparable figures to determine the displacement and location of center of gravity for the ship as a whole.

Mental demands. -- GS-9 engineers are required to search through standard guidelines to select the most appropriate ones for the specific assignments, and to make minor modifications or adaptations as are necessary for applications to particular conditions of problems. Revisions or adaptations required are governed by standard naval architectural and/or marine engineering practices and methods.

Resourcefulness and ingenuity are required in developing design details, modifying procedural details, and selecting applicable guides in order to produce the best results in accordance with requirements. The conditions surrounding assignments vary considerably in details. Typically, more than one theoretical solution to the design and operational problems or more than one series of formulas for calculation of stability or other data may be possible. Problems may arise during the progress of an assignment which require changes in or deviation from previous plans or procedures. Judgment and initiative are exercised in applying standard guides, recognizing variations to be made, and recommending solutions for problems not covered in precedents.

Supervision received. -- GS-9 engineers receive general supervision when performing work assignments which can be accomplished by applying standard professional practices, and established policies and procedures. The supervisor assigns the work, outlines requirements, and furnishes general instructions as to the scope of the engineering activities. These instructions usually include objectives of assignments, related work being performed (if any), approximate time limitations, priorities, and similar data. The supervisor encourages and expects employees at this level to use their initiative in planning the method or means of accomplishing assignments within the limitations of established policies and procedures and their training and experience in the use of standard professional principles and practices. When performing work phases which exceed these limitations, they are under closer supervisory control. The supervisor is readily available for advice; makes decisions on questionable points or deviations; gives detailed instructions when new criteria or new techniques are involved; and observes work for progress and coordination with other related designs, engineering features, and completion schedules. Completed work is reviewed for accuracy, adequacy, and conformance with established policies, precedents, and sound professional practice.

Recommendations and decisions. -- Engineers at this level make decisions as required during the progress of typical assignments, provided standard practices or other precedents are applicable. They refer to supervisors or to higher grade personnel problems not covered by precedents and matters that might affect the validity of results or affect other areas of work, and may make recommendations thereon. While their final conclusions are reviewed, the adequacy and accuracy of work details are relied upon. These conclusions are used by higher grade

professional personnel as the basis for action and commitments. GS-9 engineers usually have no direct responsibility for commitments which are binding upon their units or establishments.

Occasionally, however, in connection with field visits or contacts with shipbuilding or design contractors, they make suggestions or advise in connection with design or calculation details. In all cases, suggestions and advice are based on clear precedents and are reported to supervisors upon return to home offices.

Personal contacts. -- Personal contacts with professional personnel engaged on related work, and shipboard and shop personnel are found in most positions at this level. Work characteristic of these series usually has many interrelationships and these aspects must be coordinated and developed concurrently so that the overall design and operation of the ship, the main propulsion system, and other shipboard systems will be satisfactory.

Employees at this level, by personal contact, thus obtain and give out necessary factual information, explain agency requirements and specifications, and discuss technical problems and interferences. Tact, courtesy, and clarity of presentation are required. There is no positive requirement for persuading others to follow their suggestions and recommendations, or for making decisions on controversial issues; but incumbents attempt to come to mutually satisfactory agreements in connection with details which are covered by precedents. Contacts are usually concerned with individual assignments, and are generally limited to discussions with other individuals.

Qualifications required: Full performance of the work requires:

Good general knowledge of the principles, methods, and techniques of naval architecture or marine engineering from a theoretical and practical standpoint plus a working knowledge of the area of specialization; good knowledge of regulatory material, established procedures and policies, pertinent precedents, and sources of information related to assignments; ability to visualize objectives and analyze problems; independently locate, select, and apply established guides, choosing the best when there are several possible methods; accomplish investigative phases; develop assignments typical of the level; and reach valid conclusions and offer sound recommendations; ability to discern when established guides are inadequate and guidance of higher grade professional personnel should be sought; ability to recognize interrelationships with other engineering interests; ability to discuss engineering data with others and to secure cooperation; ability to present plans and recommendations, or prepare analytical reports, clearly and concisely; as required, ability to serve as working supervisor over a few lower grade professional personnel, technicians, draftsmen, or shop or shipboard personnel.

NAVAL ARCHITECT (APPROPRIATE TITLE), GS-0871-11

Nature of work. -- Engineers at this level are recognized as competent in conventional aspects of their subject-matter or functional area of assignment. Assignments typically require (1) broad knowledge of engineering practices, precedents, standards and techniques and (2) demonstrated ability to interpret and apply these guides to a variety of problems within an assigned

specialization. GS-11 engineers independently plan and conduct complete projects or studies of a
conventional nature. Assignments are difficult but usually involve extensions to or modifications in existing design features rather than completely novel or radical design features or studies in which basic data or fundamental guides are not present. Projects involve many variable factors or have more than one theoretical solution, or both, and considerable judgment is required to make sound compromises between the theoretically ideal and practical considerations. Related engineering requirements, e.g., electrical, must often be considered, entailing frequent coordinative action with engineering personnel in the fields concerned.

Some assignments at this level are concerned with design and development of new types of experimental equipment or adaptation of existing types of equipment to new applications, for which precedent guidelines or complete data are not readily available. In these cases, a higher-grade engineer supplements the critical gaps with specific instructions and explanations, gives advice in the initial stages and during the progress of the assignment as required, and thoroughly reviews the critical phases of the study upon its completion. Incumbents work independently in terms of the details and sequence of steps during the progress of the work and are responsible for its technical adequacy.

The following illustrative work situations, while not all-inclusive, are considered typical of GS-11 work:

1. Makes studies and calculations to develop such design details as center of thickness, blade contour, leading and trailing edge contour, mean camber line and ratio, position of maximum blade thickness, etc., for new models of propellers. Complete working plans in sufficient detail to permit the construction of prototype propellers for model basin testing. Reviews and analyzes model basin test reports and makes modifications to eliminate weaknesses in original design and to insure a propeller with satisfactory operating characteristics. In performing this work has available for reference previous plans of propellers used on similar classes of vessels or under conditions comparable to ones specified, and statement of requirements for the new model (such as approximately over-all size, diameter, pitch, and area desired to absorb the amount of horsepower specified, the number used, and the class of vessel with its hull form and speed requirements).

2. Makes buoyancy and stability studies on ships with compartmentation, where studies include calculation of stability of ship at various angles of inclination, or under similar conditions which result in the presence of many variables. Buoyancy and stability studies include intact stability, floodable length without heel, floodable length with heel, damaged stability, and operational stability (loading and ballasting), the latter three being typical of studies made at this level. Studies are made for ship being built, converted, or in service. On the basis of stability studies, recommends to supervisor such design features as number and arrangement of ballast tanks, limiting drafts, loading conditions, or location of massed machinery weight; or determines that proposed arrangements will meet established transverse and longitudinal stability characteristics to insure safe operation of vessels. Advises supervisor when results indicate that remedial action is needed to improve stability, which may include structural changes, ballasting and loading diagrams, counterflooding

measures, draft and loadline limitations, etc. In carrying out above work, is required to consider variable factors that can exist (e.g., design arrangement of particular ship, location and extent of assumed damage, degree of inclination because of heavy winds, rough seas, sharp turnings, or location of flooding) and uses judgment in determining the relative effects of such factors for the particular study. In general, studies are made in connection with ships that are comparable in all major respects to ships for which stability and buoyancy studies have been made.

3. Prepares designs for such piping systems as fireman, sprinkling, drainage, ballast, fuel oil, fresh water, flushing, and similar types for ships being built or converted. Delineates the piping systems on ship arrangement plans in diagrammatic form in order to include the information required by a contractor in development of detail working plans. Selects pipe sizes based on calculations, such as friction factor, friction drop, velocity head, etc., which will result in proper distribution of pressures required for the various services for sufficient and adequate flow. Selects pumps based on calculations of the frictional resistance and static head conditions together with the capacity demand of the various services. Determines sizing or design of orifice plates for cooling services in pump recirculating lines. Determines sizing of the drainage system to provide for the unballasting functions within a specified time. Considers damage control features in arranging equipment to allow for placement of valves to permit isolation or segregation of piping systems, flexibility of operation, etc. In carrying out above duties is guided by performance requirements, systems in ships of comparable class, reports of malfunctions, engineering reports, and similar data which indicate general requirements and limitations, but permit variations from previous plans in order to incorporate latest developments and insure improved and efficient systems.

4. Receives a variety of assignments requiring the design and development of plans, specifications and technical reports concerning hull arrangements and space allocations aboard vessels scheduled for repair, conversion, or rehabilitation by the shipyard. There are a variety of such projects in various stages of completion at the same time. Detailed plans may be individually accomplished by lower grade personnel or design agents under technical guidance. Typical of these assignments is the standardization of class berthing spaces which requires review and correlation of conflicting requests and recommendations from forces afloat, identification and resolution of space arrangement problems, and development of class plans reflecting relocated or rearranged personnel and related equipment spaces.

5. Following limitations contained in preliminary sketches and notes prepared by a higher-grade engineer, plans of previously-constructed ships, and accepted practices and techniques, makes strength calculations for and prepares plans for individual structural members. Analyses and calculations are difficult because of such factors as the following: (a) Members consist of a number of intersecting or combined beams, (b) hydrostatic pressure, vibration, bending stresses, and other variables which determine the forces applied to the structure must be considered, calculated, and integrated to determine final strength requirements, and (c) assumptions must be made as to loading conditions, design details, construction procedures, etc., in order to calculate stresses and determine sizes, dimensions, and best arrangements. Calculations are made to determine strength requirements for members of such structures as bottom structures, transverse and longitudinal framing, deck

plating, shell plating, bulkheads, superstructures, foundations, protective plating, propeller shaft struts, etc., and plans indicate such items as size and thickness of beams, girders, stiffeners, plating (seams and butts), their location, materials, and methods of joining (welding, riveting, etc.).

6. Acts as a marine propulsion systems test specialist in a shipyard. Has responsibility for the preparation of test and inspection requirements associated with construction or modification of submarines and surface ships of conventional types in areas of work such as: turbines; condensers; diesels; reduction gears; propellers; propulsion shafting; clutches; auxiliary propulsion machinery, including fuel, feed, condensate and salt water pumps; and air ejectors. As test specialist, adapts standard test requirements and develops procedures, assumes technical control over tests performed by production personnel, and assists project engineers in review of test deviation reports.

7. Performs a variety of assignments required in the development of contract plans and specifications for hull installations of cargo and material handling systems within the ship, between the ship and dockside and between ships underway at sea. Included are the preparation of schemes and contract plans for the location, arrangement, and operating clearances for such related items of equipment as masts, booms, rigging elevators, chutes, conveyors, etc. In preparing these plans, makes calculations and prepares stress diagrams which are used to determine such factors as weights, speeds, pressure loads and unit stresses, horsepower requirements, forces caused by acceleration and shock, etc., and specifies materials and sizes to meet these requirements where necessary. Prepares drafts of specifications stipulating requirements for these installations, which cannot be embodied in a plan.

8. Prepares or reviews and approves designs of conventional marine propulsion systems for compliance with established design standards and for operational efficiency of vessels in service. This work requires a variety of studies such as propeller shaft torsional vibration calculations; studies related to smokestacks for elimination of smoke nuisance; studies related to condenser scoop design to assure satisfactory hydrodynamic flow; calculations for determining the safety of high pressure-high temperature piping systems; and other related subjects as may be assigned. Performance of this work requires calculations based on fluid flow, strength of materials, hydraulics, vibrations, and wind tunnel laboratory test data.

9. Checks hull structural steel drawings and design calculations submitted by prime contractors, subcontractors, and design agents. These calculations and drawings are checked to determine if contractor is furnishing the various structures in accordance with the intent of the contract plans, general and detail specifications, appendices, standard drawings, bureau or agency standard plans and directives; and that the plans conform to sound engineering theory and practices. Typically, such calculations and drawings concern outside and inner bottom plating, including longitudinal and transverse framing; transverse and longitudinal bulkheads; deck and platform plating including longitudinal and transverse beams, girders and supporting pillars; escape, uptake and wiring trunks; foundations for deck machinery, main propulsion plant and auxiliary machinery, air conditioning and ventilation equipment,

electrical equipment, and guns and turrets; splinter protection for vital compartments, and superstructure houses and towers.

10. In a naval shipyard, develops machinery arrangement for a nuclear powered submarine under a follow-yard contract where the main propulsion plant machinery and components (excluding reactor) are significantly different from the lead design. Provides specifications and advice to personnel building sealed mockup to be used as a tool to compare alternate arrangements, lay out piping runs, resolve interferences and prove proposed procedures for installation, removal, and maintenance of components. Performs pipe stress calculations. Makes frequent contact with production shops and ship construction work to insure conformance. Serves as consulting source for shop supervisors and inspectors regarding specification interpretation, particularly in quality control aspects. Within scope of project assignment, makes on-the-spot changes in plans and specifications to effect more practical or efficient design and to facilitate installation.

Mental demands. -- The available guidelines typically require interpretation, adaptation, or supplementation. Judgment is required in correlating theories of naval architecture or marine engineering and previous experience in the area of specialization. While nearly all problems are guided by past precedents or basic principles and theories, these are not always directly applicable and the relationships of the past practices to the problems at hand are sometimes not obvious. Also, past practices may not always present the best solution, and it is necessary to recognize past weaknesses and develop plans, procedures and methods that result in improvements. Limitations on available space, weight, time, materials, costs and other practical considerations frequently require ingenuity, resourcefulness, and judgment in making compromises between the theoretical and the practical to arrive at a sound and feasible solution. Sound judgment is required to analyze the professional design work of others such as contractors and design agents. Creative thinking is confined primarily to developments from existing designs, methods, and procedures, and does not involve completely novel and unusual concepts covering the entire or the major portion of the scope of the assignment. Details or segments of assignments, however, may concern novel or unusual concepts.

Supervision received. -- Positions in these classes are typically under the general supervision of professional personnel of higher grade who indicate the major objectives to be attained. The supervisor may provide background information and any pertinent data available, point out unusual aspects of the assignment, and suggest ways of overcoming problems, but engineers at this level are allowed considerable freedom in planning and carrying out typical assignments. Their decisions relative to detailed project planning, work methods, and procedures are unreviewed. They are expected to use their previous professional experience to adapt established procedures and techniques and to make appropriate modifications or deviations when standard guides are only partially applicable. Supervisory assistance seldom is required unless difficulties are encountered involving interpretation of technical requirements or policy matters. Problems are discussed with the supervisor and mutual agreement reached as to procedures. Progress of assignments is periodically reported to the supervisor and future plans discussed with him.

Completed work is reviewed for results obtained, soundness of technical conclusions and recommendations, and accuracy of important design computations and critical elements. Assignments that require the making of assumptions, deviations from previous practice, or similar matters are usually discussed at the time the problem arises; otherwise these phases are subject to a complete review. Detailed computations may be subject to a mathematical check (by exchanging work, or by review of a higher grade engineer) if the results are of major importance. In positions such as those engaged in preparing or checking working plans, making standard calculations, or performing comparable duties, completed work may be subject to only a spot review, or only those items specifically called to the attention of the supervisor are reviewed.

Recommendations and decisions. -- Incumbents make decisions in regard to all details of planning and carrying out their assignments (such as sequence of operation, whether factual data are ample, whether all alternative solutions have been considered, etc.) which are not usually reviewed in detail. Incumbents are relied upon for the technical adequacy of their work. Conclusions and recommendations made are used by others in establishing guidelines, in making commitments, or in serving as the basis for action by others. For example, contract plans and specifications are the guides for the development of working plans. Some GS-11 engineers have authority to make recommendations that are tantamount to final approval or to make decisions that generally are binding upon their agencies. This occurs, for example, in connection with the preparation or review of working plans. Plans are prepared or checked and submitted to the supervisor for final approval, but unless incumbents call attention to certain features or contractors contest recommendations, results may be approved without further review. In some cases, GS-11 engineers make decisions on similar matters while visiting the contractor's or field offices in order to prevent delay or work stop pages. These recommendations and decisions are limited to matters covered by agency precedents and policies, but incumbents must exercise judgment in determining that guides are applicable.

Personal contacts. -- Frequent personal contacts with naval architects, marine engineers, naval engineers, and other personnel interested in or engaged on related work (within the establishment, in other establishments, other agencies, shipbuilders, design agents, manufacturers' representatives, ship operators, and regulatory or licensing bodies) are found in most positions of these classes. In addition to exchanging factual technical data required for coordination and carrying out work in an expeditious and efficient manner, GS-11 engineers explain and interpret agency requirements, discuss debatable technical issues, and make compromises and settle conflicts when there are clear precedents in connection with individual assignments. Tact, courtesy, and clarity of presentation are required in discussing debatable issues with representatives of other groups in order to maintain their good will. Incumbents may participate in conference discussions or represent their agency on technical committees. They usually have no authority to commit their agencies to a course of action or make final decisions in these groups, except where there are clear policy and procedure regulations. The primary purpose of committee participation is to obtain current technical data, explain agency's viewpoint, and discuss other technical matters.

Qualifications required: Full performance of the work requires:

Thorough knowledge of naval architectural or marine engineering principles, methods, and techniques in general, and special knowledge of them in terms of the specialization involved; thorough knowledge of governing regulatory, procedural, and policy guides and precedents; knowledge and understanding of the technical functions, objectives, and general program of the organizational segment; good working knowledge of the principles and practices in related engineering and scientific fields; and general knowledge of work being done in the area of specialization by others, such as industry, universities, and other Federal activities.

The work also requires demonstrated ability to interpret and apply effectively a variety of guidelines, precedents, and professional principles and practices relating to the area of specialization; ability to make sound technical compromises and decisions on the basis of guidelines and basic information; when guidelines are only partially applicable, ability to adapt them and make appropriate modifications or technical deviations; ability to function effectively under general supervision in planning and carrying out assignments typical of the level, usually needing supervisory assistance only on matters of interpretation or policy; ability in these instances to offer sound recommendations and work with supervisor in reaching mutual agreement on points in question; ability to recognize implications of own work with others and to effect appropriate coordination; ability to review professional design work performed at subordinate activities or by outside engineers; ability to write technical reports of investigations made, justifications for proposed designs, and recommendations for professional work needed based upon overall understanding of the program of the establishment; ability to discuss technical problems with others effectively and to secure cooperation; traits such as initiative, resourcefulness, imagination, good judgment, and decisiveness.

NAVAL ARCHITECT (APPROPRIATE TITLE), GS-0871-12

Nature of work. -- GS-12 engineers are recognized as competent in advanced or trouble-shooting aspects of their subject-matter or functional area of assignment. Assignments require (1) particularly skillful and diversified application of the knowledge, precedents, techniques, and procedures pertinent to the professional functions assigned, and (2) ready grasp of the relationship of problems and practices of related engineering and scientific fields and a continuing necessity to consider them. Assignments are characterized by such recurring complexities as extension and adaptation of established criteria and technical precedents, inadequacy of data, conflicting or controversial nature of problems, required coordination with related projects or groups, and integration of different phases or aspects.

GS-12 engineering positions are distinguished from those at the GS-11 level by (1) more extensive scope and importance of operations; (2) increased need and opportunity for innovation, skillful improvisation, and diversified application of the specialized knowledge, precedents, techniques, and procedures pertinent to the area of specialization; and (3) comparative freedom from supervisory direction.

The following illustrative work situations, while not all-inclusive, are considered typical of GS-12 work in the various classes:

1. Prepares contract designs of machinery systems arrangement which are essentially refinements of preliminary designs, requiring consultation with other professional personnel, conferences with representatives of machinery manufacturers, and coordination of design efforts of other groups to assure that equipment will meet established machinery limitations, operating and installation requirements and hull design limitations. The contract plans involve arrangements for main propulsion and other machinery rooms and systems as required. Prepares assigned sections of the detailed specifications concurrently with the development of the plans. Also reviews design and specification changes for project.

2. Develops design features and plans for construction, modification, repair, and maintenance of diesel and gasoline propelled boats and other small craft, their machinery, appurtenances, and arrangement. Makes investigations and calculations to determine hull form, stability, structural requirements, floodable length, displacement, power requirements; and determines design and writes specifications for machinery and equipment. Compiles cost estimates, reviews or supervises the review of construction plans and drawings submitted by bidders or commercial engineers, and initiates action as appropriate. Makes inspections at contracting yards during construction and repair of small craft and boats, investigates problems and controversies and within limits of policy, makes on-the-spot decisions as necessary to expedite work.

3. In a "type desk" position, is one of several engineers responsible for construction, alteration, and maintenance of a given ship type. Coordinates construction or maintenance on the entire ship as assigned, but refers matters of special significance to the supervisor, or to the machinery, electrical, and electronic staff. For example, assigned projects may include maintenance and alteration on one or several carriers of a given class. Specific problems encountered are numerous and varied, touching upon almost any feature of ship maintenance or alteration. Work typically requires thorough familiarity with the design criteria involved and a good knowledge of production problems and methods considered by designers, shipbuilders, and suppliers to the shipbuilding industry. While review of all plans is not required, all basic plans such as layouts, compartment and access, general arrangements, schematics of piping systems, aviation facilities, etc. are reviewed in detail and commented on. Maintains continuous liaison with shipbuilders and other organizations through conferences, field trips, and correspondence, in planning and executing complex testing maintenance, alteration, or construction schedules which are complicated by frequent design changes, equipment and material changes or substitutions, and funded program changes. Gives advice on the feasibility of changes, alterations, or modifications; takes action on correspondence, special operational directives, "Trial Board items"; and provides for close coordination with cognizant groups. Initiates or takes action on proposals and requests for changes under contract, alterations, etc. which involves determining effectiveness, effect on ship mission, ship capabilities, stability, cost, and effect on completion date. Coordinates action on requests for alterations and repairs to ships during periods of availability. Makes estimates on the cost of alterations, change orders, etc., based on the labor, overhead, and material cost. Coordinates technical review and comment on specifications and contract plans for new vessels.

4. Prepares initial cost estimates and reviews contract bid estimates of the total cost of a whole ship and/or the entire job of ship conversion, reconstruction, or modification for varied types and tonnage of conventional merchant ships, including but not limited to cargo ships, tankers, passenger ships, special purpose craft, barges, etc. The categories of cost include: (a) hull, hull installations, appurtenances and navigational instruments and aids, (b) all machinery components, their auxiliaries and related engineering systems, (c) all outfitting, cargo handling machinery and equipment, (d) all steward, deck and engine equipment, spare parts, and (e) all other interrelated vessel cost components, including indirect charges, overhead and profit, engineering fees, inspection costs and owner's outfit expenses.

5. Acts as a trouble-shooter and adviser on structural problems involved in development of working plans during construction. This entails conducting structural analyses, providing methods for solving various structural problems; establishing new methods and approaches for the solution of structural problems; providing structural guides for use by other engineers; recommending structural arrangements to insure an efficient and economical structure; interpreting structural data, literature, directives and correspondence; advising on and making recommendations relative to structural problems in conferences; setting up accepted methods for the solving of specific structural problems as directed by higher headquarters; and developing and preparing preliminary sketches of structural components to be used by other engineers for detailed development. May act as team leader on a structural project. Problems involve determining loads and deflections, both static and dynamic, principal stress analysis, hydrodynamics related to appendages and masts, etc.

6. Prepares, reviews, and coordinates specifications for the construction or conversion of ships including those which involve novel design or construction features for which previous specifications are inadequate. Ship specifications reflect the general, contractual and legal requirements binding upon the shipbuilder as well as the technical requirements for structure, arrangements, fittings, damage control and other hull design features of a given ship. For the preparation of the hull specifications reviews the specified ship characteristics and preliminary design plans for the assigned ship reviews design histories, board of inspection reports, changes and alterations to previous ships; and confers with the design specialists for design features being incorporated into the contract plans. From such data prepares various sections of specifications dealing with various general ship building design criteria, methods and materials. Integrates such portions with those sections prepared in conjunction with the various contract plans by the specialists in structure, stability, etc., and insures the technical compatibility of the design features and requirements. Reviews for technical compatibility and coordinates the hull specifications with the specifications developed for the electrical, marine and electronic requirements. Investigates conflicts arising from opposing viewpoints on functional, economic and practical design features and reconciles those which can be based on past design and shipbuilding policies, practices and methods.

7. Makes preliminary studies and prepares contract plans for arrangements (compartmentation and access) of a ship having diversified functional activities. In making initial studies must consider such factors as (a) location of bulkheads to obtain required fire protection and damaged stability control, proper space for machinery, fuel oil, cargo, and other activities requiring large spaces; (b) proper location of dining rooms, galleys, dry and refrigerated

store spaces, sleeping and sanitary spaces, recreation areas, hospitals, ships offices, and similar spaces, as will be convenient and compatible in relationship to each other; (c) location of proper stairways and passes from various watertight compartments and fire zones (from living quarters, public spaces, lifeboat stations, etc.) without interference with one another; (d) consideration of the most desirable methods of handling cargo and stores within, to and from ship (winches and open hatches, side-ports, and special gear); (e) adequacy of the individual compartments to accommodate the fittings and equipment to be installed and functions to be accomplished and to allow for an economical and convenient arrangement; and (f) (where applicable) rules and regulations of regulatory and licensing bodies, or other standards promulgated for the safety of the ship and the health of the personnel aboard. After determinations have been made, rough sketches prepared, and the plans approved by supervisor or others, the contract plans (such as deck plans, inboard and outboard profiles) may be developed by others. Reviews working plans prepared from contract plans and specifications as referred by others to determine whether they meet the intent of the contract requirements, and to recommend acceptance of major deviations.

8. Recommends action on requests from field offices, for maintenance and repair work and alterations for a tanker and aircraft transport fleet of approximately 70 ships. Work pertains to hull structures, main propulsion systems, auxiliary machinery systems, deck auxiliaries, petroleum cargo storage and handling, lifesaving equipment, all facilities dealing with messing and berthing on board, cargo tanks, and fittings. Such requests may also involve heating, ventilation, fire detecting and extinguishing systems, generating plants, and mechanical components of systems. Makes up overhaul schedules for contract-operated tankers and prepares the overhaul instructions.

9. Performs investigations and makes calculations to establish the preliminary design characteristics of main propulsion machinery for various types of ships, analyzes plant operation and performance, carries out special investigations or gives technical advice as required, and attends trials of ships and analyzes data on propulsion machinery. Following suggestions and general instructions of supervisor, determines plant cycles and makes heat balance calculations to determine the size, capacity, rating, fuel consumption, cruising radius, etc., to meet given plant requirements of speed, horsepower, and cruising radius for ship under consideration. Makes calculations to predict operation of ship under unusual conditions, e.g., to predict the speed attainable with half of the boilers or pumps out of commission. Determines best speeds and conditions at which to run trials of ship, and outlines the trial procedures to be followed. Attends sea trials of vessels, checks to see that test instructions are being followed, and observes the operations and conditions existing during trials. Examines and evaluates trial data by eliminating obvious errors, plotting performance curves and preparing analytical reports and recommendations.

10. Serves as specialist and technical adviser for review and approval of detailed working plans prepared by contractor engineer's staff for arrangement of machinery plants and piping systems on ships (under construction, conversion, or repair) that have complex machinery and piping arrangements (such as dual piping systems, split plant operations, compartmentation of machinery space, etc.). Examines contract plans and specifications and accompanying data at time of receipt; prepares preliminary sketches and layouts, and

interprets specifications for areas not covered in detail in order to insure that the most suitable arrangement plans will be developed. If investigation of preliminary data indicates that major deviations are required to obtain the most feasible plan, prepares reports and correspondence recommending that the changes be authorized.

Mental demands. -- A high degree of technical judgment, initiative, originality, and resourcefulness is required to (1) apply training and experience in the specialization concerned to develop and execute specific plans of action for extensive and complex project assignments from the broad objectives outlined by the supervisor, (2) recognize possible new directions of approach and devise new or improved techniques and methods for obtaining effective results, (3) overcome difficult and unusual problems where guides and precedents are not directly applicable, (4) anticipate future requirements and trends, (5) apply the latest technological advances relating to the specialization, and (6) analyze and evaluate designs, proposals, and ideas submitted by others.

Since guidelines are often inadequate or controversial or contain critical gaps, developmental positions at this level require the use of a high order of initiative, originality, and judgment in interpreting and planning assignments and in devising new schemes of attack or novel methods and techniques.

Supervision received. -- Incumbents of positions in these classes usually receive general administrative and technical supervision from a higher grade engineer. Characteristically, the supervisor indicates general responsibilities and problems, pointing out overall objectives and furnishing guidance on critical issues and policy matters. Occupants of these positions independently determine the technical action necessary in developing objectives and programs, facets of which often exceed available precedents and guides. When assignments involve novel design concepts or radical departures from previous practices, supervisors usually discuss the problems and indicate probable avenues of approach and solutions. Normally the incumbents are required to determine points of interference with related assignments and obtain all needed facts, opinions from specialists in other fields, and other information that will insure technical adequacy of their conclusions. During progress of an assignment, problems involving policy, radical departure from previous practices or deviations from preliminary instructions (when detailed study indicates the advisability of such deviation) are referred to and discussed with supervisor. Frequently, the final decision is arrived at jointly. However, where novel and radical design concepts are involved, alternate solutions may be presented to higher authority. This is particularly true where it is impossible to obtain all the desired characteristics in one design solution. Completed work is reviewed for attainment of objectives and for compliance with agency policies and practices.

Recommendations and decisions. -- The recommendations, commitments, and determinations of engineers at this level are important in view of the planning and coordinating responsibilities vested in these positions with respect to the broad scope of operations involved and/or the continuing necessity for skillful improvisation, deviation, and important engineering compromise. Engineers GS-12 provide professional advice, typically on complex problems with policy implications, which is given considerable credence because of the reliance placed on their technical competence. They render advice recognized as competent in giving interpretations and

making technical reviews and evaluations, and recommend final action on many engineering matters. They represent the organization in conferences and meetings and take actions of a decisive character. As an example of the foregoing, personnel in staff positions at top-level echelons make recommendations concerning the preparation of regulations, policies, and procedures to serve as overall guides to subordinate echelons and make final recommendations on projects.

GS-12 engineers concerned with development activities make recommendations and decisions which strongly influence the successful completion or failure of the difficult assignments characteristic of this level. They make technical decisions in determining advisability of investigating collateral or new problems encountered or identified during the development of assigned projects. They draw conclusions from theoretical investigations, experimental designs, and laboratory evaluations. These conclusions provide the basis for effective and practical technical reports covering development programs for improved techniques and methods for ship construction, equipment, or systems.

Personal contacts. -- Engineers in positions at this level normally have more frequent and wider contacts than those at the preceding level. In view of the broad scope of work for which they are responsible, GS-12 personnel must maintain liaison with organizational segments having related assignments, other agencies, contractors, and ship owners to discuss basic issues, resolve interferences and points of conflict, and coordinate work to accomplish desired results in an expeditious and effective manner. Incumbents of some positions explain and interpret agency (or organizational segment) policies, practices, specifications, and other requirements to other individuals and groups, particularly those groups who must comply with these requirements. Incumbents are required to persuade other groups, overcome antagonism or reluctance to change, secure active cooperation, and negotiate controversial matters in a manner that will result in effective work results. They give advice on their specialty and represent their activities in technical committees.

Qualifications required: Full performance of the work requires: Thorough knowledge of naval architectural or marine engineering principles and practices both in general and relating to the area of specialization; extensive knowledge of governing regulatory, procedural, and policy material; thorough knowledge and understanding of the technical functions, objectives, and general program of the organizational segment; good knowledge of other branches of engineering as they affect and relate to the area of specialization; and familiarity with present and past work in the specialization including work being done by other groups in the Federal service, colleges and universities, and industry.

The work also requires: ability to plan and carry out assignments that involve recurring complexities, such as the nonapplicability of established criteria and technical procedures, and inadequacy or unavailability of data; ability to recognize possible new avenues of approach and devise new or improved techniques and methods for obtaining results; ability to recognize critical issues that should be referred to supervisor or others; ability to anticipate future requirements and trends; ability to apply the latest technological advances relating to the specialization; ability to analyze and evaluate designs, proposals, and ideas submitted by others; ability to provide engineering advice on complex problems with policy implications; ability to

represent the organizational segment in conferences and meetings and promote good working relationships.

NAVAL ARCHITECT (APPROPRIATE TITLE), GS-0871-13

Nature of work. -- Assignments at this level are concerned with solving particularly unique or controversial problems with respect to naval architectural or marine engineering activities which directly affect important programs. GS-13 engineers correlate engineering theory and precedent applications to design, modify, or develop a variety of different types of complex or novel systems or ship plans in a specialized area (e.g., structures or arrangements). GS-13 engineers are generally considered as specialists for the organization, and frequently function as an advisor relative to the specialization involved. Employees at this level typically determine the need for, initiate, and recommend regulations, policies, procedures, and standards as broad guides to field offices, local activities, contractors, and others.

The problems at this level typically concern basic design features; they occur most frequently in connection with preliminary ship design, early stages of contract design, or development and construction of first models of large, complex, or novel types of ships or systems. Solutions to typical assignments usually affect more than one phase or area of the ship design field. Thus, while a GS-13 engineer may be regarded as a specialist in only one subject-matter specialization of the field, he is required to use a comprehensive knowledge of all other subject-matter specializations touching upon his own to arrive at feasible solutions. The work is characterized by problems of a controversial or novel nature for which available guides are the basic regulations, policies, and fundamental principles of the field or for which numerous variables and combinations must be considered concurrently. Frequently the objective desired is expressed in very general terms and compromises and decisions must be made (after preliminary studies and investigations) to define the tangible objective. Problems that arise are concerned with basic design features and their solution results in the establishment of guides and precedents.

Development assignments typically are of such breadth that they require planning and developing several phases, each involving the development or origination of some completely new features. Other assignments may be much narrower, but are of such intensity that available theory is not directly applicable and relevant experimental data are inadequate. In such cases, several lines of investigation must be pursued and correlated within the narrow area of assignment.

The following illustrative work situations, while not all-inclusive, are considered typical of GS-13 work:

1. As an authority on amphibians coordinates and performs background investigative and research activities in the screening, analysis, and evaluation of ideas suggested by staff and field elements of the organization, other governmental using agencies, industry, and universities. Determines and evaluates organizational requirements and needs, and prepares preliminary reports with respect to the development of new and radical designs and

modifications and improvements of existing commercially available equipment. Makes feasibility studies and designs of radical and unorthodox types of amphibians to obtain greater water and land speed, greater cargo carrying ability, better seaworthiness, greater overall reliability, and other characteristics required for the expeditious movement of personnel and material from ship-to-shore.

2. Serves as a headquarters thermodynamics specialist for work related to machinery systems and power plants on a variety of commercial ships including tugs, tankers, and passenger vessels; the conversion of merchant vessels to naval auxiliaries; and mobilization designs for war-time mass production. Performs a variety of individual engineering duties involved in the studies of thermodynamics, heat balances, and economic analyses of fuel consumption, as well as in the preparation of machinery lists for ships, power plants and the component parts, investigation of new types of main and auxiliary machinery systems for feasible adaptation to marine use, providing necessary defense features in ship's machinery to meet military requirements, estimating weights of main and auxiliary machinery, and preparing machinery arrangement studies.

3. Establishes the criteria for satisfactory stability and reserve buoyancy for ships of transport and cargo fleets, including preliminary design criteria for new construction. This involves the setting up of standards for judging the adequacy for ships' resistance to capsizing or foundering with respect to various hazards such as underwater damage, beam winds, turning, and over-the-side heavy lifts. In accordance with regulations, sets up standards for damaged stability calculations and is responsible for completion and reevaluation of metacentric height curves for all classes of ships under cognizance of the organization.

4. Acts as a project engineer in a "type desk" position, one of several responsible for construction, alteration, and maintenance of a given ship type. Typically has continuing responsibility for construction or maintenance or both for a specific class of ships. Coordinates construction or maintenance for ships within the assigned class exercising broad engineering management in achieving, through many subject-matter engineering specialists, major compromises in design, arrangement, equipment design and substitution, materials, and shipbuilding schedules during development design (as herein defined) and construction, or operation and maintenance. Exercises engineering review and approval on change orders and matters effecting shipboard installation of major equipment and systems, action for modification of ship capabilities as directed by appropriate authority. Provides advisory services to designers during preliminary and contract design phases bringing to bear latest engineering considerations of ship construction, operating, and maintenance practices and problems. A substantial portion of designs which are reviewed both in contract design and development design phases represent engineering work of the GS-12 level or higher. Major emphasis is placed on considering hull and ship systems as an integrated complex unit as distinguished from resolving individual engineering problems which arise. For example, serves as "type desk" engineer for the construction of nuclear powered submarines, covering new designs of such ships. Monitors and coordinates work on the submarine from its inception to its completion. Because of novel space, weight, and power requirements, unusual resourcefulness is required to assure that the design, contracting, scheduling, financing, and practical construction considerations are all compatible and meet the basic

requirements for each submarine. For assigned submarines is responsible for assuring that everything which goes aboard these submarines is technically compatible. At this level specific guides are less applicable than broad policy, program outlines, rigid deadlines, and need for complex coordinative relationships, all of which result in important commitments and decisions by incumbents of these positions.

5. Furnishes technical advice to field personnel of the agency and representatives of the maritime industry concerning the intent and application of maritime safety regulations pertaining to main propulsion and other shipboard mechanical systems. Evaluates new designs and systems and determines their acceptability or compliance with the intent of the regulations. Confers with manufacturers, design agents, shipyards, and vessel operators concerning the foregoing in order to establish acceptable design and construction procedures. Plans research and test programs of new materials and devices in order to increase safety at sea. Scientific data and evidence presented by applicants are studied and evaluated in order to establish suitability of the methods of construction for marine application.

6. Acts as a headquarters specialist on automatic and remote control systems for steam generating propulsion plants. Formulates, plans, and executes research, development, and design projects necessary to provide accurate, wide-range, compact, and reliable controls for the steam generating systems for the main propulsion plant. In order to do this, accurate information is required concerning the nature and characteristics of the system being controlled as well as the control components and control systems that will provide the degree of controllability required. In order to obtain basic design on inherent response characteristics of the steam generating system, research and test programs are planned. As part of this planning, prepares the instrumentation, test agenda, and instructions for carrying out this test work. Analyzes the results of the work and correlates the basic design characteristics with the calculated control characteristics.

7. Serves as technical consultant on problems of basic design of main boiler systems (including fire tube boiler, water tube boilers, superheaters, boiler safety valves, uptakes and smoke pipes, fuel-oil storage and burning systems) and on problems concerning auxiliary boilers for heating and distilling plant installations. Investigates and studies general or specialized problems in an effort to adopt improved techniques and designs to marine boilers in order to decrease weight and space requirements, eliminate maintenance and operation difficulties, and increase efficiency of operation and capacity without increasing weight and space required. Determines changes required in specifications and standards of boiler systems in order to secure improved equipment. Takes into consideration factors of shock, roll of ship, special indicators, or special materials needed to permit increased firing rates of boilers and decreased weight and space requirements.

8. Makes preliminary design studies for arrangement of machinery and piping arrangements in the machinery spaces in ships being built or undergoing conversion or major alteration where the following conditions are present: (a) Space and weight limitations are rigid; (b) new types of machinery or new methods of operation call for new types of installation and arrangement designs; and (c) arrangements include both main propulsion and auxiliary power machinery plants with very complex machinery piping systems (e.g., split plant

operation, dual piping systems, etc.). Contacts ship design groups to obtain size and shape of ship, speed and cruising radius desired, and approximate size and location of machinery spaces. Contacts marine component equipment designers as necessary to obtain size, weight, power, and fuel requirements of the various components needed for the design. On the basis of the foregoing and similar data, develops a preliminary plan of machinery and piping arrangement; works with ship design groups as required for changes in space, weight, location, and characteristics of machinery systems; and works with component design groups as required for modifications in component units. When study indicates that the design represents a feasible and practical solution, turns plans and studies over to other groups for final preparation of the preliminary plans, and advises on basic design problems arising in preparation of specifications, development of plans, construction, or operation of ships.

9. Develops the structural analysis for total ship structure in the contract design stage for large new ships where precedents are lacking or unsatisfactory for critical aspects, or for those large ships complicated because of undergoing major changes, requiring the integration of many variable factors and forces upon the structural design. This analysis establishes the critical design features of the structure of the ship, those features which can be handled by conventional methods, those for which a new approach is needed and those for which research and/or testing are required. Various problems are encountered requiring the utilization of the more advanced theories and techniques in design principles, construction materials and methods to improve the structural strength and safety of ships, particularly with respect to changing military operations and warfare. For the largest and more complex designs, the various contract plans will be developed by others to portray the basic design features established by this design analysis.

Mental demands. -- Broad technical policy and planning formulated at higher levels of engineering management serve as the basic guideline at this level. Within these policy considerations, GS-13 engineers base their determinations and decisions largely on their own well-grounded background in theory and precedent application, familiarity with overall policy and procedures, knowledge of latest technological advances in the specialization, and expert evaluation of all pertinent factors.

As experts or technical specialists, engineers at the GS-13 level exercise initiative, originality, and judgment in applying and adapting their broad knowledge of engineering theories, practices, and precedents. They exercise technical judgment in isolating essential features of the problem, adapting or extending any guides or precedents, developing new techniques in performing work, and, as required, making compromise decisions. They show ingenuity in developing design criteria and devising new concepts for ship designs or test methods involving particularly novel and complex engineering features, and display critical judgment in evaluating their suitability. They use initiative in keeping abreast of latest technological advances in their area of specialization and show judgment in recognizing the need for and recommending the initiation of special studies or research projects. They exercise judgment, initiative, originality, and creativeness in analyzing proposals of others and, as appropriate, modifying them to make them feasible.

Supervision received. -- Incumbents at the GS-13 level are under very general technical or administrative supervision. Instructions received from supervisors are given in terms of broad general objectives. Possible problems and possible avenues of approach may be indicated in connection with novel or highly controversial assignments. However, frequently the objective desired is expressed in very general terms and compromises and decisions must be made, after preliminary studies and investigations, to define the tangible objective. Discussions with other interested groups to develop in more detail the objectives and to come to agreement with respect to conflicts are typical. Technical problems are solved without reference to supervisors, but advisory opinions are sought as required, and discussions are held concerning the most difficult or controversial features. Review of completed work is for feasibility in relation to requirements and for conformance with overall policy. Acceptance and subsequent development of plans embodying novel design features normally require action of others.

Recommendations and decisions. -- GS-13 engineers have complete responsibility for independently interpreting, organizing, executing, and coordinating assignments characteristic of this level. They give expert technical advice concerning the area of specialization for the organization in high level conferences and meetings, and prepare technical and authoritative reports and papers. Within the broad framework of technical policy and planning formulated at higher levels of engineering management, they make final decisions on all matters during progress of their work that are not in conflict with existing policies and basic standards. Deviations from requirements and procedures may be approved by them as long as basic ship characteristics are not affected or operating efficiency is not impaired. They make joint decisions with other specialists in regard to compromises that must be made before final design plans can be developed. They make recommendations in regard to final designs, standards, and procedures, which are largely unreviewed except in cases where matters of policy, highly controversial issues, or novel designs and concepts that have not yet been proved are involved. Their recommendations are normally recognized and accepted as those of an authority in the specialized area assigned.

Personal contacts. -- Personal contacts are made with key representatives and experts of other groups (such as ship owners, ship operators, naval boards, regulatory bodies, other professional engineers) for the purpose of exchanging technical information, developing objectives and limitations of assigned work, making compromises or coming to agreement on interferences, conflicts, and basic requirements, and otherwise coordinating the phases of ship design. Some GS-13 engineers are responsible for explaining and interpreting agency policies or requirements to others. Some are concerned with negotiation of important issues with other groups.

Incumbents of some positions represent their agencies on technical committees of national significance with respect to developing and establishing standards, planning joint investigations, etc. Intra-agency conferences concern future or long range programs or administrative and procedural regulations. Diplomacy is required to persuade others to adopt designs, methods, practices, or decisions of the agency.

Qualifications required: Full performance of the work requires:

Well grounded and versatile background in naval architecture or marine engineering theory and precedent application both in general and related to the area of specialization; comprehensive knowledge of pertinent policies, regulations, and procedures; familiarity with other branches of engineering as they affect and relate to the area of specialization; and extensive knowledge of the latest technological advances in the specialization. The work also requires ability to function as a specialist and provide expert technical information and advice concerning the area of specialization; ability to interpret, organize, execute, and coordinate assignments which are typically unique and complex; ability to apply and adapt broad technical knowledge to the independent solution of unprecedented problems having a direct impact on extensive and important engineering programs; ability to isolate essential features of assignments, evaluate all pertinent factors, adapt or extend any guides or precedents, develop new techniques, and make sound compromise decisions; ability to visualize developmental trends and future needs; ability to discern the need for and take appropriate steps to initiate special studies or research projects; ability to evaluate feasibility and effectiveness of engineering proposals and conclusions of others; ability to represent the organization in high level conferences and meetings and serve as the authority on the area of specialization; and ability to maintain effective working relationships.

NAVAL ARCHITECT (APPROPRIATE TITLE), GS-0871-14

Nature of work. -- GS-14 engineers typically serve as consultants concerning complex technical aspects of extremely important programs involving development of basic theories, techniques, or criteria for the improvement of basic ship design and operation, or the resolution of special and nonrecurring problems having agencywide significance. They function as recognized authorities in their specialization with broad experience and acquaintance with current developments in research and design applications made by engineers throughout the marine industry in the specialization involved. Work requirements frequently cut across several specializations of the engineering field. Assignments are concerned with solution of extremely controversial or unique problems, frequently of an unprecedented nature, with respect to naval architectural and/or marine engineering activities which directly affect nationwide programs of an agency. Such problems occur most frequently in preliminary ship design, early stages of contract design, or development and construction of first models of ships.

This level is also typified by situations where occupants of these positions provide technical guidance and review the work of engineers of design agents or at field establishments. In these instances they (1) evaluate the theoretical and technical accuracy and adequacy of the plans and specifications produced, (2) maintain a continuous check on economic and military factors involved, and (3) translate military or other agency requirements into technical requirements which can be understood by contractor and field personnel. The technical requirements of these positions are high in that failures on the part of the contractor or field personnel are referred to the engineers in these positions who are responsible for the program from a naval architectural and/or marine engineering standpoint. GS-14 engineers determine areas needing attention, coordinate efforts of the specialists working in these areas, evaluate their work, and serve as reviewing consultants.

GS-14 positions are distinguished from positions at the GS-13 level by (1) the intrinsic technical complexity of the program, (2) the maximum degree of freedom from supervisory control, and (3) the completeness of responsibility for the technical program vested in them.

The following illustrative work situations, while not all-inclusive are considered typical of GS-14 work:

1. Conducts studies in the pre-characteristics stage of preliminary design to investigate and establish the feasibility of various basic ship characteristics to meet speed, protection, armament and other military features desired for proposed ships that represent major departures from existing designs because of new or unusual operating conditions, use of new materials and construction methods, and/or breakthroughs in design theory. Many studies are accomplished by the incumbent before the best balance of military, naval architectural, and operating characteristics, can be established. From the feasibility studies the Ship Characteristic Board accepts one and formally establishes the military characteristics, (speed, endurance, armament, protection, etc.); operational characteristics, (fueling rates, cargo handling rates, number of standby boilers, etc.); and naval architectural characteristics, (length, beam, draft, subdivision standard, etc.). These parameters form the desired characteristics which will be further evaluated and developed in the post-characteristic stage of preliminary design. Participants in conferences with key officials of related design and operating divisions, ship operators or owners, and other interested groups to coordinate major design phases and to come to agreement on basic ship characteristics when all operating requirements cannot be met.

2. Represents agency in serving on technical committees (interagency, interindustry, national, and international in scope) for the purpose of discussing highly intricate, specialized, and important technical problems, developing general plans and procedures for carrying out research and experimental projects to establish basic design data, and developing and formulating national and international safety standards for ship design and operation. As required, performs highly difficult investigations of major ship casualties, where information available is fragmentary and highly conflicting, recommends probable causes and remedial action required to prevent recurrences, and renders opinions in the status of an expert witness. Subject matter covers all fields of naval architecture (with particular emphasis on structural strength, stability and subdivision, and other factors affecting seaworthiness and safety of ship) for a wide variety of classes and sizes of commercial ships that include novel and intricate arrangements, involve use of new materials or construction methods, or involve other problems of an unprecedented nature.

3. Establishes (from given requirements in regard to horsepower, cruising radius, and approximate space and weight limitations) the basic machinery requirements for a given complex ship (e.g., large mixed passenger-cargo ships, or large and complex combatant ships) in which installation design requires novel and complex arrangement plans because of new operating requirements or completely novel types of equipment. Consults with ship designers and others to resolve conflicts in the initial stages of the preliminary design. Consults with marine component equipment designers, engineers and manufacturers to discuss performance requirements, technological advances, and similar factors that will result in development of needed equipment. Serves as consultant on technical problems of major

importance and difficulty arising during the development and construction of equipment or its installation on ships, and makes final decisions as required.

4. Serves as an expert and consultant in one or more major fields of naval architectural inquiry to remain abreast of, investigate and initiate research activity and to correlate and apply the results of such activity in the development of design criteria, techniques and methods for the improvement of ship design. (For example, in the fields of fluid and structural mechanics concerned with such problems as ship motion, ship stabilization, hydrodynamically induced noise and vibration, directional control and stability of submarines, etc., delineates specific problems requiring research, determines suitable method of approach, initiates action by appropriate research organization, monitors and coordinates the research effort, analyzes the results, and applies to practical ship designs.

Mental demands. -- The usual guidelines provide little assistance, as engineers GS-14 are largely occupied with major problems which have defied satisfactory solution, which are highly unusual, and concerning which there is little authoritative information available. Occupants of these positions are essentially guided by general overall directives outlining technical objectives, their own analysis and interpretation of broad policies and regulations, their knowledge of technological advances, a broad technical background and experience in the area of specializations, and their evaluation of conditions and circumstances relating to work performed. They develop and establish guidelines for others to follow.

An exceptionally high degree of originality, skill, and professional competence is necessary at this level. Technical judgment is needed to interpret and convert general overall objectives and policies into specific activities which will produce desired data upon which highly important actions and engineering decisions will be based. Creativeness is a significant requirement in evaluating naval architectural and/or marine engineering problems in relation to overall objectives; for judging the direction, extent, and significance of trends and developments; and for adjusting the broad development activities carried out to latest advances in technology and to the needs of the marine industry, military programs, or other groups served, as these needs are modified by changing conditions. Originality is also required in overcoming difficult problems which typically necessitate complex adaptation of precedents, and in visualizing and coordinating all the individual aspects and the many interrelationships of the important programs with which they are usually concerned. Coordinator-reviewer positions require exceptional judgment and vision in the application of a broader knowledge of agency policies, laws, regulations, procedures, and methods than positions at the preceding level, since larger and more varied programs or program functions are dealt with at this level. Originality is required in anticipating major problems, recognizing future program needs, and developing policies, as well as in developing standards, procedures, and instructions to guide operating personnel.

Supervision received. -- Engineers GS-14 are under general administrative control, since they typically function in a consultant capacity and are recognized as technical authorities concerning their areas of specialization. They may discuss broad program implications with their supervisor, but all technical aspects are worked out independently. Work is not subject to technical review other than for conformance with broad directives and policy and from the standpoint of evaluating attainment of objectives. Engineers at the GS-14 level develop and

modify the objectives and boundaries of assignments subject only to administrative control on such matters as funds, personnel available, and procurement of equipment. Review of completed work is made by the supervisor for his own information in keeping abreast of developments in the field. For positions of program coordinator-reviewers, supervisory assistance received in the solution of problems at this level is limited to general directions with respect to objectives and broad policies covering matters extending beyond the assigned area of responsibility. Recommendations and decisions are reviewed for general conformance to agency objectives and policies but not for technical adequacy or soundness of judgment, except in program planning. The review is primarily one of evaluation of operational reports which indicate degree of accomplishment of objectives. Matters referred to higher echelons relate to priorities, deadlines, budgets, administrative matters, policy considerations, and the correlation of the program with other programs under the jurisdiction of the higher echelon.

Recommendations and decisions. -- As ranking consultants, GS-14 engineers make final determinations on technical matters with respect to naval architectural or marine engineering aspects of important engineering programs having national significance. As representatives of their agencies they are authorized to reach agreements with other groups. Recommendations, decisions, and conclusions made by them are considered as authoritative and are seldom subject to technical review. Final acceptance of novel design proposals may, of course, be dependent upon action of higher authority or concurrence of other affected groups.

Personal contacts. -- The extensive scope of the program and the effect of the high level determinations made by GS-14 engineers necessitate extensive contacts with key officials and specialists of other groups (within the agency, other government agencies, ship owners, shipbuilders, design agents, or other marine industry groups). These contacts are frequently made in conferences held to exchange engineering information and negotiate mutually satisfactory solutions to important issues. For example, in presenting technical judgments and decisions which are generally given top consideration, occupants of these positions (1) supply information which has great weight in influencing action, (2) advise on policies and procedures, (3) discuss and influence the establishment of long range programs affecting future engineering work, (4) coordinate and conclude technical phases of established programs, and (5) render technical consulting service. They represent their employing activities in committees of national and even international importance, and participate actively in the consideration of major issues.

Qualifications required: Full performance of the work requires:

Broad background of scientific and technical knowledge in general, and authoritative knowledge of the area of specialization, with recognition as a consultant; broad knowledge of pertinent policies, regulations, procedures, and overall plans and objectives; and extensive knowledge of relationship of other branches of engineering with own area of specialization and of latest technological advances in the specialization.

The work also requires ability to correlate an extensive technical background of experience in naval architectural or marine engineering theories and practices with an expert knowledge of policy and procedural considerations to plan and carry out important work for which few tangible guides are available; ability to develop and establish guidelines for others to follow,

being guided by general overall directives outlining technical objectives, own analysis and interpretation of broad policies and regulations, own knowledge of technological advances, a broad technical background and experience in the area of specialization, and evaluation of relevant conditions and circumstances; ability to recognize and pursue critical developments, and to analyze and interpret the theoretical significance and potential application of experimentation; and ability to participate in high level conferences and discussions with other specialists, to establish standards, plans, or programs, and to reach agreement on major issues.

NAVAL ARCHITECT (APPROPRIATE TITLE), GS-0871-15

Nature of work. -- Engineers at the GS-15 level undertake program or project assignments of outstanding difficulty and complexity so that recognized technical leadership, outstanding creativeness, and exceptional scientific and engineering judgment are required in proving or disproving the feasibility of ideas or configurations or in originating agency policy and design criteria. They regularly undertake investigations which result in the development of new ship types and/or concepts of operation or propulsion.

GS-15 engineers frequently serve as the expert advisers and consultants in one or more areas of naval architecture and/or marine engineering to the agency, or major subdivision, engaged in extensive and intensive engineering programs. The manifestations of this factor at this level are similar to those described at the next lower level for similar positions, but, in addition, (a) consultant and advisory duties are performed at top echelon levels of the employing organization and of collaborating organizations; (b) consultant and advisory duties are performed with respect to broader and more varied areas of research, development, and application, involving the investigation and development of fundamental principles and theories; (c) more numerous and extensive contacts and liaison are required with top echelon officials and engineers in governmental, industrial, university, and military research, production, testing, and developmental organizations; and (d) consultant and advisory decisions and recommendations have greater immediate effect upon initiation, coordination, cessation, or change in direction of major programs, policies, and procedures of the primary organizational segment or agency.

The following work situations are illustrative of the level:

1. Is responsible for the continuous review and development of the replacement and maintenance program for all agency vessels to assure that they are ready at all times to meet peace and wartime needs. Initiates preliminary design studies and investigations to determine the basic form characteristics, stability, and type of main propulsion equipment for new vessels to meet changes in operational requirements. Also initiates or makes studies to determine and evaluate applicability of new methods, materials, and construction practices to agency projects and to seek solutions to difficult problems in ship design and propulsion systems brought about by the unique operational requirements of agency vessels.

2. Serves as a recognized authority in the investigation, creation, or evaluation of design theory, radical ship design configurations, and other similar advanced concepts underlying the improvement in basic ship characteristics and the development of completely new ship

types. For example, applies creative and fundamental approaches in ship design to project and evaluate the hypothesis for, and the basic characteristics of, radical new concepts such as ships for a submersible surface fleet. Such study and analysis requires the consideration of fundamental phenomena from any field (e.g., aeronautical engineering, metallurgy, etc.) for application to the entire field of basic naval architecture to ascertain the validity of further research and design investigation and development. His conclusions on the feasibility of such concepts are considered authoritative and provide the basis for management decisions to continue or abandon developments in the field.

Mental demands. -- GS-15 engineers are required to exercise a very high degree of originality and sound engineering judgment in formulating, evaluating, and correlating broad engineering and scientific programs, in guiding the analysis of unique problems, in developing new and improved techniques and methods, in proving or disproving the feasibility of ideas and theories, in resolving major design questions, and in developing new design concepts.

Supervision received. -- At the GS-15 level, engineers are recognized as final technical authorities in their areas of specialization and receive administrative control only. Supervisory control involves evaluation of fulfillment of project objectives, of the effect of their advice and influence on the program of the organization, and of their contribution to the state of the art.

Recommendations and decisions. -- Recommendations and conclusions are considered authoritative and are not reviewed technically. They typically have a far-reaching effect on the work and programs of major activities.

Personal contacts. -- As consultants and advisers GS-15 engineers furnish highly advanced technical guidance and information to top level administrative and technical agency personnel, other government agencies, and outside organizations. As authoritative experts in their specialty areas, they serve on panels and committees concerned with planning agency and interagency programs and collaboration.

Qualifications required: Full performance of the work requires:

Broad and inclusive knowledge of the fields of naval architecture or marine engineering, fundamental policies, long range objectives, plans, and operations of the establishment, and technological advances in the area of specialization; and knowledge of developments in allied fields.

The work also requires: demonstrated ability to plan and coordinate an extremely large, difficult, and diverse engineering program; ability to evaluate trends in scientific fields as they affect program objectives; ability to make decisions on courses of action having far-reaching implications; ability to function as a technical consultant and provide advice on engineering matters of great difficulty and importance; and ability to represent the establishment at agency conferences and discussions, act with authority on current and proposed programs, and maintain cooperative relationships.