Equipment Development Grade Evaluation Guide

Table of Contents

INTRODUCTION

This grade-evaluation guide is for use across occupational lines in determining grade levels of professional engineering and physical science positions concerned with development. Like research, development advances the state of the art, but it is further characterized by the creation of new or substantially improved end items in the form of equipment, systems, materials, processes, procedures and techniques. This document is identified as a "guide" rather than a "standard" because it provides grade-evaluation criteria for positions in several occupations rather than describing different classes of positions in one occupation. However, it has the same force and effect as a standard and is issued under the authority of 5 U.S. Code 5105.

Because of the breadth and variety of work involved in the development function, grade-level criteria for broad categories of development work are issued in separate parts. Part I, Product Development, Part II, Project Management and Part III, Experimental Development, are to be used in evaluating engineering and scientific positions engaged in planning, formulating, defining, monitoring, managing and evaluating governmental and contractor development work for new equipment and equipment systems. This includes such end items or products as aircraft, agricultural and automotive equipment, missiles, spacecraft, ships, power plants, transmission systems, and communication networks. Also included are their subsystems, equipment, components and associated support hardware and software.

Development, as used here, is the systematic application of scientific knowledge to create new or substantially improved equipment, systems, materials, processes, techniques and procedures that will perform a useful function or be suitable for a particular duty.

For simplicity in wording, *the term "equipment" is used generically throughout the guide to include end items or products and their parts, components, subsystems, equipment, and systems.*

In the development process, the use of teams to accomplish large-scale projects is common. Team leader positions covered in this guide are those in which leader responsibilities are not grade controlling. See the General Schedule Leader Grade Evaluation Guide for information to determine whether leader duties are grade controlling.

RELATIONSHIP TO OTHER PUBLISHED STANDARDS AND GUIDES

This guide supersedes the grade-level criteria of existing standards for those positions in engineering and physical science which are engaged in development work covered by part I, part II, and part III.

The General Grade-Level Guide for Nonsupervisory Professional Engineering Positions or the standard for appropriate engineering or physical science series should be used for positions in grade levels GS-06 and GS-07.

SERIES DETERMINATION AND TITLING

This grade-evaluation guide is not intended to affect series classification. Positions classified to grade by means of this guide are to be placed in the most appropriate classification series in accordance with definitions published in the Handbook of Occupational Groups and Families, and amplifying material in published classification standards.

The terms "Product Development," "Project Management," and "Experimental Development," are used to identify part I, part II, and part III, respectively, of this guide and are not intended for use as position titles. The title structure in published position classification standards is to be used as appropriate.

NATURE OF DEVELOPMENT ENGINEERING

Development engineering is a creative process involving the continuous exploitation of basic scientific knowledge. Its roots are so intertwined with research that it is frequently impossible to determine the point at which the evolution of knowledge into concept and then into hardware ceases to be research and in fact becomes development. In some instances, the translation of scientific knowledge into a specific item of hardware or into techniques or processes is so direct and rapid that the development process is greatly telescoped or possibly nonexistent. However, it is more generally true that development engineering is an evolutionary process involving many discrete steps.

The "team" approach to large, major development projects is a fundamental characteristic of development engineering. More often than not it is multi-disciplinary, requiring the collaboration of numerous specialists each of whom must have some understanding of many related disciplines in order to contribute effectively to the whole creative task. Another reflection of this is the Government-industry team approach.

There is a wide spectrum of Government-industry relationships in the development process. At one extreme is the situation in which industry develops products and sells its wares. At the other extreme is the situation in which Government develops what it wants and buys production. However, the more typical situation falls between these extremes.

Characteristically, the development process for equipment can be divided into five major phases of engineering activity involved in the creation of new, substantially improved, or extensively modified products. While these phases may not always be distinguishable as separate activities, the development process for equipment in general follows these steps.

NATURE OF DEVELOPMENT ENGINEERING (cont.)

1. Planning and requirements phase

This phase includes establishment of the requirements for the technical objectives and major development tasks. This step is inextricably involved in the function of overall management. To this end, the researcher and/or engineer may contribute in the form of proposals for development technology or hardware in response to expressed needs and desires from management, or based upon a knowledge of the possibilities engendered by advances in technology and engineering capabilities.

2. Conceptual phase

This phase encompasses a broad spectrum of scientific and engineering activity wherein concepts are formulated and proven by theoretical hypotheses. The conceptual phase of the development process provides visibility to the requirements involved, the approaches that could be taken, the evaluation of feasibility of accomplishment and alternatives available. However, engineering is carried only far enough so that judgment may be passed on the most likely concepts.

This phase, which consists primarily of paper studies and investigations, involves consideration of information regarding the state of the art in the various technologies, previous attempts to develop predecessors, new developments in materials and components, and problems previously encountered. Studies may be performed sequentially, concurrently, and independently at various echelons within an organization and/or by outside groups (e.g., industry, research organizations, other Government activities).

Results of studies, simulations and investigations provide management with appraisals of engineering possibilities, the probability of achievement, and estimates of probable costs and time requirements. However, management decisions to proceed with development, to delay or cancel the objective, or to perform more research, normally involve consideration of other factors such as mission, priorities, economic and social implications, and long-range plans as well as the merits of the engineering concepts.

3. Definition phase

In this step critical features and problems pinpointed in the earlier study phases are further identified and explored and the principles are established upon which a practical development program may be based. This occurs both independently of and in response to conceptual studies, since laboratories and other organizations carry on continuous research and development programs. Analysis is carried to the point where either a solution is achieved on various problems or alternative further programs may be evaluated. These activities may well result in altering the advanced concepts, the objectives and/or previously formulated requirements and criteria.

NATURE OF DEVELOPMENT ENGINEERING (cont.)

During this phase a concept which specifies product parameters and characteristics in sufficient detail to serve as the base for development of the prototype is predicated. This concept may at its outset be sufficiently flexible to permit widely different technical approaches, but there must emerge at some point a preliminary design which establishes the functional feasibility of the product concept. All engineers working on various components, subsystems, and/or engineering analysis use these design data as the basis for their assumptions in developing equipment, in selecting proven hardware, and in performing analytical investigations and studies of subsystem and system operation and response.

There may be considerable variation in the extent and depth of definition that is necessary, possible or desirable because of the differences in the design processes involved in the various end products and their integral elements. Also, the advances in the state of the art in hardware and software development technology and the understanding of phenomena that must already have been achieved in order to predict feasibility will have a bearing. In some equipment areas the definition of the critical features, the determination of the requirements, and the delineation of the characteristics and limiting factors may nearly complete the investigation and integration normally done in the Prototype Design Phase.

This is the phase in which the most imaginative and creative proposals can be investigated, but it is also the phase which requires curbing creativity when the limits of technology are strained, when the risks are great, and the costs are high. Consequently, there is considerable emphasis on performing overall studies of requirements and demonstration of feasibility and cost effectiveness during this phase at all echelons within the organization.

4. Prototype design phase

This phase represents that period of extensive engineering refinement necessary to convert to the component and subsystem level those principles, characteristics and parameters established in the definition phase and embodied in a preliminary design concept.

Initially, or as a continuation of preliminary design, engineers conduct analytical studies of each subsystem and the total product. These studies cover system operation and response, limitations, ranges of variables and reliability. Such studies may result in modifications in the preliminary design concept because of reappraisal of the basic premises relative to technological limitations and restraints, and use and functional factors involved; the emergence of new techniques and methods or the more specific application of engineering methods; and a more precise estimate of schedule, difficulties and costs.

Problem areas in reaching the objective are identified in each successive phase of the development cycle with the principles and premises documented as decisions are made on the approach and technology to be utilized. In the beginning steps of this phase, all areas must be pinpointed for which extensive development, experimentation and testing are required by specialists in the particular subject areas, and such work initiated.

NATURE OF DEVELOPMENT ENGINEERING (cont.)

As analysis and investigation precede the basic design premises, criteria, performance, and operating requirements are expanded into specific features and characteristics. Upon selection of features and hardware, thorough investigations of the mechanical, electrical, hydraulic, thermal, reliability, and other characteristics are undertaken. Various test programs are utilized to supply data for detailed design, to investigate properties of materials, and to determine operating and performance characteristics and interaction of components under various environmental conditions. Throughout the process such factors as maintenance, use, handling, integration with other systems, as well as the availability of manufacturing and production methods and facilities must be considered.

In these investigative processes some components and assemblies may be fabricated as they are expected to be used in the final product. Others may be built as a prototype for testing. Some existing equipment may be modified in order to simulate operation in a realistic environment. Similarly, a mockup or small-scale replicas may be assembled and tested before the effort and expense of building a prototype is undertaken.

The construction of a model for testing and evaluation of the complete product is not always carried out. Very often parts of the product may be constructed and other parts simulated. Possibly the entire system may be simulated by the use of computers, breadboards, etc. Similarly the prototype model itself may not be constructed. For instance, to construct a prototype of a large ship or even the hull of a large ship or the main generators and turbines of a power plant is unrealistic from both a cost and a need standpoint. On the other hand, prototypes are produced of products for which there will be large production runs or which must be duplicated by others, or for which only the testing of the real product can prove its efficacy.

5. Test and evaluation phase

The translation of creative concepts of equipments into hardware, facilities and operational procedures must inevitably involve a substantial amount of experimentation and hypothesizing. Thus, the development process is characterized by sequential testing and evaluation of the concept, the parts, assemblies, and, finally, the complete product.

Test and evaluation activity is discernible in each phase of the development process. However, test activity in those stages up through the definition phase is more readily identified with experimentation. As the hardware requirements and anticipated environment are specifically identified, each task to be performed and each aspect of design is examined for testing needs. Testing is one of the principal tools utilized by development engineers to determine and insure that valid and realistic engineering conclusions result from the application of advanced technological data, techniques and processes.

Early in the prototype design process a determination is generally made of those tests which will be necessary to prove product efficacy, and when and by whom they will be performed. While certain testing requirements are established by generally accepted practice and by procurement

NATURE OF DEVELOPMENT ENGINEERING (cont.)

and other regulations, considerable selectivity is inherent both at the outset and throughout the prototype development process.

In general, it may be said that all tests are performed to demonstrate that the goals and objectives of the product envisioned at the outset are met. Thus, testing serves not only to achieve optimum design features and system compatibility, but also to demonstrate under realistic environmental and operating conditions that the product works and is effective.

PART I--PRODUCT DEVELOPMENT ENGINEERING

COVERAGE

Part I of this guide is intended for use in grade evaluation of professional engineering positions at GS-11 and above engaged in new equipment development that involves the following duties:

- -- performing the analytical work required during the planning, conceptual and definition phases of the development process;
- -- providing technical direction, advice, review and evaluation of contractor work in developing new equipment and concepts;
- -- guiding, evaluating and integrating laboratory and other in-house development work;
- -- serving as consultant or advisor to an organizational head and others concerning research and development programs, studies, problems, and equipment.

These positions are concerned with the development of equipment and equipment systems to perform new functions or missions, to capitalize on technological advancements, and to enhance the capabilities of products for existing functions and missions. Part I also applies to positions in development engineering organizations that perform for project management offices these types of services:

- -- providing expert advice on problems or critical areas;
- -- performing studies and analysis in depth on selected specialties, subjects and equipment; and/or,
- -- providing continuing technical direction and systems engineering (integration) of the contractor's development efforts for the various technical specializations, equipment and, in some instances, the overall product.

The development engineer who plans, guides, and integrates the product efforts for the project management office may work full time in his/her specialization within his/her own engineering organization or may be detailed to, or co-located with a project management office.

EXCLUSIONS

Engineering positions in development organizations are excluded from coverage of part I of this guide when they are engaged primarily in the following kinds of work:

- laboratory-type experimentation and investigation;
- monitoring and administering exploratory development contracts with contractors or other activities in which a problem is posed and a result specified (i.e., study, proposal, advice) for which *little or no attempt is* made to structure, direct or guide the work in process;
- supervision of development engineering work;
- the conventional design of equipment including the redesign of development prototypes for production and manufacture, which can be accomplished by applying or adapting standard references, criteria and precedents;
- the conduct and reporting of tests.

CLASSIFICATION FACTORS

While the specifics of the subject matter dealt with will vary according to the engineering field involved, grade levels of professional engineering positions covered by part I have been found to depend on essentially the same elements, regardless of the subject field. In this guide, these common elements have been grouped into two factors:

(1) assignment characteristics; and,

(2) level of responsibility.

These two factors are described for each grade level in this guide.

Assignment characteristics

CLASSIFICATION FACTORS (cont.)

This factor deals with the nature, scope and characteristics of the assignment; the nature and extent of judgment and knowledge required; and the degree to which guidelines and precedents exist.

Development assignments range in difficulty depending on these factors:

(a) scope and complexity in terms of the breadth, intensity, variety of activities and number of variables involved;

(b) the applicability of precedents and/or difficulties, unknowns and obstacles involved in converting scientific principles and theories into engineering technology:

(c) the definitiveness of objectives in terms of the judgment and knowledge required to solve problems, to make compromises, and to select among alternative courses of action; and

(d) the end results expected in terms of the impact on the development project, other development efforts, and achievement of technological advancements.

At the lower levels the assignment may reflect a narrow problem for which the engineering principles and techniques are identified by precedent applications. At the higher levels the scope of the assignment typically reflects a wide variation in use, purposes and application or a broad range of functions and engineering disciplines. At these higher levels exceptional professional competence is required to establish the means by which new theories and principles may be converted into engineering criteria and end products.

Level of responsibility

This factor includes the nature and extent of supervisory control exercised over the work, and the nature and extent of the incumbent's responsibility for personal contact and for making recommendations and decisions.

The degree of control over the position may be measured by the extent to which the employee receives guidance in the assignment and the degree of freedom exercised in carrying-out these responsibilities:

(a) determining what development work to pursue;

(b) organizing the work in terms of selecting the approach to use; subdividing the work into separate parts and activities; and,

(c) determining how the assignment is to be accomplished; and,

(d) committing the organization to a course of action.

CLASSIFICATION FACTORS (cont.)

An important factor in determining the level of responsibility concerns the degree of finality of recommendations and decisions in accomplishing and determining objectives of the development program. At the lower levels recommendations and decisions may be final only as they relate to the application of well-known engineering techniques and methods. At the highest levels most recommendations and decisions may have the effect of finality.

The nature and purpose of the contacts made in resolving problems, in coordinating work, and in guiding the efforts of others reflect a wide range of variations in responsibility. The nature and purpose of the personal contacts range from situations in which clearly factual material is discussed or presented to situations in which engineers must convince high level managers of the wisdom, value or desirability of pursuing or abandoning costly and extremely important development efforts.

Qualification requirements

Qualification requirements have not been described separately, but rather have been reflected as appropriate in both the "Assignment Characteristics" and "Level of Responsibility" factors.

Illustrations

Since this guide applies to a wide range of engineering occupations, illustrations have been used to provide greater specificity to the scope and character of the assignments and the responsibilities reflected in these assignments at each grade level.

Product Development Engineering - GS-0800-11

Assignment characteristics

Assignments require the application and adaptation of a variety of engineering principles, guidelines, precedents and practices to specific problems in a subject-matter field or an area of specialization. GS-11 engineers perform independent analysis, investigation and delineation of specific engineering criteria, characteristics and features to meet a variety of operational, environmental and practical conditions.

Assignments normally cover an independent portion of a larger study or project. The technical objectives typically are defined and can be solved by using proven theory or applied technology. Assignments may involve duties such as:

(1) monitoring of a long-term development being accomplished under contract to achieve a new or an improved product; or,

Product Development Engineering-- GS-0800-11 (cont.)

(2) investigation and analysis of specific data under variable conditions for (a) evaluation of design characteristics, features, and conditions to meet specified performance and operating requirements, and (b) selection of design criteria.

GS-11 engineers, unlike GS-9 engineers, are required to plan an effective approach to overcome complexities not adequately covered by standard guides and precedents. In making plans they are expected to apply a thorough subject-matter knowledge of the engineering field involved together with the governing regulations, procedures and policies. They are expected to investigate and recommend new ways of accomplishing the technical objectives specified and to ascertain the applicability of technological advancements to the assignment. Assignments typically require a knowledge of related scientific and engineering fields as they pose limitations or other identifiable conditions in making sound technical compromises and in selecting between alternative courses of action.

Level of responsibility

The supervisor in making assignments indicates the major objectives to be attained, provides background information and pertinent data relative to requirements and unusual aspects of the assignment, and may suggest ways of overcoming problems. GS-11 engineers differ from the GS-9 level in that (a) they are allowed considerable freedom in planning and carrying out assignments with decisions relating to the detailed approach, work methods and procedure largely unreviewed, and (b) they work with others in developing a joint solution to engineering problems which are based on precedents or conventional engineering applications.

They adapt technical precedents and techniques to make appropriate modifications and engineering deviations in design features based upon the results of their investigation and analysis. The supervisor reviews and approves such deviations before final action and provides help in difficulties in interpreting technical project requirements and policy matters. Changes in and problems relating to deadlines, priorities, and funds are discussed with the supervisor. Progress is periodically reported and future plans discussed. The supervisor reviews in detail critical phases upon completion and may provide guidance as the work proceeds. The work is reviewed upon completion for technical adequacy, consistency with requirements, soundness of decisions, and compatibility with related parts of the project.

GS-11 engineers are expected to recognize aspects of the work requiring coordination with work of others within the activity. In monitoring contracted development efforts, engineers discuss details of engineering features and progress. They independently provide additional data on technical requirements and agency procedures.

Illustrations

Here are examples of typical assignments.

Product Development Engineering-- GS-0800-11 (cont.)

1. Monitors the development activities of contractors and others involved in designing specific equipment for particular purposes (such as a radar data processor equipment, engine control accessories, or a group of related components for various applications, e.g., electronic circuit); performs a range of functions, such as:

   -- studies available technological data and equipment and selects design, development and test criteria which can be utilized to guide the contractor or laboratory approach;

   -- prepares work statements, procurement data and project development plans incorporating such criteria and controls;

   -- reviews and evaluates contractor equipment and system specifications and test procedures for conformance with established criteria, good engineering practice and adequacy in meeting requirements;

   -- evaluates and recommends action on engineering reports, design data reports, pre-production and test reports, engineering change proposals, requests for waiver or deviation from specifications, etc.;

   -- participates in informal and scheduled periodic contractor government conferences to discuss engineering problems and to review contractor progress.

2. Investigates, analyzes and prepares design layouts and reports to resolve specific problems encountered in equipment and system operation and to investigate new ideas for improving performance, eliminating complexity, etc. Performs a range of these types of functions:

   -- determines the need for laboratory experimentation and testing for data bearing on the problem and conditions involved; and, confers with specialists in other fields to obtain pertinent engineering and analysis data;

   -- analyzes these findings and prepares or guides preparation of plans and reports embodying one or more design concepts with supporting engineering data; concepts may contain proposals for design changes in existing equipment and recommendations for new components and techniques; for example:

      (a) investigates erratic performance of bridle arrester of low energy shots of catapults that has resulted in considerable damage to aircraft launched from shipboard;

      (b) investigates chemical handling equipment for use on ground motorized units, airplanes and helicopters for firefighting purposes;

Product Development Engineering-- GS-0800-11 (cont.)

3. In the analysis of new and advanced concepts for a given system, e.g., vehicle, communication, power, flight, etc., works on a phase of an overall study. For example

   (a) designs space vehicle payloads intended to measure reentry heating, working from a given reentry body scheme and sensors and telemetry devices;

   (b) studies communication system for aircraft making comparative analysis of such items as derived data rates, acceptable error rates, coding method, modulation methods and equipment complexity;

   (c) makes analyses in support of automotive vehicular and component assembly, including weight distribution, center of gravity, installation space requirements, and performance.

   For such an assignment, the GS-11 engineer follows a set of conditions and requirements established by others. The engineer performs a range of these types of functions:

   -- plans approach by studying precedent designs and conditions to which the hardware will be subject;

   -- correlates current technological data with required capabilities through analysis and application of relatively straightforward techniques, although the necessary background and precedent are often inadequate in some respects;

   -- conducts studies and prepares calculations to determine the most practical approach and the best combination of basic design features and criteria to meet the specified requirements, coordinating design features with engineers and scientists working on related assignments.

Product Development Engineering - GS-0800-12

Assignment characteristics

Assignments involve these duties:

(1) developing solutions for a variety of nonrecurring problems in an engineering field or product area; and,

(2) anticipating future needs and trends, and investigating the applications of new technology or the possibility of new approaches to overcome current engineering limitations or to find solutions to continuing problems.

Product Development Engineering-- GS-0800-12 (cont.)

This level differs from the GS-11 level in that precedents and guidelines are often lacking. This requires the use of advanced techniques and the modification and extension of theories, precepts and practices of the field and related sciences and disciplines. In other instances, the conflicting and controversial nature of precedents and available engineering data requires skill in improvising and judgment in making important engineering compromises. The engineering solutions that incumbent evolves have an impact on the development programs concerned.

Characteristically, GS-12 engineers plan and carry out assignments for complete projects that entail a variety of complicating and interacting factors, relationships with other engineering specializations, and consideration of the complete development cycle. GS-12 engineers identify the scope and extent of investigation, analysis, and design required by others, and define the specific engineering requirements and design criteria for guidance of such development efforts. Problems involved in the projects require an intensive knowledge of the performance and operating characteristics to be met for which a wide range of engineering and scientific principles and theories are applicable.

Level of responsibility

Characteristically, the supervisor indicates general responsibilities and problems, points out overall objectives, and furnishes guidance on critical issues and policy matters. When assignments involve novel design concepts or radical departures from previous practices, the supervisor usually discusses the problems and indicates probable avenues of approach and solution.

In carrying out assignments, GS-12 engineers independently (a) organize the work to accomplish the objectives of the assignment, (b) recognize the limitation of current approaches in identifying and solving problems, (c) propose and justify additional research and/or investigation, and (d) recommend changes in basic requirements, deviations from normal practices and similar action. GS-12 engineers insure technical adequacy of conclusions by resolving points of interference with related assignments and obtaining opinions from technical specialists on problems as appropriate.

Recommendations for solution of major problems and conflicting requirements are discussed as they arise. Departures from previous practice and policy are discussed with the supervisor, who assesses the completed work on the basis of whether the objectives of the assignment are met.

GS-12 engineers differ from GS-11 engineers in that the GS-12 level typically involves these responsibilities:

(1) concluding action on aspects of assignments that require the interpretation and translation of engineering requirements into design characteristics and features, and

(2) coordinating the various phases of the work being accomplished by in-house organizations, by contractors, and by other agencies.

Product Development Engineering-- GS-0800-12 (cont.)

Illustrations

Here are examples of typical assignments:

1. Establishes preliminary design data and requirements for specific systems or complex equipment for new design concepts. For example:

   (a) prepares layouts for a space vehicle and determines the requirements for a variety of vehicle design features such as aerodynamic shape, mass distribution, propellant volume, power plant arrangement, etc.; or,

   (b) for an electronic guidance system, analyzes the correlation between different sensing and reference systems, compares different principles with regard to measuring accuracies, and performs analysis of probable errors and characteristics of such systems.

In such assignments, the GS-12 engineer typically performs these types of functions:

-- studies mission requirements, precedent applications, and related subject areas to establish critical performance requirements;

-- analyzes and evaluates test data, and scientific and engineering reports covering research and experimentation conducted by others to ascertain their application to present and anticipated projects;

-- adapts, modifies and makes rational assumptions for extension to areas beyond present practices of such information in the formulation of guidelines, approaches, design principles, etc.

2. Serves as the engineer responsible for the development of a specific model of equipment or group of related components. This responsibility starts with the establishment of preliminary design and performance characteristics and extends through development and final approval for production and service use. The engineer performs a range of these types of functions:

-- reviews exploratory and research programs and the development of related equipment in other units in order to determine interrelated requirements and to make preliminary analyses establishing the general performance and design characteristics;

-- obtains, evaluates, and recommends selection of manufacturer's development proposals based upon consideration of costs, engineering merits, and the ability of the manufacturer to meet requirements;

Product Development Engineering-- GS-0800-12 (cont.)

-- monitors contractor's critical development activities; this includes: approving design and material changes; making compromises in design characteristics dictated by weight, size, cost, maintainability, reliability, production, etc.; and recommending whether prototype or product meets contract requirements.

3. Provides detailed analyses in a subject-matter field (e.g., thermodynamics, fluid mechanics, structural design or shock and vibration) for a variety of engineering problems. The GS-12 engineer typically performs a range of these types of functions:

-- performs analyses to establish and to assess the adequacy of design treatment and relevant considerations; investigates and analyzes engineering and scientific methods, concepts, and theories to determine their applicability to particular design schemes and problem areas;

-- evaluates contractors' and others' work and proposals concerned with new technology for specific equipment development and design to insure adequacy and compatibility with requirements; recommends reconsideration along suggested lines when contractors' proposals are inadequate;

-- assesses the feasibility and soundness of engineering evaluation tests where data necessary to perform these analyses are insufficient or confirmation by means of a test is advisable; determines the nature of the test and parameters to be investigated; upon completion, evaluates test data, and advises equipment engineers of test results and their significance.

Product Development Engineering - GS-0800-13

Assignment characteristics

The GS-13 engineer serves as the technical specialist for the organization in the application of advanced theories, concepts, principles and processes for an assigned area of responsibility (i.e., subject matter, function, or equipment). The work requires either:

(1) theoretical expertise in a specialty that applies to a wide variety of situations, uses, and problems; or,

(2) extensive application of theories, principles and practices of one or more disciplines involving many variables and complex interrelationships.

Characteristically, GS-13 engineers plan, organize, direct, and coordinate development programs requiring diverse creative and support efforts contributed by others, such as laboratories, con tractors, and design agents, or they conduct continuing studies and analyses to determine the

Part I -- Product Development Engineering -- GS-0800-13 (cont.)

feasibility of various advanced engineering approaches, to define concepts and criteria for future programs or to resolve major controversial problems in current programs.

Assignments are of such breadth or intensity that they encompass several phases of the development process though the principal emphasis may be more apparent in one or two phases. Frequently, GS-13 engineers serve as team leaders guiding and coordinating the work of other engineers.

GS-13 engineers perform a broad range of these types of functions:

(a) establish requirements for advanced work in the area of responsibility to meet new or inadequately fulfilled technical objectives;

(b) translate these requirements into aerospace, electrical, electronic, mechanical, etc., principles, as applicable, to describe and specify development and application programs;

(c) conceive and develop new products and/or theories pertaining to new applications of existing products; and,

(d) guide and evaluate the design and development activities of contractors and others in achieving new products.

The work differs from that at the GS-12 level in that the GS-13 level is characterized by problems of a controversial or novel nature for which available guides are the basic agency regulations, policies, and fundamental principles of the engineering field. Frequently, the work involves development of engineering concepts for which limited applied research and exploration has been previously accomplished. This requires investigation and evaluation of various alternative development approaches and combinations of engineering characteristics. There is a continuing need for compromises between the most desirable application of engineering principles and the exigencies of costs, priorities, schedules, and supporting requirements. GS-13 engineers determine the need to direct further research and investigation and to alter or cancel approaches which they consider unfruitful or unsatisfactory.

Level of responsibility

GS-13 engineers function within the framework of broad technical policy and planning formulated at higher engineering management levels. Assignments are received in terms of general objectives. Frequently, compromises and decisions must be made, after preliminary studies and investigations, to define the tangible objectives.

Typically, they confer with other engineers, scientists and user organizations to develop in more detail the objectives and to reconcile conflicts. Technical problems are generally resolved without reference to supervisors. Advisory opinions are sought concerning controversial matters and major changes in approach as these relate to other assignments, funds, and priorities.

Part I -- Product Development Engineering -- GS-0800-13 (cont.)

This level differs significantly from the GS-12 level in that GS-13 engineers' recommendations are normally accepted by others as those of a specialist and are largely unreviewed except where matters of policy, highly controversial issues or unproven concepts are involved. Completed work is reviewed for feasibility in relation to requirements, and for conformance with overall policy and program objectives.

GS-13 engineers represent the organization or agency in high level conferences and meetings in explaining and interpreting policies and requirements to others, and in negotiating important issues with other groups. They serve on technical committees which develop and establish criteria and standards and plan joint investigations. They make joint decisions with other specialists in regard to important compromises in the basic requirements or approach which must be made before subsequent steps in the development process can proceed.

A particular difference at this level from the GS-12 level is the responsibility for representing the organization in presenting and justifying comprehensive proposals for major development efforts, in evaluating such proposals of others, and in negotiating compromises in basic design requirements and characteristics.

Illustrations

Here are examples of the kinds of work that are done.

1. Serves as the engineering specialist for a variety of types and models of major systems for specialized applications, e.g., engine systems, electronic detecting and tracking systems, missile warheads, etc.; typically performs a range of these types of functions:

    -- evaluates research findings and technological progress in related scientific and engineering areas; recommends development programs to be undertaken, and prepares estimates of funding and time phasing requirements;

    -- conducts or directs feasibility studies to analyze, evaluate and determine practicability and adaptability of new proposals;

    -- initiates and coordinates various project activities in-house, at other agencies, or at contractor facilities;

    -- determines technical adequacy of developments conducted to insure satisfactory progress and fulfillment of requirements;

    -- determines need for reorientation or termination of existing programs and for initiation of new programs based upon changing requirements or capabilities.

Product Development Engineering-- GS-0800-13 (cont.)

2. Serves as a specialist in preliminary design and analytical design functions for a broad specialty area such as propulsion and power for missile systems. Performs a range of these types of functions:

 -- defines overall characteristics and performance requirements for advanced concepts, and establishes in preliminary designs the basic characteristics of propellant and propulsion subsystems, structural components, and propulsion systems control systems;

 -- develops new techniques for the most accurate and complete description of a system or subsystem;

 -- applies these techniques to the analysis of existing or proposed systems to determine feasibility of new design concept and to refine the choice of characteristics for propulsion and related system performance;

 -- furnishes scientific and engineering advice and directs others in the application of advanced design and analysis techniques.

3. Performs overall systems analysis and integration for a complete complex equipment under development, such as an aircraft, missile, or communication network. Individually or as a member of a team analyzes the ability of assigned equipment to meet the mission and operational requirements. Performs a range of these types of functions:

 -- insures that the subsystems being developed by the various activities are mutually compatible and that feasible advancements to meet these requirements are incorporated;

 -- coordinates the performance of in-house system analyses and evaluation of contractors' analyses to determine the effects that design approach or proposed changes in design criteria will have upon the performance and operational characteristics; e.g., range, accuracy and reliability;

 -- integrates the various subsystem studies into a system analysis report along with recommendations for the approval of the overall design;

 -- initiates and investigates change proposals; determines the effect of these changes on performance, costs and operational requirements; negotiates compromises between conflicting characteristics and features; and prepares recommendations for contractual implementation of changed system engineering requirements;

 -- insures consistent application of technical criteria, development policy, and procedures to avoid repetition of unsatisfactory approaches.

Product Development Engineering-- GS-0800-13 (cont.)

4. As a specialist in an area with broad application (e.g., structural design of aircraft or fluid and flight mechanics for missiles and rockets) initiates, coordinates and controls major studies directed toward development of design criteria or novel items. Projects are of broad scope and complexity and must be resolved into a number of separate coordinated parts in order to accomplish overall objectives. Performs a range of these types of functions:

    -- explores subject-matter area to determine need for research and exploratory development and to define and select specific projects;

    -- determines fundamental and basic approaches, formulates related or subsidiary studies and determines whether to discontinue, continue or extend development projects and studies;

    -- assigns and controls execution of exploratory projects and programs to laboratories, colleges, other government agencies, contractors, etc.;

    -- reviews results and evaluations of others engaged in development projects, defining deficiencies and outlining corrective measures;

    -- advises engineers within the organization, other agencies, and contractors on specific application of design criteria for critical and controversial problems.

Product Development Engineering - GS-0800-14

Assignment characteristics

GS-14 engineers serve as advisors and/or as team leaders in planning, organizing, and directing extensive development efforts for organizations engaged in broad programs of applied research and development. The programs characteristically encompass a variety of functional or discipline areas and are affected intensively by advances in scientific and engineering technology. The work is characterized by problems for which engineering precedents are lacking in areas critical to the overall development effort or program.

GS-14 engineers differ from GS-13 engineers in that at grade GS-14 they serve as expert advisors and provide leadership for broad and complex programs that advance the state of the art. Characteristically, these programs are critical to a wide variety of uses and purposes or a unique mission. Such assignments typically involve the entire development process and may also involve research, production and operational efforts.

Characteristically, GS-14 engineers perform a range of these types of functions:

Product Development Engineering-- GS-0800-14 (cont.)

(a) assess and demonstrate the effectiveness of new concepts and ideas for equipment in achieving particular missions and goals;

(b) evaluate technological trends and establish the more promising approaches for achieving highly significant advancements in operational and mission requirements;

(c) formulate overall design concepts and criteria which establish the baseline for advancement of the state-of-the-art engineering developments;

(d) explore and evaluate advanced proposals to satisfy program and mission objectives and to resolve unusually critical and severe problems;

(e) review and assess overall progress in the development effort and resolve technical difficulties that can be overcome by changes in characteristics, approach, criteria, and requirements;

(f) coordinate the efforts of others who are themselves recognized as technical specialists within the agency, other government agencies and industry pursuing various research and development projects involved in the assignment.

Level of Responsibility

Supervision at this level is primarily concerned with the starting and the stopping of programs. Results of the work are reviewed primarily in terms of the attainment of objectives and impact on other missions and programs. GS-14 engineers have responsibility for converting overall objectives into development programs and policies for others to use. They adjust the broad development activities carried out to the latest advances in technology and to the changing program needs of industry, government, or other groups.

Recommendations for the initiation of new projects and abandonment or extensive alteration of objectives and boundaries of projects are evaluated in terms of the availability of funds, effect on priority and program schedules, availability of manpower, and compatibility with missions and goals of the agency.

Technical aspects of the assignments are worked out individually or with affected groups and are normally final. However, broad program implications are generally called to the attention of the supervisor (or to the project leader or management official when serving as team leader on a large major program).

The scope of the program and the nature and effect of the determinations made by GS-14 engineers necessitate extensive contacts with key officials and engineers of other groups (within the agency, other government agencies, industry, universities, research organizations, and design

Product Development Engineering-- GS-0800-14 (cont.)

agents). Frequently, they serve as spokesmen in high level conferences held to negotiate mutually satisfactory solutions to critical issues affecting agency policy, objectives and missions.

GS-14 engineers have high professional stature and thus obtain the cooperation and help of specialists in other organizations through their own personal contacts and efforts. They frequently serve as symposia chairmen or session chairmen of important technical meetings, and they are often consulted by senior technical specialists in other organizations.

Illustrations

Here are examples of the kinds of work that are done.

1. Plans, organizes and executes mission-related advanced system planning for assigned missions or program areas such as airlift systems, lunar-space exploration, or surface-to-surface guided missiles. Performs a range of these types of functions:

   -- conducts a continuous analysis of present and future capabilities for the assigned area and establishes requirements, ground rules, and assumptions for future programs and initiates changes or reorientation in objectives of programs;

   -- conceives and plans new concepts, methods and techniques which can provide a significant technical or operational impact or breakthrough in the assigned area; advises on and justifies the best feasible approach to be taken for each program recommended;

   -- formulates and recommends specific work requirements, priorities and resource allocations necessary to accomplish the long-range plans for the assigned area;

   -- serves on special agency and interagency committees, coordinating groups, etc., where decisions, commitments and conclusions have considerable impact on the long-range planning and establishment of future research and development programs.

2. As staff engineer to a laboratory or engineering organization, formulates, plans for, and provides engineering management of programs in a broad and complex field (e.g., guidance control and target detection systems, or flight mechanics). Projects and programs are those in which the organization has been assigned primary coordination, exploratory and advanced development responsibility for the agency. Performs a range of these types of functions:

   -- establishes program objectives weighing degrees of urgency against schedules and funding and resolving conflicts between competitive requirements and resources;

   -- utilizes a broad knowledge of specialties within a discipline or field to assure system integrity by establishing compatibility between equipment, other subsystems and components;

Product Development Engineering-- GS-0800-14 (cont.)

-- coordinates with project managers, other laboratories, universities, and user groups in translating operational and mission needs into practical system concepts;

-- directs preparation of plans and assigns scope of work to various components of laboratory and participating agencies such as government laboratories, educational institutions, industrial concerns, and others;

-- accepts work for the activity, allocates work to responsible groups and recommends cancellation, reorientation, or reassignment, as circumstances indicate;

-- investigates and solves problems or resolves conflicts to assure that the project will be completed in timely and professionally competent manner;

-- critiques significance of work, pointing out merit, shortcomings, and accomplishments, and recommends future efforts;

-- serves as expert advisor to agency and other government personnel, as well as contractor and potential contractor personnel in his/her area of professional responsibility, particularly in regard to the feasibility and application of new scientific studies and discoveries for major advances in technology.

3. As a team leader, establishes methods and procedures necessary to accomplish advanced studies for weapon systems, launch vehicles, aircraft, etc., with responsibility for planning the approach, establishing the phasing and timing of the various stages and identifying the objectives. Performs a range of these types of functions:

-- plans assigned system analyses considering areas of engineering specialization required, qualification and availability of scientific and engineering personnel to participate, desired capabilities, current achievements and trends in theoretical approaches for planned systems, and data having direct bearing on future technical and scientific requirements;

-- directs in-house efforts, or, as a technical consultant, advises on the correct approach to the problems, the need for more detailed investigations, the feasibility of new ideas disclosed in studies, and considerations for integration of ideas into the overall system;

-- evaluates all contributions and integrates the recommendations of the team members into a consolidated report, an important portion of which is the identification of critical technical problems and proposed solutions.

4. Plans and coordinates the efforts of a team of engineers engaged in performing system engineering and technical direction for a complex product being developed under contract, e.g., aircraft, missile, launch vehicle, communication net work. Advancing technology in one

Product Development Engineering-- GS-0800-14 (cont.)

or two principal subsystems extensively affects the overall development effort. Performs a range of these types of functions:

-- guides the engineering analyses and studies to define the performance requirements and major operating characteristics;

-- provides expert advice in the evaluation of contractors' proposals in response to request for development proposals;

-- guides the preparation of the technical portion of the system package program and technical analyses of proposed engineering changes;

-- provides overall engineering leadership and coordination to the program during prototype development;

-- assesses progress in all aspects of the engineering program, evaluates the economic and operational effects of technical decisions and advises the project manager, as appropriate;

-- assesses contractors' development efforts and modifies, realigns or redirects this effort.

Product Development Engineering - GS-0800-15

Assignment characteristics

GS-15 assignments are of fundamental significance in establishing overall agency research and development goals and missions.

GS-15 engineers differ from GS-14 in that at the GS-15 level assignments involve these duties:

(1) serving as an authority and consultant in a rapidly evolving field having extensive impact on agency research and development programs; or,

(2) providing overall leadership and direction to pioneering development efforts in achieving new equipments with previously unattainable capabilities and characteristics.

Assignments have a major impact on the agency research efforts and future operations as well as throughout the development process. Characteristically, GS-15 engineers perform a range of these types of functions:

(a) formulate and define overall mission and program objectives and requirements;

Product Development Engineering-- GS0-800-15 (cont.)

(b) initially explore and establish the fundamental value of new technology and identify the most fruitful approaches for costly and unprecedented development programs;

(c) present and support to the highest levels of management proposals and programs for pioneering research and development efforts;

(d) evaluate, on a continuing basis, performance of governmental and industry organizations pursuing program objectives, particularly as they relate to efforts requiring breakthroughs or involving highly controversial objectives;

(e) determine the effect of unforeseen developments and difficulties on overall plans and programs, and formulate and issue directives to redirect programs;

(f) provide authoritative advice at the highest levels of management within and outside of the agency on matters of exceptional importance or of far-reaching consequence to agency primary programs and missions;

(g) represent the agency on committees and in meetings as recognized authority;

(h) integrate and coordinate the efforts of others who are themselves experts within the agency, other government agencies and industry pursuing research, development and engineering projects involved in his/her assignment.

Level of Responsibility

Within the framework of agency policy, mission objectives, and time and fund limitations, GS-15 engineers are free to plan and execute their assignments. They are recognized as final technical authorities in their areas of responsibilities. Work is viewed in terms of the fulfillment of program objectives, effect of their advice and influence on the overall program of the agency and of their contribution to the advancement of technology.

They provide authoritative advice to the highest levels within the agency concerning matters of fundamental significance in establishing mission objectives and overall program goals and in managing highly advanced and important development projects.

GS-15 engineers differ from GS-14 engineers in that they typically have responsibility for evaluating the effect of significant technological change on fundamental policies, objectives and goals. They provide engineering advice and guidance to agency managers on matters of such difficulty that leading experts disagree as to the proper approach to or probable outcome of significant and far-reaching development efforts.

Product Development Engineering-- GS0-800-15 (cont.)

Illustrations

1. Provides engineering leadership, coordination and evaluation for a broad subject-matter area (e.g., propulsion and power) for untried and extensive development programs. This involves application of the most advanced concepts based on technological breakthroughs for which

   simulation tech-knacks, experiments, and/or laboratory tests are unfeasible or inconclusive. Performs a range of these types of functions:

   -- establishes long-range program objectives and requirements;

   -- identifies and describes the technical direction the program must take to provide a useful reliable end product;

   -- defines financial support requirements, proposed schedules and management support needed;

   -- continuously evaluates performance of organizations involved in meeting program objectives;

   -- represents the program to members of scientific and technical community;

   -- reports on program accomplishment to highest levels of management, justifying and supporting crucial and far reaching program changes.

2. Provides overall technical direction, systems engineering and coordination for a major, complex development program for which advanced concepts are utilized based on new technological developments in several principal subsystems, (e.g., airframes, propulsion, guidance and control). Performs a range of these types of functions:

   -- serves as the principal engineering advisor to all levels of management, contractors and their activities and coordinates the overall engineering effort required throughout the development process;

   -- guides initial exploration to define concepts and identify critical development problem areas;

   -- evaluates relative value, technical risk, and feasibility of proposed development approaches;

   -- redirects program plans and approaches to overcome critical, unforeseen difficulties and unsatisfactory results;

Product Development Engineering-- GS0-800-15 (cont.)

-- provides authoritative technical advice to the highest levels of agency management on matters of exceptional importance in the continuation or abandoning of objectives, goals, and programs.

PART II -- PROJECT MANAGEMENT ENGINEERING -- GS-0800

COVERAGE

Part II of the Development Engineering Grade-Evaluation Guide covers positions of engineers who manage the combined efforts of contractors and Government to accomplish a specific development project. Engineers in these positions report to a Project Manager who plans, directs, and controls a designated development project with full authority to allocate agency resources to accomplish the project within a set time.

The context within which these engineers function differs from project engineering of the type covered in part I. In evaluating these positions covered in part II it is necessary to consider the unusual scope of responsibilities and authority vested in Project Managers for these major development projects.

This guide applies to engineering positions which are under Project Managers who have responsibility for managing a project for development of a specific end product (e.g., aircraft, missile, space launch vehicle, spacecraft, communication network, etc.). However, some Project Managers also have responsibility for accomplishing the operational mission for which the end product is developed, such as in some space exploration areas. This guide applies to those engineering positions directly concerned with managing the development of the equipment for such projects.

The engineering positions to which this guide applies manage the development engineering work for Project Managers whose authority and responsibilities satisfy the following criteria.

1. The Project Manager has overall agency responsibility for the particular development program including its phasing out. Thus, this project effort is of temporary duration, albeit a period of a few years.

2. The Project Manager is responsible for managing the definition, prototype design, testing and evaluation phases of the development effort. However, Project Managers may retain responsibility for the project through early production runs, or until the product has been accepted by the using organization, or for the operational mission of the project.

Coverage (cont.)

3. The Project Manager exercises centralized authority and control over the management of resources such as funds, contracts, priorities, schedules, personnel, and facilities.

4. The Project Manager has the authority to direct and control the work performed by the various organizations of the agency in support of the project. In general, Project Managers do not have sufficient staff to perform the total engineering work required. Consequently, they must utilize the services of engineers in other organizations who are engaged in continuing programs for research and development (e.g., control and guidance systems, engines, structures, power supply, etc.).

EXCLUSIONS

This guide does not apply to the following positions.

1. Project Managers. This guide does not encompass the total project management functions and therefore does not reflect the usual full range of duties and responsibilities of the project manager. The guide applies specifically to the development engineering functions.

2. Engineers who develop and administer headquarters guidelines and controls for execution of development projects by project managers.

3. Positions of engineers in project management offices who perform other than the typical development management functions, or who are concerned *primarily* with other engineering functions (e.g., research, maintenance, production). For instance, an engineer may be concerned primarily with the development of fuel cells £or auxiliary power or serve as a specialist for production or structural design problems, etc. Situations may also exist where the services of an expert in a highly specialized field may be needed on the staff to serve as a consultant and adviser and not as a manager. Such positions should be evaluated by part I of this guide, or other appropriate standards.

4. Engineers performing the detailed engineering tasks involved in prescribing requirements, characteristics and criteria, and in technically directing and evaluating contractors' and others' development efforts. These engineers are often detailed to or co-located with the project office as needed. Such positions should be evaluated by part I of this guide, or other appropriate standards.

PROJECT MANAGEMENT FUNCTIONS

Project Management Engineers manage the combined effort of contractors and Government agencies in support of the development project to assure that the end product meets established cost, schedule and performance requirements. Typically, the Project Management Engineer's responsibilities include the following functions:

-- participate with key personnel in his/her and other agencies who are responsible for defining the goals for the project, and work with them in preparing a master plan for accomplishing these goals;

-- prepare engineering and support cost estimates to achieve the goals of the master plan;

-- prepare schedules for the complete project and establish a system to review, control and report on project status;

-- negotiate with other organizations of the agency and other Government agencies for research, design, test and other services as necessary:

-- determine what phases of the project will be performed by contractors; and participate in the review of bids, contractor's proposals, contract specifications, etc.;

-- participate in design reviews, contract negotiations and technical and business discussions with contractors;

-- review and assess the effectiveness of contractors in meeting the technical and administrative requirements of the contract;

-- monitor project reviews and, based on these reviews, readjust money, schedules, and work for accomplishing the project;

-- resolve any relationship problems or conflicts that impede progress; insure that contractor and Government staffs work effectively toward timely completion of projects.

For simplicity in wording, the term "manages" is used generically throughout to include the functions of planning, organizing, controlling, coordinating, reviewing, and approving the development engineering work performed by others.

QUALIFICATIONS

Professional competence in an engineering field is essential in these positions. Breadth and intensity of knowledge and abilities required may vary depending upon the scope and technical

Qualifications (cont.)

complexity of the assignment. However, the entire process of "managing" a development effort is rooted in an understanding of (a) the basic engineering and scientific theories, principles, and limitations therein, (b) the methods, practices, and techniques of development design, and (c) the criteria, premises, and characteristics underlying the use, functioning, and purposes of engineered products.

It is not necessary that an engineer-manager be competent to investigate personally all problems, or to perform the research, design, or test functions. The engineer must have sufficient knowledge, however, to judge the relative value to be gained from further experimentation. He/she must also appreciate the difficulties and risks involved in relying upon unproven theories or approaches which have not been used in similar applications, or in making compromises in performance requirements and design features. It is frequently just as important for the engineer to determine that proven hardware, techniques, and processes should be used as to explore new approaches.

As a minimum, positions covered by this guide require the following knowledge and abilities:

- knowledge of the basic techniques, processes and procedures established within the agency for managing designated projects, and the ability and willingness to use them:

- knowledge of Government and agency contractual and funding rules, regulations, relationships and administrative processes involved in developing and procuring hardware, research, studies, engineering services;

- knowledge of the objectives of the project and its relation to the total program, and the corollary knowledge of environmental conditions, uses, required characteristics and features, human factors, and similar considerations;

- knowledge of the overall development cycle and processes, and the subsequent testing and evaluation processes involved in acceptance of a product;

- knowledge of the scientific and engineering fields involved and the type and nature of work being pursued in advancing the state of the art;

- ability to plan and organize the work to accomplish a variety of concurrent activities performed in a variety of organizations (in-house, contractors, other agencies, task forces, study groups);

- ability to analyze situations, identify problems, probe causes, and suggest courses of action for technical and functional specialists to pursue;

Qualifications (cont.)

- -- ability to accomplish work effectively through others, to maintain harmonious relationships among all parties, to achieve appropriate and timely support, and to reconcile divergent viewpoints;

- -- ability to gauge the effort required to the situation at hand, to be selective in what to do and how to proceed, and to recognize the resulting impact in terms of schedule, costs, risks involved, tradeoffs necessary, etc.;

- -- ability to communicate effectively in writing and in person to-person contacts.

NOTES ON USE OF PART II

A lower limit to the level of positions covered by part II of this guide has been set at GS-12. As a prerequisite to evaluation by means of part II, positions must operate at the level of responsibility described at the minimum level for each factor.

Positions at and below GS-11 typically do not involve the significant responsibilities inherent in managing the engineering aspects of a project, nor do they require the full scope of the knowledge and abilities described in the preceding qualifications section.

EVALUATION PLAN

The evaluation of development engineering positions in this part is based upon four interrelated factors, I, Scope of the Assignment; II, Technical Complexity of the Assignment; III, Authority and Responsibility; and, IV, Technical and Managerial Demands.

The ranges in these factors relate to the specific nature of the assignments *in individual positions* and not to the nature of the development project as a whole.

Each of the four primary factors which must be evaluated has a very wide degree range. To serve as key points for evaluating each factor as it applies to a particular position, three degrees--A, C, and E--with point values of 2, 6, and 10, respectively, are defined in the degree definitions below. Definitions are not included for intermediate degrees B and D, with point values 4 and 8, respectively. However, degrees B and D and their point values are an integral part of the plan, and are to be used when an element is determined to fall between the defined degrees.

Factor I --Scope of Assignment

This factor deals with the scope of the assignment as it relates to the development of a specific end-product (e.g., an aircraft, a missile, or a communication network).

Factor 1– Scope of Assignment (cont.)

The scope of the assignment directly reflects the level of difficulty and responsibility an engineer encounters in performing these tasks:

(a) defining technical requirements and characteristics; and,

(b) planning and coordinating the various facets of the assignment to achieve an acceptable product on time within a specified budget.

Degree A (2 points): Assignments involve a major subject matter or functional area consisting of a variety of equipment systems performing various functions and purposes. These areas are mutually interdependent and represent a homogeneous grouping for which similar knowledge,

skills, processes and techniques are applicable. Typically, the assignment involves the participation of several contractors and in-house groups pursuing different portions of the development activities. Here are some typical illustrations:

(1) propulsion and power system of an aircraft;

(2) guidance and control systems including an inertial platform of a guided missile;

(3) ground support equipment for a space launch vehicle.

Degree C (6 points): Assignments differ from Degree A in that they involve a wide range of independent activities or broad critical areas of concern. Engineers may manage the major elements of the project as they relate to a specific function, or manage the various phases of the development effort for several major subject-matter areas of the project.

This degree is represented by a wide variety of combinations of elements and functions, and those areas that may be critical in achieving acceptable performance. Here are some typical examples of such assignments:

(1) overall system analyses and integration for a communications network project;

(2) integration of such program elements as the airframe, propulsion and power, and flight control and navigation for an aircraft project;

(3) analyses of factors critical in achieving reliability in design concept and quality of materials, etc., for a spacecraft project; or,

(4) integration of such program elements as guidance and control, airframe, and warhead of a missile.

Factor 1– Scope of Assignment (cont.)

Degree E (10 points): Degree E differs from Degree C in that assignments involve managing overall development efforts.

In projects involving development of a specific end product (e.g., aircraft or missile or communication network) this degree is represented by the position of the Chief Engineer for the project.

For projects involving several different end products which are not separately managed or the accomplishment of operational missions, this degree is represented by positions responsible for major subject-matter entities of extensive scope and variety, such as all electronic and electrical systems for a variety of manned spacecraft.

Factor II --Technical Complexity of the Assignment

This factor deals with the degree of complexity introduced by the technical environment and requirements of the product. The technical complexity or level of technology used affects the kind and level of technical judgment and variety of knowledge required for these types of activities:

(a) formulating approaches;

(b) guiding, directing and evaluating the efforts of others;

(c) solving problems, and resolving controversies;

(d) selecting among alternative courses of action;

(e) achieving compromises among conflicting requirements;

(f) controlling schedules and costs, and redirecting nonproductive efforts.

Technical complexity may differ significantly from product to product depending on such elements as the number of variables to be considered, the preciseness of techniques and processes available to examine data and solve problems, the number and variety of interrelationships and their effects, and the difficulties involved in application of science and technology to a given product.

Degree A (2 points): Assignments involve the modification, adaptation and extension of engineering principles and guidelines which are within the available technology. At this degree, assignments represent the next logical development step in the improvement of products based on explored and exploited knowledge. A variety of technological problems require engineering compromises and changes in various performance and design aspects of the equipment and

Factor II --Technical Complexity of the Assignment

engineering processes involved to achieve greater efficiency and reliability and enhanced capabilities.

Degree C (6 points): Degree C differs from Degree A in that assignments require the application of engineering and scientific principles to technical problems in significant areas of applied research or development for which no closely related precedents exist. Engineering requirements relate to the application of design principles from any engineering area to new developments that are considered to be within the state of the art. Some major portions or critical areas of the assignment require application of new concepts and approaches to capitalize on engineering knowledge of advanced science or technology. However, the essential application normally involves managing development efforts within available or near available technology rather than beyond the state of the art.

Degree E (10 points): Degree E differs from Degree C in that assignments involve rapidly advancing technology and science for which application has been primarily confined to laboratory simulation and study. These efforts provide approaches and concepts for new and novel products which are largely unproven and for which feasibility must be established. This level represents a pioneering effort or one for which significant technological breakthroughs and advances in the basic theoretical premises are being sought. The successful solution of the assignments' technical problems will have wide application for future development programs.

Factor III --Responsibility and Authority

This factor relates to the degree of freedom and the extent of accountability which the engineer has within the overall organizational framework involved in the project.

There is a common core of management work inherent in all positions covered by this guide. However, the manner in which the work is organized and the nature of external relationships will affect the degree of authority in any individual position. The degree of authority and accountability delegated to individual positions are affected by these types of considerations:

- -- the criticality of the assignment to the overall project or mission;
- -- interrelationships among assignments;
- -- sharing of responsibility with other participating organizations;
- -- authority and responsibility vested in review boards and panels;
- -- legal aspects and restrictions;
- -- the reliance placed on the engineer because of his/her professional stature;

Factor III --Responsibility and Authority (cont.)

-- terms of contracts with contractors and among contractors;

-- layering of review and control in the Project Management Office.

For positions covered by this guide, assignments are given in terms of major objectives to be attained along with available background information, pertinent data, and prior program decisions. All of these provide a framework within which the particular assignment is carried out. Major plans and programming decisions which establish long-range courses of action or are of critical importance in the program are normally reviewed by the highest level of management within the office in order to provide coordination among all aspects of project management responsibilities (i.e., program control, documentation, tests, mission objectives, production planning, total funding, etc.). Day-to-day actions and decisions relating to detailed plans, work methods, procedures, and coordination are usually unreviewed, except as the engineer recognizes the need to keep others informed.

Regularly scheduled project reviews are one of the essential management techniques used to achieve integration across program lines, to maintain engineering activities on schedule, to

control costs, etc. Engineers develop plans for and make written and oral presentations on program status, technical problems encountered, obstacles to be overcome, scheduling, and costs. They arrange for presentation by others (e.g., contractors, laboratories, expert advisors) and participate in program reviews for related portions of the project.

Degree A (2 points): Engineers primarily have responsibility for assessing progress and maintaining liaison between the various activities engaged in the engineering work involved in his/her particular assignment.

The engineer provides an effective channel for obtaining and relaying information between participants and insuring that good engineering practices are being pursued, that schedules are being maintained, and that difficulties which create bottlenecks and problems are being brought to proper source attention. Here are some typical responsibilities:

-- ascertaining that plans are being carried out, schedules maintained, and documentation accomplished;

-- ascertaining that problems and difficulties are being identified and steps are being taken to investigate and seek resolutions;

-- investigating and recommending appropriate action to higher project authority concerning the need to redirect efforts, to pursue additional lines of investigation, to make major compromises on previously established product requirements, to accept cost overruns, and other similar matters;

Factor III --Responsibility and Authority (cont.)

-- reporting project status and providing background information as needed;

-- interpreting agency and project procedures and requirements to others.

Degree C (6 points): Degree C differs from Degree A in that the engineer has responsibility for managing and concluding action involved in the various functions and processes to achieve the specified goals and objectives of his/her assignment. The administrative framework involved in accomplishing overall project goals has been established by higher authority. This includes overall basic patterns of organization, delegation of authority and responsibility, operating policies and procedures, long-range plans and patterns of resources allocations.

Within this framework, the engineer is delegated responsibility and authority for day-to-day activities and decisions. He/she is relied upon to provide continuity of management throughout all phases of the development process. Here are some typical responsibilities:

-- achieving appropriate staffing levels to accomplish the engineering work, i.e., obtaining support from in-house organizations, "buying" engineering services, insuring that the contractor carries out work efficiently and effectively, etc.;

-- making intermediate and short-range plans;

-- allocating resources at his/her disposal;

-- resolving problems involving his/her assignment;

-- presenting, defending and interpreting to top officials in Government and contractor activities those policy and program aspects involved in his/her assigned area.

Degree E (10 points): Degree E differs from Degree C in that full reliance is placed by the project manager or higher authority on the engineer as a recognized management authority in overall program definition, organization, direction and emphasis throughout the development cycle. Here are some typical responsibilities:

-- making substantial contributions to the project in establishing overall operating policies, priorities, procedures and long and short-range plans.

-- exercising broad authority regarding programming of effort, delegation of authority and responsibility, allocation of overall resources, insuring of functional support, approval of critical actions and changes, and continuing managerial appraisal of progress coupled with authority to require appropriate corrective actions;

-- serving as an authoritative source for decisions and guidance concerning compromises and changes in program objectives relating to management of the total project effort.

Factor III --Responsibility and Authority (cont.)

Such determinations are reviewed for the purpose of keeping higher levels of management informed on the status of the project.

Factor IV--Technical and Managerial Demands

This factor is concerned with the degree of technical and managerial knowledge and abilities, mature judgment and leadership qualities required and applied in positions covered by this standard.

Project management has been termed by some as the "art of managing the possible." However, what is possible is not always feasible or practical within the constraints imposed by objectives, operating conditions, schedules and cost framework.

A number of elements operate to differentiate the degree of difficulty imposed by technical and managerial demands affecting an assignment. Here are some such elements:

(a) the extent to which the engineer provides leadership to the agency, participating organizations, contractors, and others in creating and proving feasibility of concepts, in defining requirements, and in directing and controlling the development efforts; and,

(b) the extent to which there are conflicting pressures and requirements, and resulting controversies or difficulties in overcoming them; and

(c) the relative impact of the project on the public, industry, and Government functions; and the degree of interest (or lack thereof) in accomplishment; and,

(d) the relative urgency and importance to other programs and missions; and,

(e) the relative scope, complexity, novelty, and technical risks involved in the development effort; and,

(f) the relative number, size and nature of involvement throughout the agency and the magnitude and uniqueness of agency and contractor effort required; and,

(g) nature and extent of participation with international and other governmental entities, and the resulting complexities and difficulties imposed thereby.

There are aspects of these elements in all project management assignments. Thus, the fact that an assignment involves a large number of activities, a new product or other government agencies will not serve to measure this factor. For instance, participation of other governments may reflect a “buy in” which introduces few additional problems. Similarly, technical complexity or novelty does not necessarily place significant technical and managerial demands beyond those required to coordinate a range of functions and specialties in a well-understood field.

Factor IV--Technical and Managerial Demands (cont.)

The common core of activities and basic responsibilities involved in managing development efforts covered by this guide requires as a minimum the knowledge and abilities described in the *Qualifications* section.

Degree A (2 *points):* Technical and managerial demands stem from the difficulties typically encountered in coordinating a range of functions, subject matter, and development processes involved in achieving improved products. The practices, procedures and techniques involved in managing are applied to these types of complexities:

-- assignments normally comprise a wide variety of concurrent activities; deviations from the customary engineering practices and processes are susceptible of partial substantiation before major resources are allotted, or alternative approaches can be undertaken concurrently;

-- design criteria, engineering specifications, precedent designs, and simulation techniques are generally available and may be adapted, modified, or extended to provide a basis for management planning and evaluation and making engineering determinations;

-- when advanced or new techniques, technology, processes, and equipment are used, they can be assessed by known methods and procedures; similarly, the time and cost schedule

can be adjusted to permit analysis and investigation on which to base design assumptions and management decisions;

-- program changes and engineering compromises are frequent, since any change in design may cause changes throughout the system; such compromises involve (a) investigating various alternatives, (b) obtaining opinion of experts when data are inadequate, and (c) reconciling inconsistencies;

-- at this level the urgency interest and impact of the work arises from the necessity to meet tight schedules among many interlocking areas to assure timely development within the specified cost.

Degree C (6 points): This degree differs from Degree A in that a variety of unusual factors, pressures, and complexities create a technical and managerial situation that results in a substantial element of uncertainty and risk as to the foreseeable outcome of the development efforts.

Typically, substantial uncertainty and risk may arise when the assignment is extensively affected by advances in technology. Similarly, a high degree of uncertainty and risk may be encountered when the technical objectives to be achieved are largely undefined in complex areas of concern. These technical and managerial demands require the engineer to provide direct leadership in bringing complex innovations to fruition and in resolving critical difficulties.

Factor IV--Technical and Managerial Demands (cont.)

-- The assignment presents a dynamic situation in regard to planning and organizing the work to be accomplished. Some activities are pursued in the usual manner following established precedents and processes. However, vital aspects of the assignment present a clear-cut need to carry-out these responsibilities:

(a) develop new approaches to problems;

(b) use unusual and unorthodox methods; and,

(c) plan and pursue alternative courses of action both at the outset and throughout the development cycle.

-- When international groups and other agencies are actively participating, problems and difficulties reflected in the management processes arise primarily as a result of different practices, procedures, and methods. These differences pose obstacles throughout the development process. Negotiation is required to work out acceptable and compatible practices and procedures.

-- Positive pressures to achieve specified and rigorous goals exist because of the criticalness of the assignment to major objectives of projects, or the impact on the public or on other programs. These and similar circumstances require competent technical judgment and managerial skill. The successful accomplishment is also critical in that it provides essential building blocks and knowledge for future programs, purposes and missions.

-- Management difficulties exist because of the large number of independent participants involved (organizational segments, other agencies, contractors). These participants have varied interests, viewpoints, purposes and practices which must be considered, integrated and satisfied. Other difficulties may arise because of conditions which inhibit the communication of information to other contractors, or among participants.

-- Gaps in knowledge and know-how in the application of technology cause difficulties throughout the development cycle. Skillful technical and managerial ability is required to winnow out the salient features and to guide others in the analysis, evaluation and resolution of problems. These difficulties call for continual reprogramming and readjusting of schedules, funds, facilities, participation, etc. Such circumstances require making compromises which frequently may not be readily accepted or fully satisfactory to others or in meeting requirements. For instance, when the outcome is uncertain any compromise made may present further management difficulties because of the divergence of viewpoints among competent technical specialists within the agency, between contractors, or between the agency and the contractor.

Factor IV--Technical and Managerial Demands (cont.)

Degree E (10 points): Degree E differs from Degree C in that the successful outcome of the total development effort is jeopardized by a variety of exceptionally difficult and complex factors. These factors impose a clear requirement for creative leadership and outstanding managerial competence throughout the development process. Typically, the technical and managerial demands require the direct authoritative participation of the engineer in organizing and controlling the effort to establish (a) the feasibility of various concepts, and (b) the means by which to achieve advancements beyond the state of the art.

Situations which create a necessity for the exercise of extensive managerial skills, mature technical judgment, and creative leadership result from an interplay of most of the following typical factors.

- The assignment requires that primary project direction and coordination be exercised by the engineer rather than the contractor. This situation frequently exists because the development activities are fragmented among many internal and external organizations. Accomplishment is further complicated by the wide coverage, diversity, and specialization of subject matter, functions, and processes.

- The assignment involves managing activities in which requirements and processes of participating Government agencies, organizations, or foreign governments are conflicting, incompatible, or undefined. The reconciliation of such complexities involves effecting major compromises and concessions among the participants.

- Factors of urgency exist to such an extent that the development processes are greatly telescoped. A high degree of resourcefulness is required to meet the restrictive time factors, which are usually accompanied by equally stringent cost factors. This requires recommending or taking action which involves considerable risk and may jeopardize the satisfactory outcome of the assignment and, in turn, major programs and purposes.

- Significant major advancements in technology, new theoretical premises and/or breakthroughs to achieve project objectives are being independently pursued by various contractors and activities. While these contractors and activities may be grouped under a few prime contractors, problems are so critical to the successful outcome and the action so interdependent that the engineer must constantly determine the appropriate course of action and acquiesce in the approaches being used in order to achieve an integrated product.

- The newness of the development effort (previously untried) or the conflicting nature of requirements and objectives (when there is no acceptable alternative to the successful accomplishment of the assignment) requires outstanding leadership to achieve a productive, competent, and creative climate. Typically, the engineer is required to carry-out these responsibilities:

Factor IV--Technical and Managerial Demands (cont.)

(a) challenge leading authorities to undertake problems posing major obstacles;

(b) convince top management of the organization, contractors and other participants of the justification for abandoning major investments and pursuing new approaches, for investing substantially additional resources (funds, talent and time), and for accepting alternative which may change major objectives;

(c) build a creative alliance in resolving technical and managerial problems of exceptional difficulty.

GRADE LEVELS

Grade levels for positions classified by this guide are obtained by conversion of the total point value assigned for the four factors. Each factor has a range of five degrees, A through E, with point values of 2, 4, 6, 8, 10, respectively. Intermediate odd point values should not be assigned. However, additional points may be assigned whenever (albeit rarely) a factor exceeds degree E. Only degrees A, C and E are defined in this guide. However, degrees B and D and their point values are an integral part of the plan, and are to be used when an element is determined to fall between the defined degrees. Because of the numerous organizational and other circumstances possible, no attempt is made to describe the situations which could result in use of degrees B and D.

GRADE LEVEL CONVERSION TABLE

Total of combinations of factor points	Grade level
8--12	GS-12
16--22	GS-13
26--32	GS-14
36 and above	GS-15

Total points resulting from a number of the possible combinations fall between the ranges in the conversion table. The determination as to whether to convert to the next lower or the next higher grade should be based on application of general classification principles, with consideration of (a) the relative weakness or strength of the position compared to other positions in the organization, and (b) aspects of the position which may not have been fully covered in arriving at the point values.

PART III - EXPERIMENTAL DEVELOPMENT

COVERAGE

This part of the guide is to be used in the grade evaluation of professional engineering and scientific positions at GS-09 and above where the incumbents personally perform experimental and investigative activities to develop new and improved equipment and to advance technology.

Positions covered by this part involve a range of development processes consisting of theoretical analysis, experimentation and evaluation. These positions require:

- -- thorough grounding in the theories, principles and practices of the physical and engineering sciences; and,
- -- ability to use scientific techniques and methods to analyze, measure, and evaluate the properties and characteristics of phenomena, materials, equipment and processes.

Experimental development work may occur in any of the five phases of development as described in the Introduction to this guide. However, experimental development work is more common to the Definition and the Prototype Design phases of the development process.

Part III applies to experimental development positions in the *physical sciences* as well as the various engineering fields. This guide should be used for positions in such occupations as the General Physical Sciences Series, GS-1301, and the Physics Series, GS-1310, concerned with these duties:

- -- development of instrumentation, techniques, processes, materials, and equipment; and,
- -- investigation of physical and natural phenomena to establish performance requirements and design criteria for equipment.

This guide supersedes the grade-level criteria of existing standards for positions engaged in the kind of experimental development work in the engineering and physical sciences occupations described in this part.

RELATIONSHIP BETWEEN RESEARCH AND DEVELOPMENT

There can be no hard and fast line of demarcation drawn between applied research and experimental development. Both types of positions are commonly found in a laboratory setting. Both types of work involve the personal performance of experimental and investigative work processes. Both types of work typically require considerable theoretical analysis to establish

Relationship between research and development (cont.)

hypotheses on which to base assumptions and their validation by experimental methods, particularly at the GS-12 level and above.

Like research, development is a creative process. But the primary focus of development is the continuous exploitation of basic scientific knowledge to yield a product, process, or technique. Notwithstanding these similarities, the differences in various aspects of research and experimental development work require differences in the language and criteria for determining grade levels. While necessarily oversimplified, some of the more critical differences between research and experimental development are cited below:

	Research	**Development**
Purpose:	Extension of knowledge and understanding	Evolving of new or improved products, processes, and techniques
Assignments:	Relative freedom of choice to explore most fruitful areas in relation to the agency's program and gaps in knowledge in a given field with relative inability to predict the outcome or success.	Problems to be solved are assigned or may stem from a purpose to exploit new and existing understanding of phenomena and principles.
Results:	Publication and papers are aimed at: (a) producing theories, principles, and explanations of phenomena; and (b) the dissemination of information about techniques and processes by which understanding is achieved.	Products are: (a) papers describing application of theories, principles, etc.; (b) design concepts, criteria and data; (c) laboratory, fabrication techniques and processes; (d) laboratory and prototype models, simulations, breadboards, etc.; (e) patents and inventions.

EXCLUSIONS FROM COVERAGE

Positions in development organizations are excluded from coverage of part III of this guide when they are engaged in the following types of work:

-- planning, directing, evaluating and integrating others' (e.g., contractors, in-house, etc.) work in developing new equipment and concepts;

-- serving as staff consultants or advisors, while not personally engaged in experimental development work;

Exclusions from coverage (cont.)

-- managing the combined efforts of contractors and Government to accomplish a specific development project;

-- engaged primarily in basic and applied research;

-- engaged primarily in supervision of experimental development engineering work;[1]

-- engaged in duties concerned with the conventional design of equipment including the redesign of development prototypes for production and manufacture, which can be accomplished by applying or adapting standard references, criteria and practices;

-- concerned primarily with the conduct and reporting of tests.

FACTORS FOR EVALUATING EXPERIMENTAL DEVELOPMENT POSITIONS

The specifics of subject matter dealt with vary according to the scientific or engineering field involved. However, grade levels of development positions have been found to depend on essentially the same elements, regardless of subject field. In this guide, these common elements have been grouped into the following four factors (which parallel those in the Research Grade Evaluation Guide):

I. Nature of the Assignment;

II. Supervision Received;

III. Guidelines and Originality; and,

IV. Qualifications and Contributions.

For these positions which depend so heavily on background and innovation of the incumbent, Factor IV, Qualifications and Contributions, is double weighted both (1) to reflect its importance and (2) offset what would otherwise be a disproportionate orientation toward the assignment and work situation in the other factors. It is recognized that these factors overlap. However, each is

[1] *Note:* In the laboratory situation, team leadership or supervision of a small unit is commonly based on and carried by personal competence in planning and conducting experimental and investigative activities rather than on supervisory and administrative skill. Consequently, this guide should be used for such positions. For supervisory positions in which marked supervisory and administrative ability in addition to research and development competencies required, the General Schedule Supervisory Guide should be used.

Factors for evaluating experimental development positions (cont.)

focused on a different aspect of the job-incumbent relationship. By considering and rating them separately, greater precision and a greater degree of consistency can be obtained in the final evaluations than would be possible if a single overall evaluation were made.

Factor I--Nature of the Assignment

This factor deals with the nature, scope and characteristics of current work being undertaken by the incumbent. In the case of a team leader, a level should be credited which reflects the scope and character of projects being conducted by his/her team. In the case of a team member, the level should be based not on the total projects carried by the team, but upon *the specific projects, or portion of the team,* carried by the incumbent.

A basic premise in the treatment of this factor is that individuals at all degree levels *personally* plan and conduct work involving *experimental* processes. Characteristically, assignments are stated as scientific and engineering problems to be solved. Their solution entails an interplay among theoretical analysis, experimentation, investigation and evaluation.

The variety and intensity of knowledge required to achieve problem solutions are affected by such items as: the scope of the problem, the depth of investigation required, and the difficulty involved in overcoming obstacles. The elements to be considered in the assignment are: (1) its scope and complexity, (2) the objectives, (3) the means available for accomplishment, and (4) the expected end results.

The degree levels for this factor reflect the degree to which a problem has been isolated and defined. If both the exact cause and location of a problem are known when an assignment is made, the problem is typically less complex than a problem which is isolated (located) but not defined (cause unknown). A problem is relatively simple when it is both isolated and defined well enough to proceed with little need to consider alternatives. When the problem has not been isolated, the objectives are typically unrefined and the engineer must determine what he/she is attempting to solve before initiating any action.

A corollary factor influencing complexity is the number and nature of variables or elements involved. Other things being equal, the greater the number and complexity of influence and considerations involved, the harder the problem task will be.

The scope, complexity, and degree of skill will also vary depending upon the difficulty of the approach or techniques involved. This difficulty may be reflected in various ways, such as the intrinsic difficulty of techniques themselves or by the newness or unusualness of techniques.

For example, when little is known about a technique, the scope of the investigation may need to be broadened to verify the technique itself as well as the results obtained by its use.

Factor I--Nature of the Assignment (cont.)

Another facet influencing the scope and complexity of assignments is the number of problems involved in an assignment. Since problems within an assignment are almost always related, the complexity increases as the number of problems grows. The availability of the technological information on how to attack and solve the problems also affects complexity. If such information does not exist, then the employee must formulate the approach himself.

In considering the expected end product of the development effort, the impact of the results on scientific theory and engineering practice may be of significance. Also important are these considerations:

- -- the extent and complexity of the validating processes;
- -- the necessity for converting abstract concepts into hardware or into easily understood statements of theory; and,
- -- the effectiveness of the product in solving other problems and in opening new areas of investigation.

Factor II--Supervision Received

This factor deals with the supervisory guidance and control exercised over the position. Much care is required to evaluate this factor. In experimental development a considerable amount of effective supervision may exist with only a minimum of formal supervisory contact. On the other hand, consultation with colleagues is essential to maximum effectiveness of employees at all levels, and should be distinguished from supervision.

The effect of controls upon the position may be measured by the incumbent's freedom for determining the course of action, and the degree of finality of his/her recommendations and decisions. The manner in which the engineer receives assignments, the opportunity for procedural innovation, and the degree of acceptance of the final product should also be considered.

Factor III --Guidelines and Originality

This factor reflects the degree to which (1) guidelines are available and useful and (2) innovations in concepts, methods and interpretations are involved in the assignment.

Guidelines usually consist of such information sources as technical handbooks, periodicals, reports, patent disclosures and discussions with colleagues. In experimental development work such information sources characteristically are inadequate in some respects.

The degree of technical judgment, intuition and insight required to fill in, adapt or extend theories, methods and techniques can vary widely. For example, an engineer with little experience can adapt a new technique or use new theory when the application and results are similar to existing ones. On the other hand, considerable technical judgment may be required to apply existing techniques or theories when their use is risky and the results are inconclusive.

Factor III—Guidelines and Originality (cont.)

Some problems are so well understood and approaches so well defined that there is little opportunity afforded for introducing compromises and innovations. In other instances considerably more technical insight and creative effort may be required to identify a problem than to achieve its solution once understood.

Factor IV--Qualifications and Contributions

Unlike the other factors this factor is not restricted to present and immediate past job performance. It is intended to focus on the total qualifications, professional standing and recognition and scientific contributions of the incumbent, as these bear on the dimensions of the current assignments and work performance. Particular care must be observed to consider only those features of the factor that have a significant impact on the job.

The degrees of Factor IV are expressed in part in terms of contributions and recognition in a specialized field. In some situations, security regulations or other circumstances prevent publication of development results. Thus, it may be impossible to evaluate the work on the basis of its impact on the larger engineering and scientific community. In such cases, the work must be evaluated by means of the best possible judgment of its importance and the impact it has as a technological or development accomplishment for a specific project or program. In some cases, there may be impact on the agency's overall development program or mission.

The quality and scientific significance of innovations, reports, and publications, and especially the number of such quality contributions are of primary significance. Undue emphasis should not be accorded to mere numbers of contributions, without evaluation as to their direct or indirect impact on the field of work involved.

The consistency and recency of quality contributions as they bear on critical technical obstacles impeding advancements in the field are important at the higher levels. Other elements of significance may be the difficulty of circumstances under which contributions were achieved and the ability to improvise and change plans quickly (e.g., to capitalize on unexpected events, or to salvage important information from an expensive set of experiments which would otherwise be a total loss).

Positions of the type covered by this guide are characterized by a continuing personal struggle to keep abreast of rapidly advancing and changing disciplines. In resolving borderline determinations of degrees of this factor, consideration should be given to whether the incumbent is engaged in current and vigorous professional development.

In evaluating the degree of this factor consideration may be given to the level of education completed. In general, positions covered by this guide are of such nature that a bachelor's or higher degree is typically a requirement. Moreover, for some types of work, particularly basic theoretical analysis, graduate education is generally regarded as almost essential to the professional stature represented by the higher degree levels of Factor IV.

EVALUATION SYSTEM

Each of the four primary factors has a very wide degree range. To serve as key points for evaluating each factor as it applies to a particular position, three degrees--A, C, and E--are defined. The degrees have point values of 1, 3, and 5, respectively (2, 6, and 10 in the case of Factor IV).

Definitions are not included for intermediate degrees B and D, point values 2 and 4, respectively (values 4 and 8, in Factor IV). However, degrees B and D and their point values are an integral part of the plan, and are to be used when an element is determined to fall between the defined degrees. Additional points may be assigned whenever (albeit rarely) a factor exceeds degree E.

If one or more of the factors do not meet the criteria at the degree A level, no points should be given for Factors I, II or III; however, a point value of 1 may be given for Factor IV.

The evaluation system involves these tasks:

- a separate determination of the proper degree (A, B, C, D, or E) for each factor;
- assignment to each factor of the point value of the degree assigned; and,
- conversion of the total point values to a GS-grade by means of the Grade-Determination Chart and accompanying instructions.

PROCEDURAL SUGGESTIONS FOR USE OF THE EVALUATION SYSTEM

The procedures for application of this guide are a matter for agency determination. The guide may be applied by procedures ranging from normal use by position classifiers (with adequate care and attention given to ascertaining from subject-matter specialists the degree of novelty and complexity of projects and the contributions and professional stature of the incumbent), to application by a panel with joint engineer and classifier membership. Joint participation on the panel affords an excellent opportunity for close cooperation and the merging of the contributions which can be made by professional personnel and by classifiers. Joint engineer-classifier membership on panels is recommended.

We suggest that panels meet as a group, and reach an understanding as to job facts before they undertake to evaluate the job. However, the individual raters should rate independently. The classification record should identify the scientists and engineers who provided the appraisals, because of the importance, in the evaluation process, of subjective judgments of knowledgeable scientists and engineers.

Information will need to be developed when the position is reviewed regarding such considerations as achievements, publications, appearances before professional organizations, and

Procedurals Suggestions for Use of the Evaluation System (cont.)

reviews of the engineers work, etc. The supervisor may present the data to the panel in a variety of ways. However, it also needs to be incorporated in a brief summary of the more important background elements which can be appended to the position description.

Information concerning the incumbent should be redeveloped or modified with changes in incumbency or the competence and stature of the incumbent. Experimental development positions are particularly susceptible of changes in performance which may occur gradually over a period of time. This makes it particularly important that they be periodically reviewed to determine what changes may have occurred.

Many research and development installations have promotion panels that make periodic reviews of the qualifications and professional development of their engineers and scientists. Although the role of such panels may vary, they commonly evaluate the knowledge, abilities, personal qualities, achievements, and contributions of the candidates as these relate to the requirements of the position to be filled. Such appraisals of the man-job relationship for purposes of selecting candidates for promotion require knowledge and judgment similar to that required for grade-level evaluation. Accordingly, agencies may find it helpful to use a single panel for a variety of purposes, such as promotion, position classification, and employee development.

This guide requires coordination and makes possible a meaningful integration of the qualifications review and the classification review. It provides a ground on which the job knowledge, and knowledge of the incumbent's performance and capabilities, which are possessed by the technical staff of the organization, can be related to classification and qualification standards and the other personnel and management processes. Such coordination and management participation should help to provide a basis for more effective personnel management, in a broad sense, with regard to experimental development positions.

GRADE - DETERMINATION CHART

Total point value assigned to the four factors may be converted to grade in accordance with the chart below:

Total of factor point values	Grade Level
4 - 6	GS-09
8 - 11	GS-11
13 - 16	GS-12
18 - 21	GS-13
23 - 26	GS-14
28 and above	GS-15

Total points resulting from a number of the possible combinations fall between the ranges in the conversion table. The determination as to whether to convert to the nest lower or the next higher grade should be based on application of general classification principles, with consideration of (1) the relative weakness or strength of the position compared to other positions in the organization, and (2) aspects of the position, e.g., supervisory responsibilities, which may not have been fully covered in arriving at the point values.

DEGREE DEFINITIONS

Factor I -- Nature of Assignment

Degree A (1 point)

Assignments consist of series of interrelated tasks for problems which have been isolated or defined. These problems are limited in scope and depth, typically by these characteristics:

- -- the problem has been singled out of a larger structure of investigation or project;
- -- unknown factors or relationships are primarily matters of a factual nature, or the mechanisms involved are fairly well understood;
- -- the data can be obtained by use of established analytical, experimental, and investigative methods and techniques with minor modifications and adaptations;

-- the objectives to be reached are clearly identified and can be realized on the basis of knowledge of pertinent technology that is available within a laboratory (e.g., prior research and development studies, literature in the field, scientific equipment and procedures, and advice and assistance of team members and supervisors).

Assignments are more complex than at the initial and advanced trainee levels (GS-05 and GS-07) in that their accomplishment involves the independent application of a series of steps and procedures requiring close observation of (1) the details of findings, and (2) the accuracy and precision of somewhat difficult methods and techniques. Assignments reflect problems involving several variables (factors, elements, conditions) which influence cause and effect relationships that must be discerned and factored into the conduct of the work. However, the relationships among these variables are normally conventional, although somewhat intricate to treat.

Typical assignments relate primarily to the factfinding and investigative phases of the work rather than to the interpretative phases.

The work results in specific proof or demonstration of changes in or additions to a tangible product (e.g., instrumentation, device, theoretical analysis, breadboard, model, experimental technique). The engineer prepares reports and other documentation to describe conditions and factors of importance to the results. He/she draws tentative conclusions from these data.

Assignments typically are confined to a single area of investigation such as a product characteristic or improvement, a component or a specific task; here are some examples of such assignments:

-- devise a special instrument to measure amplitude and frequency distribution of a new solid state random noise generator;

-- perform analyses of the energy balance in alternate configurations of inertial-powered mechanisms to determine their practical limits of miniaturization in advanced missile applications; devise and test out design changes to improve their efficiency.

-- develop a circulating memory for a signal processing system using a stated storage device and design and logic circuits to read digital information into and out of the device.

Degree C (3 points)

Degree C differs from degree A in that assignments involve problem definition and solving processes in addition to factfinding. Typically, this range is reflected in the need to perform these duties:

-- isolate and define the specific engineering problems involved;

- -- determine how the work can be accomplished; and,
- -- carry out independently these objectives.

The engineer or scientist:

- -- formulates concepts and hypotheses;
- -- performs theoretical analyses to predict performance characteristics;
- -- experiments to validate hypotheses; and,
- -- evolves an experimental design, development model or understanding of phenomena.

Assignments are generally long-range investigations necessary to solve problems or establish premises on which further development can proceed during the definition and prototype development phases. However, assignments may also be short-range but intense experimental investigation needed to produce a "cure" for unexpected difficulties encountered in evaluation and production phases of development projects. Complexities arise primarily from either (1) the depth of investigation needed to resolve obscure problems (i.e., theoretical base is inadequate, or demonstration and proof is lacking, etc.), or (2) the scope of investigation needed to treat and coordinate a variety of engineering and scientific tasks. At this degree, investigations of obscure problems typically concern a narrow specialty area such as a specific component, phenomena, product characteristic, or technique. However, the assignment involves in-depth investigation to establish the nature and boundaries of the problem as well as in seeking solutions. Other assignments with a broader scope typically involve a more limited inquiry to identify the type and extent of development effort needed and a broader effort in seeking solutions.

The end product of assignments results in significant innovations in these matters:

- -- producing new equipment, techniques or methods;
- -- augmenting theoretical bases and criteria for the design of equipment;
- -- curing faults and improving performance; or,
- -- demonstrating feasibility of changes in concepts, characteristics and methods for the development of equipment and processes.

Assignments reflect either depth of investigation or breadth in the number and kinds of problems involved and the organization of the work into blocks or tasks which can be accomplished by others or in a sequence of personal investigation; here are some examples of such assignments:

- -- explore and develop a prototype of novel electronic circuitry for advanced fusing systems for a specific missile;

- -- investigate the application of thermoelectric principles for refrigeration in a deep submergence vessel and develop experimental model of proposed thermoelectric system.

Degree E (5 points)

Assignments require a high order of expertise in a broad or intense area of specialization. Degree E differs from degree C in that an extensive and penetrating investigation is needed to explore new technology or to reconcile many divergent and conflicting requirements and constraints. Projects are of such scope, intensity, and complexity as to require subdivision into separate phases.

Assignments are typically critical in defining and establishing meaningful objectives and concepts on which the development of far-reaching innovations in equipment and technology can be based.

Characteristically, the engineer or scientist has responsibility as a team leader for formulating and guiding development projects which involve many major technical problems. Usually, little information is available or available information is fragmented and un-associated. The incumbent performs the more critical analyses and often directs a variety of intense probing to establish: (1) the nature of the problems, (2) those areas representing high risk and critical attainment, and (3) the approaches which could be utilized to solve the crucial difficulties. He/she evolves goals, concepts, and premises which guide other engineers in making choices of alternatives in resolving individual technical problems.

Assignments involve major proposals for solutions to problems of both depth and scope, which require team effort; here are some examples of such assignments:

- -- establish fundamental theoretical concepts and experimental evidence for novel automated marine power plant control systems;

- -- develop a prototype model of a new fuse for a specific missile involving a variety of novel concepts.

Factor II --Supervision Received

Degree A (1 point)

The supervisor (or team leader) outlines the nature of the problem, the requirements to be met, and the critical features involved in the assignment. Also, when precedent data, studies and techniques are not apparent the supervisor provides advice on the sources of information and the methods and approaches which may be utilized. When unusual criteria or techniques are used, the supervisor gives detailed instruction and closely follows their application to the assignment.

Assignments generally involve a specific problem of a broader project which requires the incumbent independently to lay out and accomplish a number of successive steps. He/she assumes responsibility for the accuracy and reliability of results. Questionable points and deviations from the normal situation or practice are discussed with the supervisor.

The supervisor observes the work in progress for compatibility with related work, general acceptability of methods or approach used, and proficiency. Completed work is reviewed for compliance with instructions, accuracy of methods and data, adequacy of treatment, and conformance with established scientific procedures and sound engineering and scientific practices.

Degree C (3 points)

Engineers receive assignments of problems or a subject for investigation within a specialty area. In contrast to degree A, assignments are given in terms of broadly stated requirements and purposes to be met. Typically, the engineer or scientist determines the specific technical objectives to be achieved, and formulates a proposal. He/she lays out a plan of action, including estimates on the type and kind of effort, costs, facilities, and time schedule involved. Such planning takes in the overall experimentation and other efforts (e.g., shop, field testing, etc.) to be accomplished. Typically, he/she must provide sufficient detail to justify his/her definition of the problem and selection of approaches for solving the specific problems.

Normally, assignments are a part of a larger development proposal or general investigation. Therefore, proposals require approval by the supervisor (team leader) or the customer. The incumbent independently carries out the plan of attack resolving conflicts and obstacles, and investigating relevant tangents. He/she seeks advice of experts when such action is deemed advisable. Characteristically, the incumbent determines when sufficient demonstration, proof, refinement and design have been accomplished to satisfy the requirements and purposes. He/she is responsible for coordinating his/her work with that of others to insure compatibility of approach as well as consideration of constraints and interlocking requirements.

The incumbent keeps his/her supervisor informed of progress. He/she recommends other courses of action for unsuccessful ventures, and for promising innovations in equipments, techniques, etc., which may need further work. Recommendations for major changes affecting requirements, costs, facilities and time are subject to final approval of the supervisor. The supervisor reviews completed work for adequacy and effectiveness in meeting requirements.

Degree E (5 *points*)

Supervision at this degree is concerned primarily with the starting and stopping of projects. Results of the work are reviewed primarily in terms of the attainment of objectives and impact on

the mission or overall project. Typically, assignments are made on the basis of the expertise of the incumbent in advancing an area of endeavor. Within the framework of broadly defined missions and functions, the engineer or scientist chooses the procedures to attack and the direction to pursue in accomplishing the objectives and purposes of the assignment.

Recommendations for the initiation of new projects and abandonment or extensive alteration of the objectives and boundaries of projects are evaluated in terms of the availability of funds, effect on priority and program schedules, and availability of staff resources. Technical aspects of the assignment are worked out individually or with affected groups and are normally final. Advice and findings are accepted as authoritative and conclusive by management officials and customers. Findings and evaluations are typically of fundamental significance in questions and issues broader than the assignment itself.

Factor III -- Guidelines and Originality

Degree A (1 point)

In general, technical and procedural guidelines pertaining to the work assignments are available. The methods and techniques of analysis, experimentation and investigation are not only known, but also have been applied to similar problems and subject matter. This degree differs from the initial and advanced trainee levels in that the engineer or scientist selects and evaluates the applicability and limitations of various analytical and experimental methods for the assignment. Based upon an examination of the problem involved in the assignment, he/she determines those means that could be used to produce accurate, reliable and valid findings.

Originality is typically limited to a search for information about the use of methods or procedures and to adapt these findings to the requirements and conditions of the specific problem. Technical judgment is required to understand the limitation of available techniques, instrumentation and equipment available and to insure that analytical procedures, measurements and observations are made under conditions which reflect scientific, engineering and operating requirements. The incumbent makes only minor innovations and modifications of procedures and techniques.

Degree C (3 points)

This degree differs from degree A in that technical guidelines and precedents are inadequate, controversial or contain critical gaps in a basic area such as:

-- knowledge of behavior characteristics;

-- measurement criteria;

-- theoretical base; or,

-- methods and techniques by which to analyze, investigate, or evaluate development problems.

Assignments require mature professional judgment and keen insight in dealing with technological problems in a specialty area. The employee uses these qualities in converting generally stated problems into specific isolated and defined engineering problems to be attacked. Such problems necessitate highly developed skills in experimental development processes. The work requires the use of initiative, ingenuity and judgment to accomplish these duties:

-- use advanced techniques and new approaches;

-- adapt and extend techniques, methods and processes from other fields;

-- explore advancements in knowledge of phenomena, theories and concepts.

Critical judgement is required to remain on course, to winnow out irrelevancies and side issues, to reach realistic and reasonable solutions to problems and to reflect valid conclusions and demonstrations on which to base the design of improved and new products.

Degree E (5 points)

This degree differs from degree C in that guidelines and precedents are generally inadequate and do not provide an understanding of phenomena or means for converting knowledge or concepts into materials, equipments, processes or criteria.

Assignments typically involve several major problems that require extensive experimentation to establish the feasibility of evolving and synthesizing new approaches and technology. The engineer or scientist is required to apply outstanding technical judgment to accomplish the one or more of the following tasks:

-- assess the probability of solving of these problems once understood; and,

-- chart a many-faceted development program that will explore and resolve these problems individually and collectively; and,

-- reconcile divergent and conflicting requirements and constraints.

Typically, assignments involve major obstacles which are of such significance in the field that other groups are also trying to find solutions. To overcome such obstacles the incumbent must apply a high degree of ingenuity as well as an expert knowledge of the specialization and related technology.

Major innovations are usually achieved that result in new equipment and substantial improvements in existing technology. The solution in such technological problems often leads to the intellectual insight required to understand a more general or basic problem.

Factor IV -- Qualifications and Contributions

Degree A (2 points)

This degree differs from the initial trainee levels in that in addition to the fundamental knowledge of the discipline, the employee is expected to have acquired (by further education or experience) an understanding of the scientific and engineering techniques and processes by which the materials and characteristics of equipment are identified and utilized.

The incumbent typically assists higher graded employees by performing subsidiary investigations for a development project or general investigation in a specialized field. His/her work is independently conducted. He/she is expected to demonstrate the abilities to perform these types of tasks and responsibilities:

- -- discern how the objectives of the assignment may be accomplished;
- -- ascertain the tasks involved;
- -- select precedents and choose compatible standard guides when several are involved,
- -- carry out detailed steps and procedures in an accurate and valid way;
- -- recognize when further guidance is needed; and,
- -- prepare factual, analytical, and investigative data clearly and concisely in appropriate format.

Contributions are expected to be tangible showings of ability to perform a variety of these kinds of experimental development activities:

- -- reports of the application of a technique described in scientific literature;
- -- adaptation and design of instrumentation devices and circuitry when available instruments are inadequate in some aspects;
- -- breadboard, models, or simulation of theoretical concepts to perform a given function in an equipment;

-- comparative analyses in the laboratory of different models of equipments to identify the principles and techniques used to obtain the performance characteristics and to get data to use in improving equipment;

-- plan and conduct field tests of early experimental equipment to specific environmental data needed for further development.

The employee serves as a source of information on his/her own assignments primarily to others working on the project or for similar projects. He/she explains to shop and technician personnel what task is to be done and those features requiring special attention.

Degree C -- (6 points)

This degree differs from degree A in that the engineer or scientist is expected to be professionally competent in a specialty field requiring skillful application of a range of engineering and scientific principles, techniques, and methods.

The engineer or scientist will have shown ingenuity and proficiency in utilizing complex theoretical, experimental and investigative techniques and methods. This competence, which is gained in work of increasing complexity and versatility, typically is augmented by further study leading to an advanced degree (or other means to remain abreast of the advancing technology applicable to his/her field).

The engineer or scientist displays a keen awareness of and ability to use recent advances in scientific knowledge and technological know-how in accomplishing these tasks:

-- setting realistic plans for complex problems;

-- identifying possible approaches;

-- postulating hypotheses; and,

-- evolving techniques and methods.

The engineer and scientist show a thorough competence to resolve the issues involved, both by checking out and accounting for anomalies, and by reaching sound engineering and scientific compromises as necessary.

He/she is qualified to speak and deal responsibly on technical matters in his/her area of immediate specialization within and outside his/her own organization. He/she may serve on task groups organized to resolve technical issues or present papers on his/her work at technical meetings.

His/her conclusions are in the form of theoretical investigations, experimental designs, and laboratory evaluations. These conclusions provide the basis for significantly advanced and improved techniques and methods for equipment, products, and processes. He/she must recognize the need for and justify supplemental work to be performed by himself and other organizational segments, laboratories, or agencies.

Degree E (*10 points*)

This degree differs from degree C in that the engineer or scientist has demonstrated marked technical leadership in a specialized field of experimental development. He/she must be competent to gauge the extent to which:

- -- the perimeters of the state of the art can be pushed; and,
- -- the technological gap can be bridged between imaginative and futuristic concepts and practical materials, hardware, and processes.

He/she must have demonstrated the ability to plan, organize, and bring to fruition a broad attack on complex problems. Typically, he/she establishes requirements for workers in other fields whose efforts must be integrated to solve problems that are interdisciplinary in scope. The resolution of these problems results in clearly evidenced innovations which are of fundamental significance in advancing new technology and previously unrealized developments.

The engineer or scientist is recognized as an expert in his/her field. His/her advice is sought by colleagues who are themselves specialists in the field on critical issues and interpretations. Also, because of such personal competence and leadership, the laboratory's reputation is such that management officials and other activities solicit proposals to resolve problems of great difficulty. Engineers and scientists not only initiate proposals for far-reaching developments, but also sell these proposals to high-level management officials (local and beyond) to obtain support (interest, resources, and time) to carry on the work to a more definitive stage.

Sufficient note has been taken of the consistent contribution of his/her work and recognition of his/her competence that he/she is invited to present papers to technical symposia. His/her participation is sought on special task forces and committees for matters extending be yond his/her field. On these committees he/she is characteristically the spokesman or principal investigator for his/her field or his/her activity. Typically, the purposes of such groups are to carry-out the following duties:

- -- develop new programs;
- -- evaluate various proposals and to lay out long-range research and development plans;
- -- evaluate highly controversial issues;
- -- investigate critical difficulties, failures and obstacles in important and extensive development programs.

Typically, the engineer produces inventions, patents or innovations that are highly ingenious. These contributions may be of primary importance in defining new concepts, configurations, and performance characteristics for particular development projects. The contributions also may help in establishing new theories and an understanding of phenomena that open the way for future developments in the field.