# 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.