

History of the Power Systems Protection Committee

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I. FOREWORD

THE Power Systems Protection (PSP) Committee of the Industry Applications Society (IAS) of the Institute of Electrical and Electronics Engineers, Inc. (IEEE) is a relatively young committee of IEEE, which was formally elevated to committee status on January 1, 1977 from its former status as a subcommittee of the Industrial and Commercial Power Systems (I&CPS) Committee. The identifiable roots of this committee, however, date back almost fifty years, and its existence as an identifiable entity to February, 1961, when it was established as a subcommittee of the I&CPS Committee, at that time an American Institute of Electrical Engineers' (AIEE) committee. Any history of the PSP Committee that fails to trace its evolution from its earliest roots to its present status would not be complete.

II. INTRODUCTION

As is true for evolutionary processes in general, the evolution of the PSP Committee from its beginnings to the present day was greatly influenced by its environment. In this case, the environment consisted of the goals and activities of the parent committee, the I&CPS, its subcommittees and working groups from its earliest beginning until its elevation to committee status on January 1, 1977, and the corresponding goals and activities of its sister committees, the Industrial Plant Power Systems (IPPS) Committee, the Commercial Buildings Power Systems (CBPS) Committee, and the Power Systems Technology (PST) Committee all of which were also elevated to committee status of January 1, 1977 from their former status as the subcommittees of the I&CPS Committee subsequent to that elevation. Hence, the history of the PSP Committee is intertwined with that of the IPPS, CBPS, PST, and their common parent, the I&CPS. The history which follows has been written in a manner intended to trace that evolutionary process rather than to achieve a rigorous adherence to a chronological sequence of events.

PSP's history can be divided into three general time frames and status levels as follows:

Working Group—Pre-1961
Subcommittee—1961-1977
Committee—1977-present.

III. WORKING GROUP STATUS PRE-1961

The beginnings of what has evolved into the PSP Committee can be traced to the abbreviated and simplistic treatment of system protection contained in two AIEE publications of the 1940's. The first of these was "Electric Power Distribution of Industrial Plants," prepared by the Industrial

Power Systems (IPS) Committee and published in 1945. The second was "Interior Wiring Design for Commercial Buildings" prepared by the Commercial Buildings Electric Systems (CBES) Committee (not certain of its correct name at that time) and published in 1949. There is no direct evidence of a continuous ongoing effort to address the problems associated with system protection and coordination subsequent to the issuance of those publications. However, sufficient continuity of committee membership existed to justify a presumption that such activity did exist on at least an informal basis.

In 1956 a second edition of "Electric Power Distribution for Industrial Plants" was issued as AIEE Number 252. By this time, the book was better known by its nickname, "The Red Book" after the color of its paperback cover. This was the beginning of what was to evolve into the present day "hard-back" IEEE Color Book Series, the driving force behind the growth of, not only the PSP, but its sister committees, IPPS, CBPS, and PST, which ultimately led to their establishment as full-fledged IEEE committees.

At approximately the same time the second edition of the "Red Book" was published, a companion volume, "Grounding of Electrical Power Systems," prepared by the Industrial Grounding Subcommittee of the IPS was published as AIEE Number 953, and promptly nicknamed, the "Green Book" after the color of its cover. This was the second of the present day IEEE Color Book Series.

Subsequent to the 1956 publications of the "Red Book" and "Green Book," the ISP and CBES merged to form I&CPS. At the time of that merger, work was already under way to rewrite and expand on the 1949 publication "Interior Wiring Design for Commercial Buildings." In keeping with what had become a tradition, this publication was nicknamed the "Gray Book." The first edition of the Gray Book was not completed and published until after the 1963 merger of AIEE with the Institute of Radio Engineers (IRE) to form the IEEE. When issued, it was designated as the Standard Number 241 "Recommended Practice for Electric Power Systems in Commercial Buildings." Similarly the AIEE 952 and 953 were redesignated as the IEEE Standard Number 141 and the IEEE Standard Number 142 and retitled in subsequent additions of "Recommended Practice for Electric Power Distribution for Industrial Plants" (3rd edition, 1964) and "Recommended Practice for Grounding Industrial and Commercial Power Systems (2nd edition, 1972), respectively.

The Working Group for Chapter III of the 1956 Red Book, which dealt with system protection and coordination, although it had completed its specific task, was never completely disbanded. Even then it was recognized that the treatment of the complex subject was insufficient to meet all of

the needs of the industrial power systems designers and users. It was also recognized that grounding practices treated in the "Green Book" had the potential for substantial impact on the protection and coordination aspects of system design. The merger that created the I&CPS further complicated the problem because the treatment of the protection and coordination of commercial power systems needed, despite substantial differences in needs and practices, to be at least philosophically consistent with the treatment of those matters as they pertained to industrial power systems. Hence, by the late sixties, it was becoming increasingly apparent that a need existed to address the problems associated with protection and coordination of industrial and commercial power systems on a continuing basis, rather than by "ad hoc" treatment of Working Groups in support of Chapter III of the "Red Book" and Chapter IV of the "Gray Book" as if they were one-time independent tasks.

IV. SUBCOMMITTEE STATUS—1961-1977

Although there was a developing recognition within the I&CPS of a void in technical coverage of the system protection aspects of industrial and commercial power systems design, the impetus for the creation of a continuing subcommittee charged with responsibility for that coverage actually came from an external source. On January 6, 1961, Mr. J. Kinghorn, Chairman of the Power Division of AIEE, wrote to Mr. J. Diffenbaugh, Chairman of the Industry Division of AIEE, to inform him that the Relay Committee of the Power Division wished to establish a subcommittee titled "Consumers Relaying Coordination Subcommittee." The suggested scope of the proposed subcommittee was stated in the following way.

Develop and encourage good protective practices so as to yield maximum values and satisfaction for consumers of electric power. This *includes* study, investigation, and recommendations to obtain the best possible *application and coordination of protective relaying within the electric systems of consumers and with the connecting utility*. Cooperate and maintain liaison with the Industrial and Commercial Power Systems Committee (Industry Division) to promote activities of mutual interest.

The proposed subcommittee would have replaced an existing subcommittee having a much narrower scope, which rather than the underlined wording contained the wording "...involves...application and coordination protective relaying *common* to the electric systems of consumers and of the connecting utility."

When the membership of the I&CPS was appraised of the Relays Committee proposal, it was the consensus of that body that the proposed scope constituted a clear infringement on the I&CPS scope in that "application and coordination of protective relaying within the electric systems of consumers" was entirely within the responsibility of the I&CPS as defined by its scope. That scope read as follows.

Treatment of all matters in which the dominant factors are the application operation and maintenance of ma-

chines, devices, and equipment necessary for generating, transmitting, and distributing electric power within industrial plants and commercial buildings. Design of power systems within industrial plants and commercial buildings are included in the scope of this committee, but design of devices and equipment are excluded.

After consideration of the Relays Committee proposal, the I&CPS unanimously voted on February 2, 1961, to form its own subcommittee to handle relaying practices and other system protection needs within the confines of industrial plants and commercial buildings, and that subcommittee be titled "System Coordination and Protection Subcommittee" with a scope as follows.

Investigation, study, and recommendations of preferred application practices of protective equipment used within industrial plants and commercial buildings. This includes the coordination of relays, circuit breakers, fuses, and fuse-switch combinations. Cooperate and maintain liaison with the Consumers-Utility Relaying Coordination Subcommittee of the Relays Committee (Power Division) to promote activities of mutual interest.

It was further voted that the scope of the proposed Relays Committee Subcommittee be reworded to read "...common to (rather than within) the electric systems of consumers and with the connecting utility," and that references to liaison with the I&CPS be changed to liaison with the System Coordination and Protective Subcommittee of the I&CPS. The Relays Committee later adopted a scope which adopted the wording proposed by the I&CPS.

(Between 1961 and 1976, the subcommittee initially created as the System Coordination and Protection Committee underwent at least two name changes. For purposes of clarity and simplicity, it will be referred to in the balance of this history by its name immediately prior to achieving committee status, Power Systems Protection (PSP) Subcommittee.

The PSP was established to fill a recognized void in the technical coverage of the area indicated by its scope. However, the mere act of its establishment did nothing to fill that void. At its inception, the immediate problem facing the PSP was to define its role better and to develop strategies and mechanisms for fulfilling that role in line with its stated scope. At the outset, it was recognized that the real gap in technical coverage was not a lack of information, but rather a lack of a suitable vehicle for communication of that information to the constituency to be served, namely, the designers and operators of industrial and commercial power systems.

The first step taken in addressing that communication gap was the compilation of a "Bibliography of Industrial System Coordination and Protection Literature" published in 1962 as AIEE TRANSACTIONS Paper Number 62-1377. It was obvious that the first step, although better than nothing, fell far short of satisfying the long-term need for a number of reasons.

- 1) Most engineers who had access to the necessary literature had little need for this bibliography.
- 2) Much of the literature was written with experienced

relay engineers in mind and, as a consequence, would be of little direct assistance to the perceived constituency.

- 3) The available material was fragmented, repetitious, and incomplete regarding the overall need of the perceived constituency.

As a follow-up to this initial step, several strategies were considered.

- 1) Assume that the presently available literature was adequate and nothing beyond periodic updating of the bibliography and taking measures to make the literature more readily accessible would be warranted. Adoption of this strategy would in effect constitute an abdication of the PSP's assigned role as defined by its scope. Hence, this strategy was rejected out of hand except as a last resort fall back position.
- 2) Substantially expand the coverage of this aspect of system design in future editions of the "Red Book" and "Gray Book." This approach was rejected for several reasons: a) substantial duplication of effort; b) severe volumetric imbalancing of the texts since existing coverage of that subject matter, limited as it was relative to needs, already constituted a major component of those texts; c) somewhat conflicting needs; d) potential for perceived and even actual technical conflicts which would need resolution; e) differing timetables for future editions; and f) further delays in already overlong timetables for text preparation and revisions.
- 3) Prepare and publish a companion book to the "Red Book" and "Gray Book" which would constitute comprehensive, yet readily understandable coverage of system protection and coordination of industrial and commercial power systems. This alternative too has a number of disadvantages including a) the long delay inherent to undertaking any such effort with volunteer workers as demonstrated by prior experience with the "Red Book" and "Gray Book"; b) the danger that when completed, such a text would be 1) an overly simplistic treatment of the complex material; 2) a rehash of the material already available in the "Red Book" and "Gray Book"; or 3) beyond the level of comprehension of the intended constituency; and c) substantial duplication of and potential for conflict with material already available in the "Red Book" and "Gray Book" unless the coverage in those texts were to be eliminated or significantly curtailed.

After considering the alternatives, the PSP determined that despite the difficulties and potential pitfalls only the preparation of a completely new book would be truly responsive to its scope and the perceived needs of its constituency. Consequently the PSP notified the I&CPS of its intention to pursue that course at least to the extent of verifying that there was, in fact, a substantial need for and level of interest in such a book. In October, 1965, the PSP presented a Committee Report at the second I&CPS conference in Buffalo, NY which documented the rationale for recommending the

preparation of a book on "Protection and Coordination of Industrial and Commercial Power Systems" along with an outline of the proposed content of such a book. The enthusiastic reaction of the attendees to that proposal led to the endorsement of the I&CPS of what was to become, when published ten years later, the "Buff Book" of the IEEE Standard Number 242—"Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems," the fifth in the IEEE Color Book Series.

Over much of that ten years, since the subject matter involved encompassed almost all of the PSP scope as it was then perceived, the "Buff Book" constituted the primary activity of the PSP. Although over this time frame many papers were written and presented, they were in large measure keyed to information to be presented in the publication. In fact, many of those papers constituted draft material intended, after editing, to be incorporated in the book. The format adopted for the book was designed in a manner intended to serve the broadest possible constituency from the neophyte to relatively sophisticated designers and operators of industrial and commercial power systems. Consequently the earlier chapters covered in some detail all of the components and concepts common to virtually all, even the most rudimentary, systems in a logical step-by-step manner. The latter chapters dealt with the more sophisticated protection needs and how their protection could be integrated and coordinated with a more basic system design. The final product, although far from perfection, at least in its initial edition, probably constitutes the most complete and understandable treatment of an important and complex subject available anywhere under a single cover. Future revisions and updating, if the experience of the other Color Books is repeated, will improve in quality, quantity, and utility for the user.

From a chronological standpoint, completion of the first edition of the "Buff Book" did not end the subcommittee era for the PSP. However, by 1975 when that edition was published, the wheels were already in motion to subdivide the I&CPS into several committees. By this time the IEEE Color Book Series consisted of five in print and at least another five in various stages of preparation. Preparation of those books resulted in spin-offs to evaluate areas not adequately documented in the literature but required for good coverage of some aspect of the publications coverage. As a result, subcommittees grew in size and complexity and then subdivided. Even so, many subcommittees exceeded in size and complexity most of the IAS Committees other than I&CPS. Central control and effective administration of the entire I&CPS complex had reached almost unmanageable proportions with a committee structure. Consequently it was proposed that the I&CPS be restructured into a Department of the IAS and that four new technical committees, IPPS, CBPS, PSP, and PST be established along with redesignation of the Codes and Standards Subcommittee of the I&CPS which has been by delegation acting for all of the IAS as a Staff Committee of the IAS within a new Industrial Power Systems Department (IPSD).

During the balance of 1975 and 1976, the PSP was gearing up to take on a new role as a committee. Along with restructur-

ing that gearing up included a re-examination of needs and strategies. Although much of the preliminary work associated with the new projects was initiated prior to the PSP's elevation to committee status, the culmination and bulk of the work associated with those undertakings falls within the committee ear and is covered there.

V. COMMITTEE STATUS—1977-PRESENT

In the interest of restricting the initial effort of the PSP, "the Buff Book" treatment of system protection was deliberately restricted to fault protection and coordination. However, the scope of the committee encompasses far more than fault protection per se. It includes all systemic abnormalities and exposures to disruptions in the quality and continuity of service. During the final phases of preparation of the initial "Buff Book" two other problem areas, falling at least in part within the scope of the PSP surfaced and were addressed.

The first of these was the absence of an established understandable methodology for the calculation of available short circuit current under fault conditions, especially as related to the first few cycles after a fault occurs. The method adopted as a standard by the Switchgear Committee of the Power Engineering Society as a basis for rating and applying switchgear, although probably more accurate than the method it supplanted, was cumbersome, complex, and entailed sophisticated field measurements in some instances which would be beyond the capabilities of most engineers dealing with industrial and commercial power systems. This development coupled with inconsistencies in the proposed treatment of this subject in the "Red Book," "Gray Book," and "Buff Book" led to a decision on the part of the I&CPS to develop a simple, but reasonably accurate, methodology for uniform application throughout the Color Book Series. Ultimate responsibility for developing that methodology was vested in a Working Group which currently makes up a part of the PST Committee. However, a substantial portion of the work performed in that area was performed by PSP members who were also members of that Working Group. The satisfactory final implementation of a uniform methodology for the calculation of fault currents will perforce be dependent on the cooperation of the PSP with the PST, IPPS, and CBPS in addressing gaps in and remaining differences regarding the proposed methodology.

Another area, if it has not already become the principal project of PSP, has become an important part of the work of that committee. The scope of the I&CPS was, and consequently those of its successor committees are, systems oriented. That is the design of system components is specifically excluded, but the application of those devices in an integrated system is specifically encompassed by the stated scopes. One of the

largest and most complex remaining problems associated with the protection and coordination of power systems, whether they are industrial, commercial, residential, or utility, is the lack of a consistent, or in many instances identifiable, basis for rating those components as regards their withstand capabilities, hence their component protection needs. Where the withstand capabilities of components such as transformers, relays, cable, bus, instrument transformers, switchgear and switchgear components, fuses, switches, etc., if stated at all, are stated on entirely different bases, the rational design of a fully coordinated protection scheme for a system made up of those components is impossible. Even an ultraconservative approach to application would be difficult to implement unless the so-called weakest link could be identified with a high degree of confidence. Consequently the PSP has taken on the task of preparing still another IEEE color book, "the Blue Book," with the objective of codifying a rational basis for rating the various circuit elements as regards their protection needs. This publication is currently projected to be completed by the mid-1980's or at least as complete as information gaps will permit.

Two other areas are receiving attention in the PSP Committee: 1) the problems associated with wave shape distortion: its causes, treatment, and impact on the quality and acceptability of electric power supplies; and 2) surge protection of the system and its components.

At the present time the PSP is made up of the following technical subcommittees and working groups:

- Low-Voltage Protection Subcommittee
- Medium-Voltage Protection Subcommittee
- Rating Structure Subcommittee (Blue Book)
- Protection Book Subcommittee (Buff Book)
- Wave Shape Distortion Subcommittee
- Working Group on Surge Protection
- Various Technical Liaison Representatives.

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