AN INDEPENDENT PEER REVIEW PROCESS DEVELOPED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS FOR THE U.S. DEPARTMENT OF ENERGY

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Peer review is the foundation of acceptability of scientific and engineering information. If properly managed, it provides the manager of governmental, industrial, and other organizations with credible and timely technical materials. This paper summarizes the results of a program developed by the American Society of Mechanical Engineers (ASME) in cooperation with the Institute for Regulatory Science (RSI). The program was funded by the U.S. Department of Energy (DOE) and used primarily by several offices of DOE. However, it was also used by other organizations. The Peer Review Committee (PRC) formed by the ASME was responsible for development and enforcement of policies and procedures to ensure the integrity and credibility of the Program. Review Panels (RPs) appointed by the PRC were responsible for peer reviewing specific projects. The day-to-day operations of the RP were managed by RSI. Judging by the large-scale recognition of the Program, it can be concluded that it was credible, timely, economical, and applicable to virtually all scientific and engineering activities.

Keywords: Peer review

INTRODUCTION

The American Society of Mechanical Engineers (ASME) is one of the oldest professional societies in the United States. It has over 100,000 members not only in the U.S. but also in many countries of the world. Although the emphasis of ASME is mechanical engineering, its membership includes numerous other professionals who have direct or indirect interest in mechanical engineering. ASME is involved in a number of scholarly activities, such as:

1. **Standards Development:** Many of these standards have been adopted by the American National Standard Institute and the International Standards

Organization. The development of standards continues to be a major part of ASME's activities.

2. **Conferences:** Much like other scholarly organizations, ASME organizes numerous conferences and meetings and publishes scholarly journals. Peer review is a prerequisite for acceptance of papers for presentation at ASME meetings and publication in ASME journals.

3. **Publications:** ASME is also engaged in publication of books, preparation of numerous position statements, and other activities requiring consensus on a specific topic or passing peer review.

In the early 1990s, the U.S. Department of Energy (DOE) awarded a grant to the Institute for Regulatory Science (RSI) encouraging the development of the concept of Best Available Science (BAS). A key part of BAS was the development of processes and procedures for independent peer review using the experience of ASME as a model. Shortly thereafter, various committees of the U.S. Congress and other organizations criticized certain research and development (R&D) activities of DOE. The description of these criticisms is beyond the scope of this paper. However, these criticisms led to the formation of a committee of the National Research Council (NRC), the research arm of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The NRC reviewed numerous R&D activities of DOE. The NRC Committee's report addressed certain R&D activities of DOE performed in 1995 (NRC 1996), was particularly critical of these activities, and recommended the establishment of an external independent peer review program.

Using the existing grant to RSI, an Executive Panel of a yet-to-be formed ASME Peer Review Committee (PRC) was established, and the first reviews took place in October 1996. Shortly thereafter, the ASME PRC was formed. It consisted of 15 individuals covering all anticipated disciplines needed to perform peer reviews of environmental and related activities of DOE. Over the next several years, this program expanded and covered peer reviews for other sponsoring organizations.

THE ASME/ RSI PEER REVIEW PROCESS

Once the ASME PRC was formed, the primary task was to develop a document describing the peer review process. A draft document was prepared in November of 1996 and the final document was updated several times (ASME 1997; ASME 1998; ASME 2000). The peer review system was designed to be flexible enough to accommodate many different applications as they are identified.

The peer review process described in this paper was based on the close cooperation between the staff and volunteers of ASME and the staff of RSI. Consequently, it is usually known as the ASME/RSI peer review process. However, the many different principles governing the peer review process were derived from processes that resulted from operations of ASME, a century-old professional society.

There are some unique features of the structure of the ASME/RSI peer review process and the application of the process developed, as follows:

1. Consistent with its historic role of providing technical reviews and comments on governmental peer review activities, the ASME/RSI peer-review process was designed to provide an unbiased, independent, accurate, and timely response to sponsors.

2. Traditional peer review as performed routinely by all professional societies for their technical publications had to be modified to accommodate the unique needs of government agencies.

3. Peer review is particularly useful in evaluating requests for grants. Many agencies support research and development in specific areas of science and engineering. Often, the total amount of funding requested by all applicants is larger and, in some cases, significantly larger than available funds. Peer review is a key process not only to evaluate the technical acceptability of specific proposals, but also to rank them in accordance with specific criteria.

4. Another application of peer review is in technology development. Once a technology reaches a certain level of maturity, the supporting agency must make a decision on whether it should continue funding the work. The potential for success of that technology, based on parameters provided by the supporting agency with or without input from a reviewing group, is subject to peer review.

5. Often, agencies support competing technologies to ensure the availability of an option if one technology fails to meet its predicted performance. However, the evaluation of competing technologies and the selection of the most promising technology can benefit from peer review.

6. Many agencies routinely prepare requests for proposals (RFPs) and requests for applications (RFAs). Peer review provides a reasonable method for evaluation of the validity of the technical criteria of RFPs and RFAs, responses to them, and the prioritization of various responses based on the selected technical criteria.

7. Some agencies, including DOE and the U.S. Department of Defense (DOD), have facilities requiring environmental restoration. Assessment of technological needs, evaluation of available technologies and needed technology developments, and optimization of engineering processes are subject to peer review.

8. A major function of certain government agencies is the promulgation of regulations. A number of these regulations are based on the evaluation of available scientific and engineering information. Traditionally, regulatory agencies have separated the technical aspects from administrative and societal judgment in developing regulations. The science and engineering upon which the regulation is based must be sound, and therefore would benefit from peer review.

ADMINISTRATIVE STRUCTURE

As stated above, the peer review program of ASME was performed collaboratively with RSI, the recipient of grants and contracts. At RSI, the Principal Investigator of the Peer Review Program was responsible for the overall performance of the program. At ASME, the project was managed by the Director of Research, an ASME employee.

The ASME Director of Research and the associated staff were responsible for all activities related to the operation and management of the PRC including the approval of peer review reports by the PRC. At RSI the Administrative Manager of the Peer Review Program (AMPRP), an RSI employee, managed operational logistics, text and copy editing of all reports, and numerous other administrative and managerial activities. The technical operation of the Review Panels (RPs) was the responsibility of the Technical Secretary.

Activities of the sponsoring organization were managed by Project Teams consisting of various project managers and others. Finally, the sponsor appointed a Peer Review Coordinator who was the link between the sponsor and the peer review activities—particularly the PRC.

The PRC consisted of a committee of volunteers that adopted policies and procedures of the peer review process and oversaw the actual peer review. An Executive Panel oversaw the day-to-day operations of the PRC. It consisted of the Chair, two other individuals, and the Principal Investigator of the Peer Review Program.

STRUCTURE OF THE PEER REVIEW PROGRAM

As stated above, the ASME/RSI peer review process is based on the oversight of the entire process by the PRC. The PRC includes an Executive Panel (EP) responsible for the day-to-day operations of the PRC. Review Panels (RPs) formed by the PRC perform the peer review.

Peer Review Committee

The PRC was formed as a standing committee of the ASME Center for Research and Technology Development and designed to oversee peer review for one particular technical area. Its members were chosen on the basis of their education, experience, and peer recognition. An attempt was made to ensure that all needed competencies and diversity of technical views are represented in the PRC. The members of the PRC were appointed by the then Board on Research and Technology Development of the then Council on Engineering (now reorganized as the Knowledge and Community Sector) of the ASME. Except for the EP, membership in the ASME was not required for appointment to the PRC. Specific functions of the PRC included the following:

1. As the overseer of the peer review process, the PRC enforces all relevant ASME policies, including compliance with professional and ethical requirements.

2. It approves the appointment of members of RPs based on specific criteria.

3. It routinely reviews and approves the Reports of the Review Panels.

4. If the sponsoring agency chooses to respond to the recommendations of the RP, it reviews and accepts the response by the agency.

Executive Panel

As the full PRC only meets periodically, the day-to-day operation of the peer review program is managed by the EP which acts on behalf of the PRC between its meetings. It consists of three to five members who must be ASME members and typically are former division chairs, vice presidents, or presidents of ASME. The EP meets as necessary but most of its operation is performed by teleconference or correspondence (mail, fax, e-mail).

Review Panels

The peer review is performed by a RP consisting of at least three reviewers who have expertise in the area being reviewed. For obvious reasons, the number of individuals serving on a RP depends upon the complexity of the subject to be reviewed. Although every review is unique, it was found to be desirable to establish a guide on the nature of the process. Accordingly, four types of review were established as follows:

Type I: This type requires five or more individuals who meet and perform peer review of a complex project, including multiple but related technologies. Frequently, a Type I review requires a site visit.

Type II: This type requires at least three individuals who will meet and perform an in-depth review of a subject or technology. Occasionally, Type II reviews also require a site visit.

Type III: This type is similar to Types I and II, except that the RP does not meet and all activities are performed via mail, e-mail, and teleconference.

Type IV: This type is used for peer review of competing submissions such as grant proposals. The number of individuals constituting a RP depends upon the number and nature of submissions. However, each submission must be reviewed by at least three individuals.

Selection of Reviewers

One of the most important issues facing the PRC is the development and implementation of clear and unambiguous criteria for the selection and make-up of the RPs. It was decided that the selection of a reviewer must be based on the totality of that individual's qualifications. However, four generally recognized and fundamental criteria were identified for assessing qualifications of a reviewer:

1. **Education:** As a general rule, a minimum of a B.S. degree in an engineering or scientific field is required for any peer reviewer. However, in practice, most reviewers have advanced degrees.

2. **Relevant experience:** Relevant experience of sufficient duration and depth is another area of importance in the selection of a reviewer.

3. **Peer recognition:** A third and often-neglected area is peer recognition. Election to office of a professional society, serving on technical committees of scholarly organizations, and similar activities are considered a demonstration of peer recognition.

4. **Contributions to the profession:** The individual's contribution to professional advancement may be demonstrated by publications in peer-reviewed journals. In addition, patents, presentations in meetings where the papers were peer-reviewed, and similar activities are also considered as contributions to the profession.

Formation of RPs

Experience with numerous peer reviews demonstrated that it is useful to categorize reviewers in a manner that will result in a credible and independent review. Based on the experience gained in the conduct of this program, the areas of competency of the reviewers are categorized as follows:

Category I: Broad areas of knowledge.
Category II: Areas of general knowledge and experience.
Category III: Areas of direct and detailed knowledge and experience.

The following example may be used to demonstrate the significance of the categorization. A mechanical engineer may have worked in heat transfer of heterogeneous systems during his entire career. For the last few years, this engineer may have worked in thermal processes involving combustion with a special interest in fluidized bed combustion. In this case, his competencies in our classification system would be as follows:

Category I: Heat transfer in mechanical systems.
Category II: Combustion.
Category III: Fluidized bed combustion.

A typical RP might include one individual from category I, one individual from category II, and one from category III. Obviously, it is not always possible to find individuals who are in the correct category, are available, and have no conflict of interest. This is particularly critical in Type I and Type IV reviews where broad subject areas are being reviewed.

Conflict of Interest

Those who are involved in peer review recognize that one of the most complex and contested issues in peer review is rigorous enforcement of absence of conflict of interest. For obvious reasons, the ideal reviewer is an individual who is intimately familiar with the subject under review and yet has no interest in the outcome of the review. Despite this apparent difficulty, there are numerous examples demonstrating that peer reviews can be successfully performed without the reviewers having a real or an apparent conflict of interest. The guiding principle for conflict of interest is as follows:

> *Those who have a stake in the outcome of the review may not act as a reviewer or participate in the selection of reviewers.*

Everyone who participates in the peer review process signs a statement indicating a lack of personal or financial interest in the outcome of the review. For obvious reasons, absence of conflict of interest is of utmost importance for members of the PRC, particularly for members of its EP. Due to the large number of projects that may be reviewed by the PRC, it is not always predictable if a member may have a conflict of interest in participating in the review of a future project. Accordingly, a member of the PRC with a potential conflict of interest in a specific situation is recused from participation in that project.

Review Criteria

Review criteria are questions that the sponsor would like to have answered by the RP. In most cases, the sponsor will identify general criteria with the expectation that their various project managers will use them to develop project-specific review criteria. The project-specific questions identified by the project manager are usually provided to the Technical Secretary of the RP who prepares proposed specific review criteria. The final criteria result from consultation among all involved. In cases of disagreement, the EP makes the final decision.

Review Reports

One of the key reasons for the speed and economy of the peer review process described herein is the standardization of the reports resulting from the peer review. The *Technical Peer Review Report* is the product of peer review. Depending upon the desires of the sponsor, it may be completed in its first phase. In this case, the subtitle of the report is *Report of the Review Panel.* The subtitles of two potential stages of the *Technical Peer Review Report* are *Interim Report* and *Final Report* respectively, the latter including the response to the recommendations of the RP by the sponsor and approval of the report by the PRC.

The content of the *Technical Peer Review Report*, outlined below, was optimized with the objective to reduce the labor of members of the RP to an absolute minimum.

1. **Preface:** This segment contains information about various activities that led to the report. It includes the names of all individuals involved in the review. It was typically prepared by the staff of RSI and approved by the EP/PRC.

2. **Peer Review Process:** Although there were minor changes in the review process as it progressed, experience showed the desirability of briefly describing the process that was in effect at the time of the review. Again, the text was prepared by the RSI staff and approved by the EP/PRC.

3. **Executive Summary:** This section included a brief description of the project along with the Findings and Recommendations of the Panel. The first part contained the project summary and the second part, with minor exceptions, was prepared by the RP.

4. **Project Summary:** The sponsor provided the information used to describe what was reviewed. Experience showed that occasionally additional information was necessary to complete this part. Once completed, the Summary was provided to the sponsor for review and approval. The approval was found to be necessary since the RSI staff was summarizing the sponsor's work.

5. **Criteria, Findings, and Recommendations of the Panel:** This chapter consists of Criteria (questions given to the RP); Findings of the Panel responding to each criterion; and Recommendations that were derived from the Findings. This part was prepared by the RP with the assistance of the Technical Secretary.

6. **References:** Literature cited in the Project Summary constituted the bulk of the list of references. In addition, references identified by the RP and elsewhere in the report were also included.

7. **Acronyms:** Many reports included extensive abbreviations and acronyms. This section, prepared by the RSI staff, contained their description.

8. **Biographical Summaries**: This section consisted of standardized biographies of individuals involved in the review. These included members of the RP, PRC, and technical staff of ASME and RSI. Typically, the staff of RSI prepared these biographical summaries and provided them to the individuals for approval.

9. **Appendices:** These often consisted of materials that were added to help the reader.

10. **Minority Views:** Although provisions were made for inclusion of minority views, there was no occasion that a minority view was expressed or desired.

Follow Up

Revisions of the Report of the Review Panel: The Findings and Recommendations of the RP are provided to the sponsor for review. During this process, the sponsor may request a revision of the Findings and Recommendations for the following reasons:

1. A clear error is identified.
2. The RP misunderstood a subject and its findings reflect it.
3. There are ambiguities requiring clarification.

This information is provided to the RP for consideration of possible corrections to their Findings and Recommendations.

Annual Meeting and Annual Reports: For multi-project/multi-year programs, provisions were made to convene an annual meeting where an annual report was presented to the officials of the sponsor. The meeting was organized by the ASME staff and included members of the PRC and others who were interested in the subject.

STAKEHOLDER PARTICIPATION

Recognizing the value of stakeholder participation in peer reviews, Love et al. (2002; 2003) developed a new stakeholder participation process. This process was applied to several peer reviews and the results were reviewed by the PRC. Probably the most successful application of this process was in a review performed for the Nevada Operations office of DOE (ASME/RSI 2001).

RESULTS AND DISCUSSION

During the period 1996 to 2005, about 300 projects were peer-reviewed using the ASME/RSI process. These reviews covered all four types of review. The 2002 report (ASME/RSI 2002) contains a compendium of lessons learned.

The peer review process initially developed for one segment of DOE found wide application not only within DOE but also elsewhere. Initially, the DOE Project Teams were reluctant to participate in the peer review program and considered it to be at best a nuisance and at worst disruptive. As the peer review program progressed, the DOE Project Teams usually found the peer review to be helpful.

During the initial phases of the ASME/RSI peer review program, it was argued that ASME may or may not be able to provide oversight of peer review for a multidisciplinary program that includes virtually all areas of science and engineering. However, experience during the review program showed these arguments to be false.

1. Throughout its history, ASME has developed a close relationship with virtually all professional societies. The Peer Review Committee included a broad representation of all anticipated disciplines.

2. Experience demonstrated that ASME was able to identify highly qualified individuals covering relevant disciplines.

Table 1 shows the diversity of the educational degrees of the peer reviewers. Although the percentage of certain disciplines varies somewhat from year to year, there is a remarkable stability in others. For example, the combined chemistry and chemical engineering disciplines constitute slightly more than one third of all disciplines. Similarly, mechanical engineering constitutes about 10% of the disciplines of the reviewers.

Table 1. University degrees of reviewers (as percent of the total)

	FY97	FY98	FY99	FY00	FY01	FY02	Average	Standard Deviation
SCIENCES								
Chemistry	15.6	27.3	30.2	21.2	23.5	20.0	23.0	5.2
Earth Sciences	8.2	7.6	9.0	15.3	3.4	9.0	8.7	3.8
Ecology, Environmental, Agriculture	4.9	7.6	0.0	3.4	0.4	1.0	2.9	3.0
Biology	4.9	5.8	3.2	0.8	3.4	2.9	3.5	1.7
Mathematics	4.9	1.7	3.2	2.5	2.6	3.3	3.0	1.1
Health Physics, Radiation Biology, Pharmacy	4.1	2.3	1.1	0.0	3.4	2.4	2.2	1.5
Physics	4.1	5.8	4.8	5.1	12.8	11.0	7.3	3.7
Medicine	0.0	0.0	0.0	0.0	0.4	0.0	0.1	0.2
Others	5.7	1.2	4.2	0.8	3.8	2.9	3.1	1.9
ENGINEERING								
Mechanical	12.3	5.8	10.1	4.2	12.8	9.0	9.0	3.4
Nuclear	11.5	6.4	4.2	2.5	6.4	4.3	5.9	3.1
Chemical	9.8	13.4	15.3	12.7	12.0	12.9	12.7	1.8
Civil	9.8	8.7	8.5	22.0	7.7	14.8	11.9	5.6
Others	4.1	6.4	6.3	9.3	7.3	6.7	6.7	1.7
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0		

ACCEPTANCE OF THE PROGRAM

As stated above, the activities of the DOE Office of Science and Technology, an office within the Office of Environmental Management, were criticized by the NRC (1996). A subsequent report (NRC1998) no longer criticized these activities. Instead, the report recommended an increased utilization of peer review. Another study by the NRC (2002) reviewing activities of the Army Corps of Engineers cited the ASME/RSI Peer Review and recommended that the Corps use a peer review remarkably similar to the ASME/RSI process described in this paper. Finally, the Office of Management and Budget (OMB) developed a bulletin mandating peer review for federal agencies. The published bulletin (OMB 2004) specifically quotes ASME as having developed and used a peer review process, implying that it meets the OMB requirements.

CONCLUSIONS

The ASME/RSI independent peer review process has demonstrated its usefulness in virtually all areas of science and engineering, particularly in science and engineering related to environmental programs. It has been recognized by both the OMB and the NRC. The process can be used worldwide with appropriate modifications.

ACKNOWLEDGMENTS

The activities reported in this paper were supported by a grant (#DE-FG02-97CH10876) from the U.S. Department of Energy. The Program benefited greatly from the willingness of highly distinguished individuals to serve on the Peer Review Committee. In addition to certain authors of this paper, Gary A. Benda, Erich W. Bretthauer, Irwin Feller, Robert A. Fjeld, John T. Greeves, William T. Gregory III, Peter Lederman, Jeffrey Marqusee, Lawrence Mohr, Goetz Oertel, Glen Suter, and Cheryl Trottier served as members of the Peer Review Committee. The authors are grateful to the staff of ASME including Howard Clark, Carolyn Davis, Michael Tinkleman, and Norma Johnston. We also thank the staff of RSI, including Sharon Jones and Anthony Leone.

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