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Mark Bodnarczuk
Fermi National Accelerator Laboratory
P.O. Box 500, Batavia, Illinois 60510

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Mark Bodnarczuk

Fermi National Accelerator Laboratory*

Box 500 Batavia, Illinois 60510

ABSTRACT

This paper opens with a brief overview of the purpose of Fermilab and a historical synopsis of the development and current status of quality assurance (QA) at the Laboratory. The paper subsequently addresses some of the more important aspects of interpreting the national standard ANSI/ASME NQA-1 in pure research environments like Fermilab. Highlights of this discussion include, 1) what is hermeneutics and why are hermeneutical considerations relevant for QA, 2) a critical analysis of NQA-1 focussing on teleological aspects of the standard, 3) a description of the hermeneutical approach to NQA-1 used at Fermilab which attempts to capture the true intents of the document without violating the deeply ingrained traditions of quality standards and peer review that have been foundational to the overall success of the paradigms of high-energy physics.

FERMILAB'S GOAL

Fermilab is a single purpose, high-energy physics laboratory that houses and operates the highest energy particle accelerator in the world, the superconducting Tevatron. All scientific disciplines have foundational presuppositions which heuristically guide the direction of the research programs of the entire discipline. High-energy physicists are committed to the powerful presupposition of atomism, i.e., that the entire universe is composed of fundamental constituents which interact with one another according to specific laws. The ancient atomists Democritus and Lucretius (5th and 1st century B.C.), believed that there was a reality underlying the observable universe and that it was composed of unchangeable, indivisible, and invisible particles which they called atoms. They claimed that the changes that we observe in our physical world (motion, growth, death) are due to the arrangement and rearrangement of these invisible atoms.

Modern theories of high-energy physics still conceptually explain the macrocosmic world by appealing to microcosmic entities, but the fundamental constituents that high-energy physicists explore today, quarks and leptons, are not simply rational or conceptual constructs of the mind. Quarks and leptons interact physically in the beams and detectors at Fermilab. The superconducting Tevatron produces proton and antiproton beams with energies of nearly a trillion electron volts each (TeV) and is currently colliding them together in the center of the huge sophisticated Collider Detector at Fermilab (CDF). In the collisions, the energy poured into each of the particles during the acceleration process (relativistic mass) is released and transformed into myriad particles. Most times the colliding proton and antiproton beams create more than 10^{30} particle events (10^{12} = 1 trillion), a few of which are the exotic particles like the the W and Z vector bosons, carriers of the weak force. In addition, Fermilab has just completed a fixed-target physics run in which 800 GeV protons from the Tevatron were directed toward stationary targets, providing a variety of secondary and tertiary beams for 16 experiments. Located

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on 6,800 acres of land, 30 miles west of Chicago, with an annual budget of about $170 million and 2,200 employees, Fermilab is a premier high-energy physics laboratory.

THE HISTORY AND STATUS OF QA

The history and interrelationship between QA professionals and scientific researchers has been long and sometimes antagonistic. In the early 1970's, what was then called the Atomic Energy Commission launched a program to standardize the quality assurance programs at laboratories that were involved in nuclear reactor research. Because this was a new endeavor, one of the key issues was to find QA models that could be used as guides in developing these programs. The early programs used models from the aerospace and nuclear industry as a guide, producing the Reactor Development Technology (RDT) Standards. These were heavily influenced by traditional safety methodologies. Over the course of the next ten years, some of the scientists and engineers who did the technical work at these laboratories increasingly viewed this approach as a rigid bureaucracy which could usurp management prerogatives and even threaten the goals of some programs. The result was a rejection of this type of so-called "institutional quality assurance" by many laboratory personnel. Some researchers even left the laboratories because they felt that the regulations were undermining the process of scientific advancement. Most ironically, these programs (even when implemented) often produced little or no progress toward effective institutional QA programs. QA professionals wondered how they could develop an institutional QA approach that assured real quality and didn't drive the scientific talent away from the laboratories or stifle one of the most important aspect of scientific progress; creativity.

By 1981, the need for new directions in QA was unavoidably recognized. But the one problem faced previously (the need for appropriate QA models to be used as a guide) once again demanded a solution. What should the DOE use as a model for QA design and how could they avoid the confining effects of the previous AEC programs? A few years earlier in 1979, an ASME Committee prepared an American National Standard called NQA-1 which was to be used in designing, building, and operating nuclear power plants. The DOE subsequently began using NQA-1 as the preferred model for QA. Shortly thereafter, DOE Order 5700.6A and 5700.6B (Quality Assurance) required all DOE contractors to have a QA program that meets the eighteen basic requirements of NQA-1. However, this order has been slow in implementation because some national laboratories resisted taking a single document like NQA-1 which was specifically designed for nuclear reactors and applying it to all laboratories, even basic research facilities like Fermilab.

Fermilab historically has had rigorous peer review and quality standards which produced a successful 20 year operating record of proposing, building, running, and completing high-energy physics experiments. Yet this was accomplished without a formalized, institutional QA program. After the advent of DOE Order 5700.6B (Quality Assurance), the Director's Office at Fermilab organized the Quality Assurance Committee (QAC) and as Chairman, I was directed to create, develop, and implement an institutional QA program. The QAC is composed of appointed QA Officers from each Division/Section at the Laboratory who share line responsibility for QA in that division and represent their division to the QAC.

THE HERMENEUTICS OF NQA-1

DOE Order 5700. 6B (Quality Assurance) raises the primary issue addressed by this paper. Although NQA-1 was written and designed specifically for use in nuclear reactors and nuclear facilities, the DOE Order requires even non-nuclear facilities like Fermilab to comply with the 18 basic requirements of NQA-1. During the last two years, one of the significant problems that faced the new QA staff was how to integrate and apply NQA-1 to the existing laboratory structures in a way that both satisfied the requirements and did not displace the deep sense of peer review and quality traditions that are built into the high-energy physics community. Some QA professionals suggest that the full "traditional" application of all the requirements of NQA-1 is appropriate even in these non-nuclear facilities, while other QA professionals have asserted that this approach is unrealistic and even counter productive. Given the fact that non-nuclear laboratories must use NQA-1 as a standard, how can this be accomplished effectively? This paper describes one model that has been used successfully to address this question. The remainder of the paper will attempt to show that the success or failure of an NQA-1 based institutional QA program at a non-nuclear laboratory like Fermilab depends crucially on how NQA-1 is interpreted and how it is applied.

What is hermeneutics and why are hermeneutical considerations relevant for QA? Webster's dictionary defines hermeneutics as "the methodological principles of interpretation in regard to legal, literary, and biblical texts." Hermeneutics has two distinct yet related components. The first is the interpretation of documents within the *context* in which they were written, the second is the application of those interpretations to other *non-related contexts* and environments. These two components comprise an important concept which we will call *context sensitivity*, i.e., not directly imposing something that was written for one *specific context* indiscriminately upon an entirely *different context*.

For instance, the writing and passing of legislation in the United States is not an end in itself. One law must often be interpreted in myriad different contexts, making it difficult to determine the true intent of the law as applied to widely divergent cases. A major hermeneutical problem today in jurisprudence is trying to understand what the United States Constitution meant within the historical context in which it was written, and how we can apply those same laws today in a country that is far removed both in time and culture. The Supreme Court must fold *context sensitivity* into its decisions about, and interpretations of, our laws. This paper suggests that NQA-1 is as subject to the interpretive and applicative principles of hermeneutics as any other field including jurisprudence. In fact, the problems of applying one law to vastly different cases is precisely analogous to our issue of applying one standard (NQA-1) to many very different nuclear and non-reactor laboratories. Using NQA-1 likewise demands *context sensitivity*.

We will now present a critical analysis of NQA-1, focussing on the teleological aspects of the standard (teleology has to do with goals from the Greek word *telos* which means end or purpose). What is the overall goal and teleological purpose of NQA-1? As stated earlier, NQA-1 was specifically designed as a guide in developing QA programs for nuclear reactors and nuclear facilities. It consequently describes both the requirements and non-mandatory guidelines for siting, designing, constructing, operating, and decommissioning nuclear facilities. The document has a modular design, i.e., the basic and supplementary requirements allow an individual to use the entire document or only portions of it. The number of modules used depends upon the nature and scope of the work being performed and requirements imposed by the sponsoring agencies. NQA-1 was designed to provide an organized framework which applies to any structure, system, or component essential to the satisfactory performance of a nuclear facility. The full "traditional" application of NQA-1 to nuclear facilities operated under contract for DOE is required and appropriate. The real issue in this paper is this, to what degree do the goals, categories, and guidance found in NQA-1 capture the essential components of *all* projects including those at non-reactor facilities? The answer to this question depends on how the standard is interpreted and subsequently applied.

There are two standard ways of interpreting NQA-1, traditionally and non-traditionally. The traditional approach uses NQA-1 as a "grid" into which the "wax-like" management structures and the procedures of personnel are poured. The result is a molded structure formed "in the likeness of" NQA-1. The mapping between NQA-1 and the organization is designed to be 1-to-1. This approach is appropriate and necessary for nuclear reactors and other high-level nuclear facilities. But in basic research facilities like Fermilab, the nature and design of the management structure and the broad parameters of the operations of the laboratory are the choice of the contractor. It is in these environments that "non-traditional" interpretation and application of NQA-1 has been used with success. In these situations, NQA-1 is used as a standard against which the existing quality traditions and peer review standards of the laboratory and the scientific community are measured and, if necessary, changed or re-normalized.

The issue at stake here is the appropriate use of NQA-1 in the appropriate environment. More precisely, it is using NQA-1 as a tool, matching the proper application of the standard to the job being done. This is just good common sense. All tools must be appropriately matched to the jobs they are used for. One does not use a twenty pound sledge hammer to gently tap a tiny gear into a Swiss watch and neither does one use a tiny jeweler's hammer to break up the black top in a driveway. Both are hammers. Both are useful when used properly. Both are useless or destructive when used in the wrong application. Attempts to apply NQA-1 traditionally in non-traditional, non-nuclear environments can lead to the "twenty pound sledge hammer effect" on the creativity of laboratory scientists. The result can vary from covert resistance to overt noncompliance.

The non-traditional hermeneutic for NQA-1 attempts to capture the true teleological intents of the document without displacing the deeply ingrained traditions of quality standards and peer review that have been foundational to the overall success of the theoretical and experimental paradigms of high-energy physics. By using the non-traditional approach, Fermilab has not only overcome some of the historical antagonism between scientists and QA professionals, but it has developed an institutional QA program that fully complies with the intents of NQA-1 without seriously constraining the creative abilities of our scientists. This same basic approach is elastic enough to accommodate alternative versions which have been used at other laboratories with success.

CONCLUSION

What are hermeneutical considerations and why are they relevant for QA? The important issue here was *context sensitivity*, i.e., not taking a document specifically designed for one context and indiscriminately imposing it upon very different contexts. In our case, this means flexibility in the way that NQA-1 is applied to "non-traditional" basic research facilities. What are the teleological aspects of NQA-1 given this "non-traditional" interpretation? NQA-1 should function as a standard/reference point against which procedures and quality traditions in the scientific community can be compared, measured, and if necessary renormalized. It should not be viewed as a structure into which the "wax-like" management structures and procedures of personnel can be poured.

Finally, some QA professionals have suggested developing another national consensus standard to use in non-nuclear environments where institutional QA is needed or required, but as we have suggested this is not necessary. NQA-1 *is* an appropriate standard for non-nuclear environments *if* interpreted and applied properly. In addition, developing another national consensus standard would not only demand a significant amount of time and money, but in the end it would reintroduce the same problems that we have solved hermeneutically, namely how should this *new* national consensus standard be applied to a wide variety of national laboratories.