

TQM, ISO 9000, and Commissioning (“Lets be practical”)

Wayne A. Dunn PE and Wade H. Berner EIT
Sunbelt Engineering, Inc.

Abstract:

Diversity between building projects and construction methods is such that it is not possible to evoke a single phrase, *commissioning*, directly or conceptually and assume all building performance problems are solved. Commissioning has been defined as everything from a testing phase that concludes construction, to a quality management technique applied to a project from concept to turnover and beyond. Therefore, simply purchasing commissioning may not yield desired performance. A link is needed that ties managing performance to the process that verifies achievement of defined performance goals. That link may be certification.

TQM (total quality management) was developed by W. Edwards Deming to assist in creating a management environment that would yield consistent performance. International Standards Organization (ISO) applies discipline to that concept requiring a structured well-documented management environment capable of withstanding an audit. One could quickly build a library in the study of management techniques devoted to achieving performance: Peter Drucker (Management by Objectives), Tom Peters (In Search of Excellence) and Stephen Covey (7 Habits) just to name a few. This may be the path to certification.

This presentation is intended to provide an overview of the relationship between recognized quality management techniques and commissioning. Specifically it will deal with tying the quality certification process defined by ISO to commissioning as defined in ASHRAE GPC1-1996. Questions that will be raised are:

- Is it possible to certify a construction project to ISO standards?
- Is it practical to certify a construction project to ISO standards?
- Will a fully commissioned, ISO certified facility guarantee desired performance?

It is the belief of this author that design-build projects are gaining momentum in the industry, battling only barriers of price versus performance. Imagine the power of an ISO certified Design-build Corporation that guaranteed not only price and schedule but also performance; specifically performance that exceeds traditional codes or standards.

TQM, ISO 9000, and Commissioning

Total Quality Management (TQM) is a principle that specifies a management strategy for quality control. TQM was developed many years ago to enhance the management environment for the purpose of improving and streamlining manufacturing performance. In effect, increasing product quality, improving productivity, as well as, reducing or eliminating the need for massive checking and revisions of the final deliverables to the end user.¹

International Standards Organization (ISO) is a defined process which offers assistance in assessing the consistency of performance through a structured process of documentation. Like TQM, ISO Standards are commonly used in manufacturing where a physical commodity is mass produced. Consistent performance does not ensure desired performance. Certifying a process to

an ISO standard will only be beneficial if the achieved level of performance is satisfactory. Simply put, if you have a process that consistently produces poor performance, than ISO will ensure that every product produced will yield the same inferior performance as the first. Neither TQM nor ISO were developed for unique project specific applications.

Commissioning is a project specific procedure designed to prevent errors and verify performance by planning for success. Beginning with design concept and concluding with the end of the first year of warranty performance goals are defined (design), realized (construction), proven (start-up), and maintained (turnover).² This complete project quality management definition of commissioning begins with determining commissioning scope and developing a commissioning plan. Commissioning participates in design review relative to the basis of design, design intent and test specifications. This design phase step is essential to ensuring performance verification is in the construction contract. Continuing into the construction phase, the commissioning testing documents are produced and construction inspections are audited. Start-up phase involves component, system and integrated system verification. Finally, documented proof of performance, as well as, system operation manuals are turned over by the commissioning team to the Owner's staff to ensure effective technology transfer.

However, commissioning has many interpretations. These interpretations vary in scope from enhanced test and balance to complete project quality management. Due to this wide range of commissioning expectations, it is safe to say that merely employing commissioning can not guarantee superior performance. It has been proven that a commissioning process initiated into a project from design through turnover, improves performance substantially.³

The concept put forward by the authors, is one of taking our complete, project specific, quality verification interpretation of commissioning and molding it with the consistency of an ISO process. This strategy lends itself to improving the quality of a building. Evaluating the plausibility of such a combined effort brings up the following questions.

- Why use a certified verification process for design-build construction?
- Is it possible to certify the verification process for a design-build construction process?
- Is it practical to certify the verification process for a design-build construction process?
- Will this certified process of consistent quality guarantee desired performance?

Why Use a Certified Verification Process for Design-Build?

The benefits of certification are obvious, defined performance and improved customer satisfaction. The obstacles to certification could be any of the following:

- Cost of implementation
- Extension of schedule
- Potential to increase liability

These common fears can be overcome with the integration of commissioning and ISO into design-build. Perceived cost, schedule and liability increases, incurred by the certification process, are countered by efficiencies created through effective commissioning.⁴

Understanding Design-Build

Design-build is a procurement method where one group is contractually responsible for both design and construction of a project. Industry leaders predict that in the next decade, 50 to 80 percent of all major commercial and industrial construction projects in the U. S. will be performed using a design-build agreement. As recently as 1995 this number was less than 20 percent⁴. (See Figure #1)

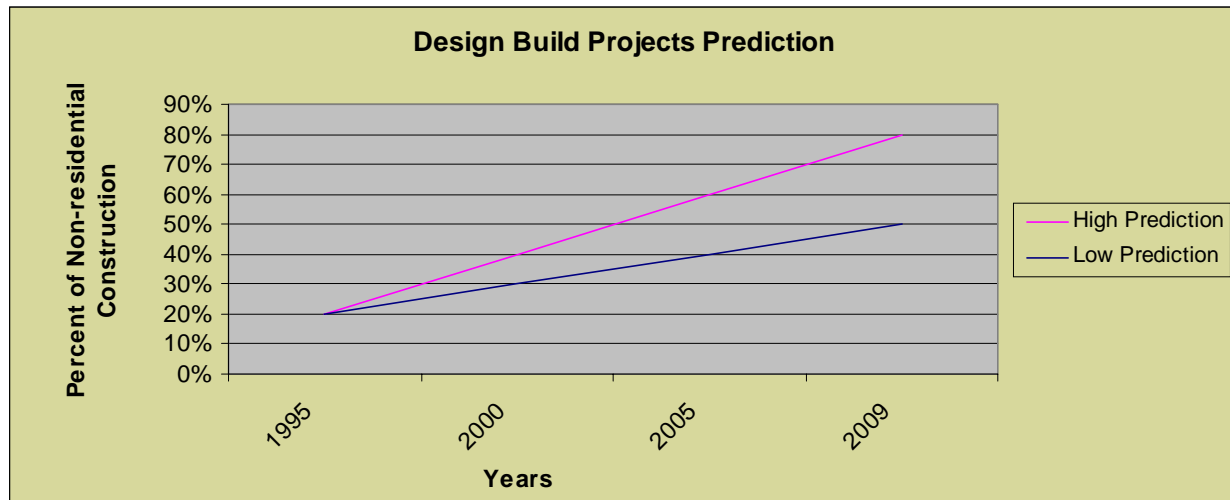


Figure #1 – Design-Build Prediction for 2009 (50%-80%)

A major driving force for design-build projects is the cost and schedule benefits realized when a design-build format is applied. Cost and schedule can be driven down due to the following⁴:

- Reduced design time with direct interaction/ partnership between designer and builder.
- Reduced construction time by fast-tracking or overlapping phases of the project.
- Shorter project schedule reduces cost by lowering financing and administrative costs.
- Reduced conflict between design and construction eliminating of change order costs.

Although design-build formats can improve project costs and reduce the project schedule, what it fails to clearly improve is quality. (See Figures #2a & 2b)



Figure #2a



Figure #2b

Figure #2a emphasizes how reaching the initial goals of design-build can sacrifice quality. This can result in an inexpensive, quickly produced facility with poor performance.⁴ Specific quality issues associated with design-build are:

- Less input and control by Owner over the final design. Architect works for the contractor.
- Quality suffers if contractor arbitrarily changes materials or equipment to reduce budget.
- Designer selection may have been based on price rather than qualifications/ experience.
- The design firm's objective may be to turn out a generic design quickly.
- Equipment and systems are accepted without proper verification or testing.
- Owner's specific needs are poorly reviewed and final design may not meet expectations.

Figure #2b shows the ultimate objective is equal emphasis on all three project priorities. The only way to make quality a priority is to make proof of performance a project deliverable.

Understanding Commissioning

Commissioning is essentially performance verification. A commissioning team uses comprehensive testing, coupled with a structured documentation process to ensure a facility will perform to the expectations of the Owner. Commissioning can even take it a step further using test results to determine opportunities to optimize building performance for even higher efficiency. We must remember, as we mentioned at the beginning of this document, due to the variance of commissioning definitions, simply employing the process will not guarantee performance. Certification is part of the quality solution.

Understanding ISO

ISO 9000 is a generic term to describe a series of standards relating to quality control. ISO 9000 is composed of twenty certification elements. ISO 9003 (Model for Quality Assurance in Final Inspection and Testing)⁵ is the logical standard to apply to commissioning. Sixteen of the twenty ISO 9000 certification elements are used by ISO 9003 which relate to management, document control, corrective actions, quality systems and training. Of these sixteen ISO 9003 certification elements, fourteen apply to certifying the commissioning process.

Is it Possible to Certify a Design-Build Verification Process?

Manufacturing quality control is described under two distinct entities. The first, TQM is a strategy as to how a corporation or process should be managed to promote quality. The second entity, ISO, is essentially standards for certification and evaluation. If the manufacturing program changes from the certified process, the ISO program must adjust to accommodate any change. When the manufactured products are buildings, where no two construction projects are alike, then constantly modifying the ISO certification of each project would be very challenging.

Introducing Commissioning into a Design-Build Construction Process

Even in design-build, commissioning functions at the direction of the Owner and reports, contractually, to the Contractor. The Contractor will liaise directly with Commissioning indicating testing schedules along with identifying and resolving problems.

The contract documents will require the Contractor to conduct performance verification testing of all components, systems and integrated systems. Commissioning verifies that this testing is conducted and documents the process. Should a component/system continue to fall short of performance requirements, solutions are developed by the entire Project Team. The contractor corrects the deficiency and, together with commissioning, re-tests the component/system.

Facility turnover requires the contractor provide project specific technical information for the operation and maintenance manuals on all components/systems. Commissioning develops the systems manual, coordinates training and turnover of the project documents.

Certifying the commissioning effort allows the process to be used on multiple projects. Once the process has been certified, it receives timely ISO audits to ensure continuing compliance. Commissioning, unlike ISO, is structured to adapt to the needs of a particular project.

Introducing ISO Certification into a Design-Build Construction Process

When a project is built and commissioned, the process by which it was commissioned is ISO certified. As each subsequent project is constructed and commissioned, the facilities design and performance criteria vary to suit the project. Therefore, the commissioning effort adjusts to meet the goals of each facility. ISO's only responsibility is to ensure that the commissioning process remains in compliance with the certified standards.

In order to implement ISO certification for the design-build construction of a new facility, a commissioning procedure must be developed to fit the ISO standards requirements. Certifying the commissioning procedure allows for it to be used on a range of facilities, not just the current program. ISO can remain its rigid form of audit for future projects, because commissioning will customize itself to accommodate ISO. As stated in the commissioning section above, commissioning is a procedure specifically developed to adapt to any construction process.

This can be done because ISO does not require the same data for auditing every product. So, even though ISO can not adapt from project to project, commissioning can provide the appropriate data from changing projects that fit the ISO format. If the quality control program audit data, documented by commissioning is in accordance with ISO certification requirements, then the ISO auditor will be happy and certify the commissioning effort.

As shown below in Figure #3, commissioning process requirements varies slightly from that of the ISO standards. Adjusting the layout of the commissioning process can provide the foundation for an ISO certified process. Based on these similarities, it is possible to move from a completely commissioned project to an ISO certified project.

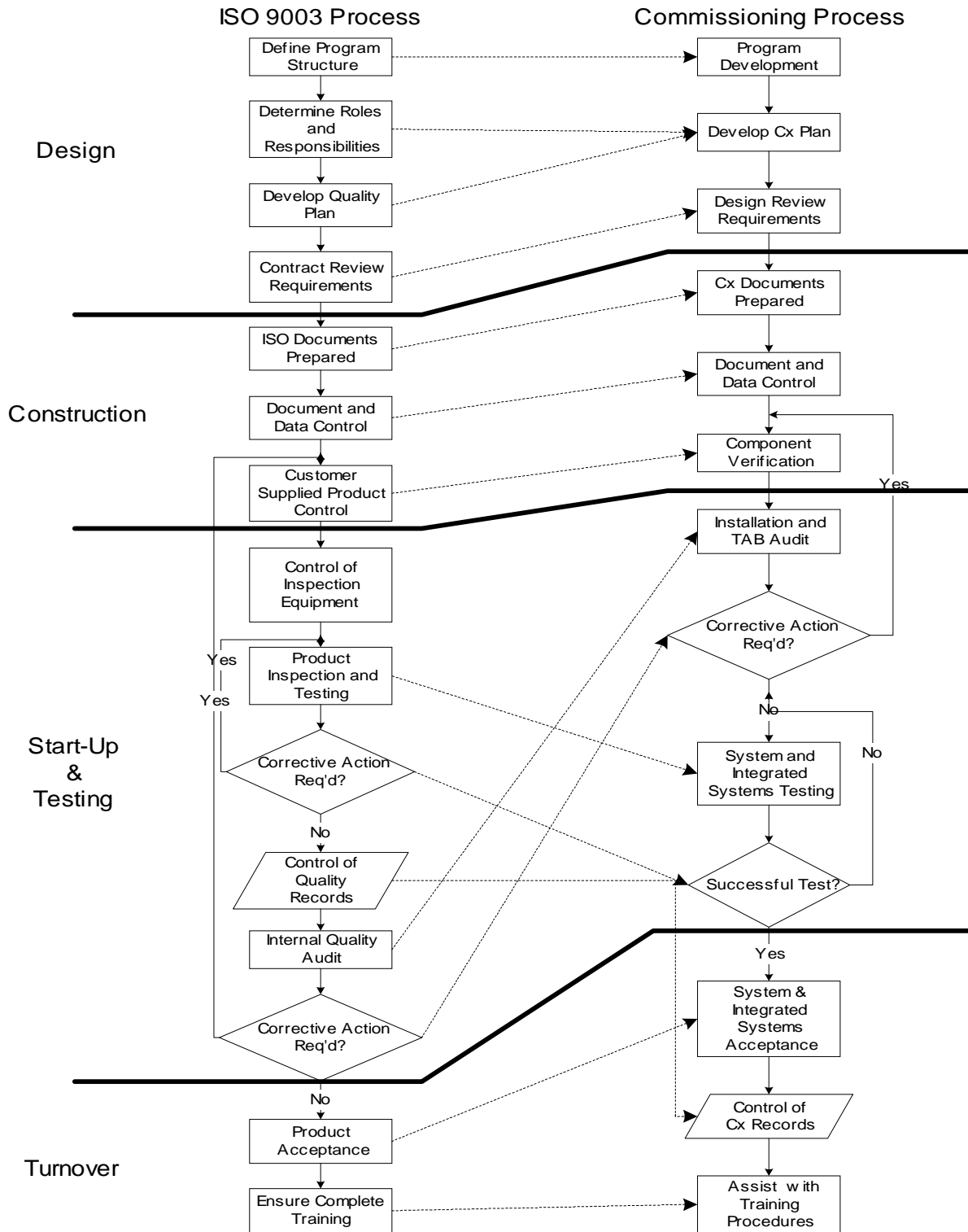


Figure #3 – ISO 9003 Process Applied to Commissioning

Is It Practical to Certify a Design-Build Verification Process?

The practicality of implementing a certified verification can be evaluated simply as matter of price. Pricing depends on the complexity of the project and at what phase in the project, the process is introduced. Increasing the project complexity will increase the cost of construction, as well as, the cost of the verification process. Commissioning costs vary according to Figure #4.²

SCOPE	COMPLEXITY →		
	From DESIGN	.5%	2%
From CONSTRUCTION	.1%	1%	2%
From START-UP	0.05%	.5%	1%

*

Figure #4 – Commissioning Costs at Different Implementation Stages
(* - ISO certification can only occur when commissioned from this stage)

Understanding the Project

Building projects vary dramatically both in size and complexity (e.g. apartments, laboratories). Therefore, determining the best time to incorporate commissioning into the project is very important. One must look at the desired performance of the project as well as its complexity. These factors are crucial to determining the need and level of commissioning to be implemented.

ISO is not based on the same criteria. ISO is a defined process that requires complete implementation regardless of size and complexity of project. Therefore, a complete integrated design and turnover commissioning process is required to achieve ISO certification.

Design Phase

Commissioning begins with initial design concepts setting performance goals and ensuring the design can be tested to meet those goals. The commissioning team then assists the project team in establishing the following objectives:

- Establish goals for project duration and cost (include \pm percentage) together with deciding on relative importance of project duration, cost to specific quality objectives.
- Determine the need for managed quality and how comprehensive a quality assurance program will be required. Establish goals for this program that encompass building elements not covered by codes (i.e. power quality, comfort, air quality, noise, and energy signature).
- Identify the operating and maintenance policies, procedures and personnel to enable input from that source into design, construction and commissioning.

ISO 9003 certifies the design phase commissioning effort through its quality system requirements 4.1 and 4.2⁵. These sections outline program and design phase efforts to be carried out which involve defining program structure and developing the quality plans.

Construction Phase

One of the benefits of undertaking commissioning during design is that the phase is set for the verification process. Contractors are aware of their roles in the commissioning scope and the Owner is aware of what will be done with regards to performance verification in their building.

Component verification, functional testing of systems and integrated systems are the meat of the construction phase commissioning process. Testing is the sole indication of building performance that can be obtained before project closeout. Once the building is complete and trended data is accumulated, the building performance can be reviewed again. At this point any further fine-tuning becomes the responsibility of the Owner's trained operating personnel.

ISO 9003 certification ensures construction conformance using requirements 4.3 to 4.7⁵. Documents are created for project recording and auditing purposes. The document and equipment control systems are initiated and begin tracking project data.

Start-Up and Testing Phase

As construction concludes commissioning activities intensify with extensive start-up and system testing. Commissioning oversees equipment Start-up procedures and functional testing of the control system for approval of use for testing, adjusting, and balancing (TAB). Commissioning is directly be responsible for all TAB and approves TAB efforts through field audit.

Commissioning then directs, witnesses and approves functional performance tests for equipment, system and integrated system commissioning. Functional testing includes operating the systems and components through each of the written sequences of operation. This includes startup, shutdown, unoccupied mode, manual mode, alarms, power failure, security and all systems or equipment interlocks. Items of non-compliance are reported by the commissioning, corrected by the Contractor, and the system re-tested.

ISO 9003 sections 4.10 through 4.17⁵ outline the auditing process that occurs for ISO to certify a testing process. An internal quality audit is performed to certify all the appropriate documentation has been filled out correctly and provided.

Turnover Phase

During turnover, training occurs before fine-tuning begins. Commissioning is responsible for coordinating meetings, ensuring owner participation, and reviewing information quality.

The CA's responsibility during this phase also includes verification of project completion and coordination of turnover documents. Objectives during turnover and acceptance are:

- Conclude all aspects, including documentation, of performance verification
- Conclude all training as well as equipment and systems demonstrations
- Prepare a commissioning report

In addition, in order to review the building performance, it is essential that there is a comprehensive list of system control points to be trended over a selected period of time. This is crucial in proving building performance and determining the optimization points in a system.

ISO 9003 section 4.18 requires competent and trained personnel to conduct the testing of the product or facility. They certify the competency by gathering proof of experience from the commissioning team and recording the commissioning training data for the Owner's staff.

Can We Guarantee Performance?

Yes, Commissioning is performance verification. Owners expect performance; commissioning must provide an Owner with proof of performance along with evidence that performance can be maintained. The commissioning professional entrusted with the planning, witnessing and documenting success should bear the same measure of responsibility as those entrusted with designing and constructing the project. In fact, it is incumbent on commissioning to seek system optimization opportunities that would enhance project performance beyond contract goals.

The purpose of ISO certification is to guarantee consistent performance by structuring and auditing an entire process. It is a defined sequential process that is inflexible in its procedure to set up guidelines and checkouts for ensuring performance.

Coupling commissioning and ISO certification will produce one unique and powerful hybrid. A process that lays out a procedure to achieve performance goals, verifies and documents that those goals are met, and does this consistently. This defined sequential process:

- Reviews the performance criteria during design to ensure incorporation.
- Audits procedures throughout the entire project for conformity to basis of design and design documentation regarding the achievement of performance goals.
- Validates the performance of all components, systems and integrated systems of a facility.
- Fine-tunes the facility for peak performance once construction is complete.
- Documents every procedure, at every phase, to include with the turnover documentation which further outlines the performance goals of the facility along with maintenance procedures on how to maintain them.
- Repeats this process for every facility it is implemented on.

Performance is a major concern in this day and age where efficiency and cost savings motivate facility designs and construction. Owner's want design-build.

In addition, as buildings increase in complexity and codes/standards grow tighter, performance is becoming the most difficult goal to reach. When the processes of commissioning and ISO are banded together for the purpose of verifying this new level of performance, then the results are both proven and guaranteed with certified documentation.

References

1. Dunn, W., P.E. & Whittaker, J., P.Eng., Ph.D, *Building Systems Commissioning and Total Quality Management*. ASHRAE Journal, Edmonton AB, Canada, Sept., 1994
2. Dunn, W., P.E. & Berner, W., E.I.T., *Evaluating Commissioning Scope and Investment*, 1999
3. The Chartered Institution of Building Services *Symposium Proceedings of Testing and Commissioning of Building Services Installations*. London, England:. Nov. 3, 1977
4. Bradley, Don, *What is Design Build? Is it Right for Your Project?* , Tompkins & Assoc., 1999
5. Praxiom Research Group Ltd., *ISO 9003 Translated into Plain English*, Internet, Jan., 2000

Authors: Wayne A. Dunn PE & Wade H. Berner EIT

Wayne and Wade both work with Sunbelt Engineering, Inc. (www.sunbeltengineering.com) in sunny Florida. Wade is the ambitious young guy who does the work (i.e. writing 80% of this article). Wayne's responsibility is to write this synopsis, give the speech, and take the credit.

Wayne Dunn is recognized for leadership in project management, systems quality assurance, and commissioning, having participated directly in this specialty for ~20 years. This recognition has led to Wayne's direct participation in seminars, speaking engagements, and committees setting guidelines or standards for Building Systems Commissioning. Together with Sunbelt Engineering, Wayne has acted as the principal in charge of commissioning over 1 ½ million square feet of new office space as well as two lab retrofits and one new teaching laboratory.

After graduating in Industrial Engineering Wade Berner worked with the Canadian Federal Government on commissioning their national virus laboratory. Indentured by Wayne in August 1997, Wade began work as the site engineer, leading and coordinating the commissioning efforts on Brown University's new teaching laboratory. Wade was also the site engineer for the State of Florida Capital Circle Office Complex Phase II expansion (~½ million square feet).

Currently, Wayne and Wade are commissioning the Lockheed Martin Astronautics (LMA) launch platform infrastructure systems for the Evolved Expendable Launch Vehicle Project. LMA (www.ast.lmco.com) is an ISO 9002 certified corporation and is internationally recognized for leadership in performance based engineering applications (e.g. F-22, Atlas V, Titan, X-33).