Attributes of a Comprehensive B149 Field Approval Program

At ENEFEN our specialization has been combustion systems since 1982. Originally, we were the clients of local Authorities Having Jurisdiction (AHJs), who evaluated and approved our engineered designs that were installed on hundreds of projects. In 2003, recognizing the requirement for third-party field approval services, we developed our own unique method of conducting field approvals on behalf of other companies prior to the existence of the Standards Council of Canada (SCC) gas fired appliance Inspection Body (IB) program. In fact, we were among the proponents for the creation of this program and one of the parties who contributed to its development. ENEFEN became the first SCC accredited IB in May 2013, a designation we maintained singularly for many years after. In recognition of our combustion expertise we were granted "type C" IB accreditation by the SCC. This designation allows us to both design and field approve fuel-fired appliances. ENEFEN remains as the only "type C" IB in Canada

Since 2003 we have completed nearly 10,000 field approval projects for various industries, with heating capacities ranging from thousands of Btu/hr to billions Btu/hr and with widely varying levels of complexity and control strategies, from simple certified burner management systems to sophisticated SIL rated IEC61511 solutions (standard for functional safety of safety instrumented systems for the process industry sector).

As a result of our extensive experience, we have learned that a life-cycle analysis is important for systems of all sizes and functions. Owners of fuel-fired appliances require functional appliances long after the field approval inspector leaves the site. In many cases the industrial and even commercial appliances last for as long as 30 to 40 years. As such, it is essential that a long-term life-cycle is incorporated when initially evaluating these appliances.

Currently the life-cycle of an appliance is not explicitly addressed in the CSA B149 family of codes. However, the 2015 version of CSA B149.3: *Code for the field approval of fuel-related components on appliances and equipment*, contains reference in the PLC based BMS section 9.7.1 to full compliance with the IEC61511 standard, which includes consideration for the life-cycle analysis. Furthermore, the 2020 version of CSA B149.3: *Code for the field approval of fuel-burning appliances and equipment* includes the addition of Appendix I: "Risk-based program for determining requirements for an appliance in a complex and integrated facility". Importantly, this appendix uses the IEC61511 standard as the main tool for evaluation of compliance. Moreover, this progression demonstrates a gradual but certain shift towards the recognition of life-cycle as an essential part of the field approval process.

Despite this observed shift, consideration within the Codes for the full scope of hazards encountered in industrial and commercial fired appliance installations remains incomplete. Nevertheless, and in consideration of our expertise and experience, we continually advocate a holistic view of the problem be the basis of a comprehensive field approval program. Though we feel support for this holistic approach to field approval is already evident throughout the Codes by inclusion of such terms as "suitability for their

particular purpose", "proper pressure, function, operation", "reliability", "reasonable concepts of safety, substantiality, and durability", etc, we acknowledge the omission of any direction on how to implement such a program other than relying entirely upon the knowledge and experience of inspection personnel conducting field approvals. To address this gap, we have developed our own proprietary methodology known as the "Fired Appliance Evaluation Paradigm" illustrated in the diagram below. This methodology is the basis of how we look at all appliances we inspect and is representative of the holistic view mentioned previously. Commitment to this methodology compliments our duty as Professional Engineers to advise appliance owners of any and all potential problems which may be encountered with their appliances rather than restricting our approach to the issuance of rating plates alone.

The diagram illustrates twelve areas of focus which must be considered in the appliance evaluation process culminating in field approval as conducted by a professional who is knowledgeable and experienced with the appliance design, application, and all relevant codes and standards. Moreover, it represents the responsibility of the involved professional to possess and apply a comprehensive knowledge base of the intent and purpose of codes and standards rather than reliance upon such to serve as prescriptive design guidebooks.

It is our experience that these twelve factors are interrelated and essential evaluation components and that the optimal solution for the life-cycle of an appliance can only be found if there is balance among them whereas solutions which focus upon one of these factors alone are most prone to failure.

Individual consideration of these twelve essential factors is as follows:

1. SAFETY – Since CSA B149 Codes are defined as safety codes, the primary assumption of many evaluations is that safety is assured by following the codes alone. While it may be true of simple applications, where a fail-safe design providing for an immediate transition to a de-energized state is sufficient, this cannot be assumed for continuous industrial processes where start-up or shutdown of the process may be the most hazardous aspects of the operating cycle. Using the analogy of an aircraft viewed as a process, it would not be advisable to turn off the engines mid-flight. The aircraft must first be brought to a safe landing before the engines are turned off. Likewise, there are some industrial processes, which also require a "safe landing" in order to protect the process or the environment in which the process operates. It is therefore essential to view the safety of any appliance beyond the two traditional objectives of safety of people and safety of property (starting with the appliance itself) by incorporating safety of the process and safety of the environment. Importantly, balance among these categories of safety must be sought to mitigate the extremes of insufficient safety or its counterpart excessive safety. With the former the appliance will never shut down, as opposed to the latter, where it will never operate.

2. SUITABILITY – CSA B149 Codes require an evaluation of the suitability of an appliance but, as mentioned previously, do not explain what this entails. Of course the suitability of individual components for pressure, temperature, flow, electrical rating, and similar physical characteristics as well as metallurgy and suitability of other materials of construction are important, so too is the suitability for process, ambient conditions, fuel quality and pressure, electrical area classification, control strategy, or level and quality of supervision. It is actually not uncommon that an appliance, which at the first glance seems to meet all of the requirements of these Codes, is not suitable for the service it was purchased for.

3. PROCESS – In an industrial process where an appliance serves as just one part of a larger process, inherent with integrated control strategy and expectation of uninterrupted flow of a product through the process, limiting evaluation to the single appliance proposes obvious concerns. However, as written, CSA B149 Codes do not give any consideration to such scenarios; rather, appliances are considered individually which necessarily requires the evaluator to be aware of the overall process integration. . Moreover, these overall process requirements may dictate the specifics of the design of an appliance including its physical arrangement and control interlocks with other parts of the process, and may override typical code requirements used for standalone appliances. An incorrectly designed appliance may affect not only the above-mentioned safety of the process but also its effectiveness.

4. PERFORMANCE – Another omission from the B149 Codes as written pertains to the overall performance of an appliance. Performance is therefore assumed to have been a point of negotiation between the appliance manufacturer and the user based upon design specification, warranties, and calculations. In reality, many appliance installations fail to incorporate any mechanism to verify performance in any manner. As a result, it is entirely possible to have a seemingly "code compliant" appliance poorly performing or not performing at all. This may be due to improper sizing of components, improper installation or simply an incorrect design assumption. Whatever the cause, based upon our experience, the effect of inadequate performance can be a major safety hazard. Consider the following routinely experienced scenario. An operator pressured by the process demands, may try to "improve performance" of the appliance by bypassing the safety functions, de-tuning combustion, or modifying other parameters which should not be adjusted. The most common "solution" for a poorly performing appliance in the oil and gas industry is to increase the fuel gas pressure regulator set point to presumably "push more heat" into an appliance. This is routinely done without a combustion analyzer and in total disregard for the balance required among fuel and air to ensure complete combustion. Of course a clear understanding of performance would discourage such action; however, when compounding situational factors such as a process shutdown in the middle of the night at -40 deg C ambient temperature arise, operators may choose to do whatever it takes to "keep things going" in order to avoid an even larger problem with the entire process.

5. RELIABILITY – As previously indicated, with no specific consideration of appliance life-cycle within the B149 Codes at present, traditional field approvals fail to evaluate appliance reliability as a critical item to be addressed. In consequence, a seemingly code compliant and suitable appliance, which performs properly in a given process during the initial commissioning and testing may reveal major reliability problems after hand-over to operations. Whether it is the quality and reliability of individual components, the interaction of those components, a change to ambient conditions, or a lack of redundancies, the result is similar to that of poor performance just considered. As operators encounter constant nuisance trips and shutdowns, the "fix methodology" of changing permissive set points, bypassing safeties, and doing whatever it takes to eliminate nuisance trips, again to the detriment of safety, will be deployed. Therefore, a typical field approval, which concentrates solely upon "certification" of individual components, will fail to address the poor reliability of the assembly of such components and the associated hazards resulting thereby.

6. MAINTENANCE – Limiting field approval to the evaluation of certified components alone also fails to address how potential maintenance problems will impact an appliance. Depending upon how components are installed, their location or arrangement may make it impossible to be removed or even accessed for maintenance. As well, components may be difficult to procure or may even be obsolete. In other instances, the performance of specified maintenance activities may require highly qualified factory technicians with specialized equipment from far away locations while in others, a local maintenance technician may be dedicated to keeping the appliance running due to constant

failures. As demonstrated, it is evident how maintenance issues can affect the safety, reliability, and cost of running the entire process.

7. OPERATION – Other than a few vague references to operating manuals and training, the B149 Codes do not address potential problems associated with the operation of appliances. On one side of the spectrum there are appliances with a simple ON/OFF control and without any first-out annunciation or indicators to show operators what the appliance is doing. On the other side there are very complicated PLC based systems with multiple screens and alarms scrolling every few minutes. Inadequate system feedback can impact the ability to diagnose issues while an excessively complex user interface can be overwhelming. Both present the potential to cause safety issues with an appliance. Additionally, specialized training to become proficient in an appliance's optimal operation is rarely universal among operations staff due to cost, scheduling, and personnel complexities. When the primary well trained operator is no longer on shift, an obvious safety hazard becomes apparent when the backup operator with less training is required to intervene to keep the process going. There are simple methods of helping this situation, but currently they are not required by the B149 Codes.

8. EFFICIENCY – Notwithstanding the valid connection between efficiency and performance, we identify efficiency separately due to its affect upon other aspects of our evaluation methodology including environment, compliance, and economics. First there is fuel efficiency, which is increasingly the focus of various legislative requirements. A low efficiency is obviously not desirable because of extra fuel being consumed to essentially warm the atmosphere. While a high efficiency may sound better from an environmental perspective, it requires more complicated controls and increased maintenance not to mention it may also create higher NOx and CO emissions, increase flame temperatures leading to premature failure of heat transfer surfaces, or create problems with stack condensation and corrosion. In general, ultra-high-efficiency is very expensive and difficult to achieve and maintain. Second there is difficulty in maintaining efficiency throughout the full range of operation of an appliance. As a result, many of the claims of burner manufacturers regarding the efficiency of their product may only apply to one fixed point of the operation but are simply not true with either modulating or high/low type burner applications. Third, there is the efficiency of the process itself expressed in the quality of the process output. It does not matter that the thermal efficiency of the appliance is high if it results in a poor quality of the product it handles due to over-heating, under-heating, excessive fouling of heat transfer surfaces, or potential for fires.

9. ENVIRONMENT – The impact of any given appliance upon the environment it operates within is also essential for the evaluation process. Taking the approach as a field approval provider that the environmental impact of an evaluated appliance is someone else's problem is reckless and dismissive of the fact that a field approval is by definition an official permission to use the appliance safely. Besides the obvious but gradual impact of poor efficiency upon global warming, there may also be an immediate environmental impact due to either products of combustion or other process gases from an appliance. There may also be an environmental impact from potential product spills

from an appliance or due to excessive noise or smell from the appliance operation in a surrounding neighbourhood. In many instances it is the impact of the appliance on the operators and other workers which requires the need for special personal protective equipment (PPE). From a hazard mitigation point of view there should be a preference for elimination of these hazards and environmental impacts instead of reliance upon last line-of-defense equipment like that of PPE.

10. COMPLIANCE – Compliance is all about meeting regulatory AHJ requirements within a given jurisdiction. Canada has ten provinces and three territories, each containing multiple areas of jurisdiction within. Each AHJ has developed their own regulations and interpretations related to compliance. This is also true for some of the industries which are considered to be self-regulated. Therefore, it is important to understand that the compliance of an appliance refers to adhering to local AHJ regulations and their interpretations of a specific code or standard. There is no guarantee that all AHJs will include the B149 Codes in their requirements nor is there currently any coordination between AHJs as to which version of codes and standards, if any, are "in force". From a regulatory perspective, certification of fired equipment is often viewed as a guarantee of safety and performance. However, the general idea that a certified product is safer and better than a B149.3 field approved appliance is often false if that product is not used within its narrow range of certified parameters. It is important to understand that the B149 Codes are just guidelines and have no regulatory importance unless they are "adopted" by an AHJ, and even then, each AHJ can interpret them in a different way. It is our experience that exclusively following the B149 Codes does not guarantee safety, efficiency, reliability, compliance or any of the other design aspects mentioned in this paper. An AHJ's role is regulatory and not that of a combustion expert or equipment designer, so they may not have in-depth technical experience to address these concerns. To this end, AHJs often rely on registered Professional Engineers to provide this subject matter expertise. By extension, field approvals are supposed to be equivalent to the safe acceptance of an appliance offered through certification but only if conducted by knowledgeable and experienced field approval personnel, which includes the authentication by a Professional Engineer registered in the province of the installation.

11. STANDARDS – The selection of standards and codes to be followed in a fired appliance project is dictated not only by the regulatory compliance requirements but also by the due diligence of the equipment designer and all Professional Engineers involved in the project. The B149 Codes include in their list of referenced publications over 80 codes and standards which the designer is supposed to be familiar with and follow where applicable. The purpose of the B149.3 Code is meant to serve as a guideline for those conducting field approvals, not as a design how-to for fired appliances. It does not and never will cover all of the possible applications and variations of designs. The main body of the code is compulsory but all annexes are informative only. Therefore the B149.3 Code alone does not instruct how to achieve or guarantee the overall safety, suitability, function, operation, reliability, and durability of a fired appliance, as well as all other qualities of design which are implied in the Code as essential parts of the evaluation. The knowledge of these qualities must come from the practical experience of the personnel involved in the design as well as the field

approvals of these appliances. In cases where specific requirements are not mentioned in the B149 Codes, suitable requirements must be used from other standards such as NFPA, FM, API, or from both published or proprietary design literature. These other standards for specific appliances are often required to augment the generic requirements found in the B149 codes to ensure the overall safety of the specific appliance.

12. ECONOMICS – Although the economics of achieving compliance are rarely discussed in the context of safety it is our experience that they are the major deciding factor in fired appliance purchasing decisions. The PPE issued to an operator, which is supposed to be the last-line-of-defense hazard mitigation method, is sometimes the only mitigation method present simply because it is the most inexpensive by comparison. Direct and indirect costs can be attributed to all of the other aspects mentioned in this document: reliability, suitability, process, performance, maintenance, operation, efficiency, etc. have associate costs. If low cost is the major driving force behind the purchasing decision, all of these aspects and the sustainability of the installation will naturally be compromised. It is our experience that a properly executed and comprehensive field approval program based on knowledge and experience of combustion systems is the most cost-effective method of finding proper balance between the initial and long term costs of the project. To achieve this goal, a field approval should start at the design stage of the project and continue throughout its construction, installation, commissioning, and into operation. Starting the field approval process after everything is installed and is already operating often results in the need for costly modifications, which interrupt the process.

Careful consideration of these aspects and their interconnectedness is in our view what constitutes a comprehensive field approval program. Furthermore, we feel that owners undertaking this comprehensive and holistic approach will be provided with what can rightly be viewed as an insurance policy to ensure a positive and sustainable outcome of associated projects. This insurance policy will also serve to mitigate the liability the owner inherits by virtue of the regulatory perspective which assigns ultimate responsibility of ensuring compliance to equipment owners. Although the equipment vendor, designer, manufacturer and installer are equally expected to ensure regulatory compliance in the initial phases of the project, ultimately it is the owner who will have to deal with the appliance and its state of compliance in the long term. An argument that the equipment vendor assured the owner of the equipment compliance will not relieve the owner from this liability, especially after the system warranty has expired. Similarly, a poor quality field approval conducted by inexperienced internal or external resources does not protect the owner from long term liability of non-compliance. In summary, compliance is not about the cheapest approval label; rather, it is about the most comprehensive and most holistic field approval possible. Without hesitation, we declare that our field approval program provides the most comprehensive coverage available and will prevent buyer's remorse for owners committing to this approach.