Boiler & Process Equipment Fuel Switching Projects

10 things you need to address besides burners and gas piping

This article seeks to assist those in their boiler or process oven fuel retrofit journey. The dramatic impact that fracking has brought to the world with the proliferation of low cost natural gas has seen a dramatic increase in fuel conversions. This article is written mostly around issues that are relevant for central plant, field erected, single or multiple fuel burner boilers, although there are important issues that apply to any size or type of process equipment fuel conversion or retrofit.

Most of these projects get justified based on dramatically reducing fuel and maintenance costs. I hope that by understanding the issues presented below you also understand this as a rare opportunity to also increase safety and reduce operational risks as well.

Hopefully I am catching you near the start of your project. In some cases, I am likely way too late. I wrote this after going through a recent $3MM project with a client. I'm hoping that there's something in here that helps you to make your project more successful. When I speak about "success" in my world that does not necessarily mean minimizing your budget. In my world project success has more to do with addressing risks and being able to operate safely. Many of these are the things that attack the largest killer ever known to mankind's industrial accident world, "Human Error". You need to understand that your projects costs may have been focused on simply changing out burners and controls and running some gas piping. This may only be half the story once you completely understand the entirety of what needs to be included for a compliant risk averse project as you read on below.

If you're in the middle of reading this, and you have responsible charge for a project, continuing to read may not be a good thing for you. You're in a tough spot because if you now go to the management team and tell them you forgot about a few things they will likely judge you as incompetent. The people they answer too will likely indicate that there is no budget for what you are now asking for. None of this will make you popular. I am hoping that part of your justification for addressing some of the issues identified below might be that failure to comply with laws and codes, (basically ignorance of the law), is not a defense. If someone gets hurt many of the things I am speaking about that follow will likely be brought up and used against you when OSHA and the plaintiff's attorneys get you into court. The company you work for may or may not defend you. Some of that will depend on if personal criminal charges are brought. Sometimes in those cases you are completely on your own. If you're lucky enough to work for someone who has a "Zero Harm" or "Just Cause" environment, you're OK. For those who do not, my prayers are with you before you read on.

Now let's get on with 10 important considerations you have hopefully already addressed:

1. **Procedures**
   Do you realize that codes and standards applicable to your project require that detailed relevant procedures exist? This should not be a new concept for you. It should not be an "extra" requirement because you are now retrofitting the fuel system. This should be something you already have that now likely needs some editing. The procedures required would include:
   A. **SOP's, (Standard Operating Procedures).** Covering things this such as drum level control, starting turbines and pumps, and even fuel switching.
   B. **Abnormal Operating Conditions.** Covering unusual conditions such as problem flame conditions, fuel pressure excursions, water level issues, etc.
   C. **Start-up/Shut down.** These should include from a cold start, and from a re-start. Best in class start-up/shutdown procedures use valve line-up tables for consistency and completeness along with pictures of tagged components. This implies that all valves and instruments are tagged to even make this possible. Your work scope should include valve and instrument tags and these should all be identified in revised P&ID's (piping and instrumentation diagrams).
   D. **Emergency.** This would be a step beyond abnormal conditions. It might include safety relief valves lifting, a tube rupture or severe steam leak, or a fireside explosion. Some of these might be conditions where the plant needs to be abandoned by everyone including operators.
   E. **Maintenance.** Maintenance staffs need to know how to perform preventive maintenance and safety testing on all the new fuel systems. It's not real straightforward to figure out what exactly the required preventive maintenance scope needs to be. The most important guidance document for this, (NFPA 85 – Boiler Combustion Hazards Code, available at www.nfpa.org), used to be very explicit about it. It now tells you (NFPA 85, [2015], in section 4.4.1).

      > *"A program shall be provided for inspection and maintenance of equipment at intervals consistent with the type of equipment used, service requirements, and manufacturers recommendations."*

It's going to be important that you verify that everything is installed and operated as the manufacturers specifications indicate and that you derive what the inspection and testing scope and intervals are. These requirements are sometimes not readily apparent. For example, lubricated plug valves are used in many cases to isolate fuel trains. In the literature that comes with some of them periodic sealant installation is called for and in some cases, that is given as annually. You may have never even thought that valves need to be serviced annually. There are many other examples of components and inferred maintenance requirements from the components manufacturers that are not explicitly spelled out in the text of NFPA 85.

Another not so obvious requirement is that automatic valves need to have periodic seat leakage testing. This is frequently called "bubble testing". It's the process of making sure that when a valve is closed there is no flow downstream past the stem to seat connection within the pipe. If you have never done this before it's something that will require some tools and training to accomplish.

2. **P&ID's up to Date**

   The switching of burners and fuels will require that P&ID's, (piping and instrumentation drawings), are made to new 'as built" conditions complying with whatever MOC, (Management of Change), protocols you have. There will no doubt be new instruments and things like pressure switches, likely PLC racks or cards, and additional valves and piping that never existed. These will all need to now be on new or revised P&ID's along with set points of devices.

3. **Alarms Philosophy and Database, and Rationalization**

   This retrofit provides you with an opportunity to evaluate the functionality of all your alarms. A great reference on proper alarm management and operations can be found in the International Society for Automation's (ISA's,) standard 18.2 Alarm Management Lifecycle document, (www.isa.org). This document tells you about establishing alarm philosophies, and databases, and about rationalizing alarms. Rationalizing alarms has to do with understanding what people are supposed to do when an alarm occurs. How long it might take them to do that certain thing in response to an alarm. It also addresses issues such as what does the alarm consist of, "a horn, a light, a horn and a light"? Do they repeat, can they be silenced? If so for how long? This process of deciding all the issues surrounding your alarms is called, "rationalization". It is best done with a cross functional team of people in a series of meetings. This needs to be documented and then operating staffs need to be trained on the outcome. If you have never heard of or considered this standard (ISA 18.2) then an entirely new scope of work should be considered to address the state of your alarms.

4. **Training.**

   The entire topic of training can take more time than you have so I will try and summarize the key points. Training first is all about content, delivery, and then validation. It's also about knowledge and skills. Remember, knowledge is book learning and skills are hands on things. The content you will likely need for training will include all the items I have identified above (Yes, all of items 1. through 3.).

I then advocate as well having a "Master Reference Manual". How does BMS (Burner Management System) and CCS (Combustion Control System) work? This would be a document written in plain English that includes a narrative about all the equipment and how it functions. All training should start with a needs assessment. In fact, anyone who does training for you should have heard about ANSI Z490.12016, (Criteria for Accepted Practices in Safety Training), and should understand how to apply that for you. Once a needs assessment is complete, and content is developed the knowledge delivery may take on many forms. These could include PowerPoint presentations that are narrated for self-learning or presented live in classrooms, walk down of the equipment (show and tell), and P&ID review. Validation of this will usually be done with written tests. The development of tests is also somewhat involved because one must consider the types of questions that are valid questions. If you have never heard of Blooms Taxonomy you will need to do a little research to better understand that test questions come in many forms. In some cases, you are asked to just recall memorized information. Other test questions would have you synthesizing this information and applying it with critical thinking. Good written tests are a strategic mix of both.

The skills part can take the form of simulators or well coached on the job training and then witnessing tasks completed correctly with a check off sheet for validation. The skills part also needs to be thought through. It requires someone with operating experience and practical skills who can also communicate well.

5. **Life Extension Studies or Fitness for Use Studies or Evaluations**
   Have you ever wondered if new burners and additional retrofits are lipstick on a pig? Before you decide to make a significant investment in the fuels part of your boiler you might do well to have everything else evaluated. These kinds of evaluations go by many names including, "Life Extension Study, Remaining Life Study, Fitness for Use Study". They also can take many forms, from someone crawling through to the addition of as many NDT (Non-Destructive Testing) options as you care to pay for. These can include taking tube thickness surveys, evaluating metallurgical considerations, digital X-rays of superheater tubes and more.

   One of your best partners for this effort will be your jurisdictional inspector. You might be thinking of this person as your "state" or "insurance" inspector. These folks have special training related to pressure vessel integrity and can for sure provide the guidance you need regarding at least who to talk to for these services and what to talk to them about. Every state has a State Boiler Chief who would be happy to help you with this. All state boiler chiefs can be found for this and other pressure vessel issues at www.nationalboard.org. This is the National Board of Boiler and Pressure Vessel Inspectors in Columbus, Ohio. They are an umbrella organization for all jurisdictional inspectors.

6. **Records of steam piping fitness for use, (ASME B31.1), requirements for inspections, review of hangers, etc.**
   Besides evaluating just, the boiler itself, what about all the appurtenances and high energy piping within the plant? Is there a desuperheater or attemperator? What is its condition? What about

relief valves, what are they rated at? Has anyone done NDT inspections of feedwater piping systems for things like flow accelerated corrosion? What about something simple like pipe hangers? Have you evaluated them to see that they are still in place, loaded properly and maintained? Yes, even pipe hangers need periodic maintenance depending on their style and type. Have you kept up with the periodic piping inspections required by ASME B31.1 (Power Piping Code, www.asme.org) of particularly vulnerable areas of the piping system?

7. **Service Records, repairs of pressure vessels, (tube leaks).**
   Do you have assembled service records of repairs? Repairs to refractory and or tubes would be especially important. Chronic repairs might again indicate time to deal with bigger issues than just a fuel change out. If there have been multiple patches to certain things like superheater tubes it might be time for a swap out. This is not something done casually. It's better you review this now and deal with it than after more issues with a new burner system installed.

8. **Gap Analysis for Compliance with Nationally Recognized Consensus Standards and Codes**
   Before you understand gap analyses you need to understand something about how OSHA and the legal system work. In both cases, it has been my experience, that if there is ever a problem everyone comes looking to see what nationally recognized consensus codes or standards you may not have complied with. Consensus codes and standards are documents prepared by one of over 900 standards creating organizations. The most important ones, in my opinion, use the ANSI (American National Standards Institute, www.ansi.org) process to insure integrity of their standard creating system. These documents will usually be from organizations like ASME (American Society of Mechanical Engineers), ASSE (American Society of Safety Engineers-www.asse.org), NFPA (National Fire Protection Association), API (American Petroleum Institute, www.api.org), and ISA, (International Society for Automation).

   Conducting a "Gap Analysis" means that someone will review the current requirements of the right codes and standards and see where your systems fall short. You can then rank these shortfalls as A, B, or C priority items. It's much better to plan a compliance path for as many issues as you can. Very few organizations comply with everything all the time. However, "Best Practice" organizations comply in a conscious and proactive manner with things that make sense for them at the time. They decide what makes sense at the time by doing PHA's (Process Hazard Analyses) and assessing risks. They don't just wing it and hope for the best.

   One of the most basic of these codes that will be a key to many of the compliance issues in a fuel change is NFPA 85 (Boiler Combustion Hazards Code). This address compliance requirements for both single burner and multiple burner boilers. You need to understand all the issues that address compliance with NFPA 85. These could be many things that are not necessarily directly related to flame safety. These issues could relate to the fuel delivery systems to the boilers, the state of the entire burner management system, and even water level or steam pressure trip issues.

   Gap analysis is not just a chance to comply more with applicable codes, it's also a time to consider what your gap is to new technologies and to "best practices". I look at it this way. If I have a chance to buy a new car, I sure as heck would get one with all the latest safety features like

side impact air bags, intelligent cruise control, and lane departure warning. This retrofit is a chance to upgrade some of your technology. For example, consider just the case of flame detectors. I might have been burning oil and had optical flame detectors before. They might work fine and maybe can be retrofit with a small change to make them suitable for natural gas. I had a flame failure signal before, I now also still have a flame failure signal but it's just with natural gas, right? Well, that might be right but you are likely going to want to take advantage of this time to upgrade flame detection technologies. There have been dramatic changes in the way flame detectors work over the past few years. The newest optical flame detectors learn flame signatures. This means they can learn flame signatures for different fuels and different firing rates. In the case of multiple burner boiler's, they will also be able to discriminate amongst other burners that are on. This means that you will now be able to alarm and trip flame quality issues in addition to just flame failures. These features can provide you with much more protection than you have ever had before.

9. **Bringing gas onto the site for the first time? Know how to properly do gas piping work!**
   Let's face it, you hear about natural gas explosions all the time related to piping systems. There have been a few very high-profile incidents that have led to changes in key documents related to the safe handling of natural gas piping systems. This has included requirements for purging in what's called the National Fuel Gas Code or NFPA 54. In this document there are now requirements related to special processes that must occur whenever gas piping is being purged out of service, (making it safe to work on), or purged into service, (filling it back up with gas). If systems are in service above 125 psig then a completely different standard applies called, NFPA 56, (Standard for Fire and Explosion Prevention During the Cleaning and Purging of Flammable Gas Piping Systems). You need to understand both documents and how your installation, commissioning, and maintenance activities will comply as your fuel switch progresses. NFPA 56 has rigorous requirements for creating purging plans that consider more than 45 different factors. This document also requires considerable training of staff that does this kind of work.

10. **Review any "Near Miss" Incidents and consider this a time to make additional progress on operations related risk reductions for boiler facilities.**
    Finally, in your overall consideration for what the scope of this fuel change project should be, consider evaluating any "Near Miss" incidents that may have occurred over the past several years related to boiler operations or maintenance. Consider this as a prime time to get things done that might otherwise be delayed or further deferred. You would never want to be in a position where you just did a major retrofit of a boiler fuel system only to repeat some previous "Near Miss" which ended up getting someone hurt.

Hopefully you now understand that there's a lot more to a fuel retrofit project than what initially meets the eye. The original justification for such a project might have been to reduce costs. Now you can see that this is a rare opportunity to also dramatically reduce operating risks and increase reliability at the same time. It won't be easy, and now making the case for things that you forgot may involve some political risk. I'd rather deal with this than having to face the families of loved ones I was supposed to be protecting with all of my knowledge, professional training, and best efforts.

About the author:

John R. Puskar, P.E. is a multi-state licensed professional engineer. He started and then sold 28 years later the world's largest boiler and combustion equipment safety testing and inspection company. He is the ASME 2015 Uzgiris-Barnett National Safety Award winner for his lifetime body of work in the combustion equipment safety area. He is the author of the 2014 book published by Wiley and Sons called, "Fuels and Combustion Systems Safety – What You Don't Know Can Kill You". Wiley is now having the book translated into Chinese. Mr. Puskar has served or currently serves on several NFPA safety committees including 54, 56, 85, 86, and 820. Mr. Puskar has created combustion equipment safety programs for the world's largest multinational industrial companies including Ford Motor Company, GM, Alcoa, and US Steel. Mr. Puskar has trained thousands throughout the world in these areas of practice and has written and had published more than 50 articles on the topic.